Supporting Capabilities for the Gemini 8m Telescopes:

A Report and Analysis of Gemini Science Workshops

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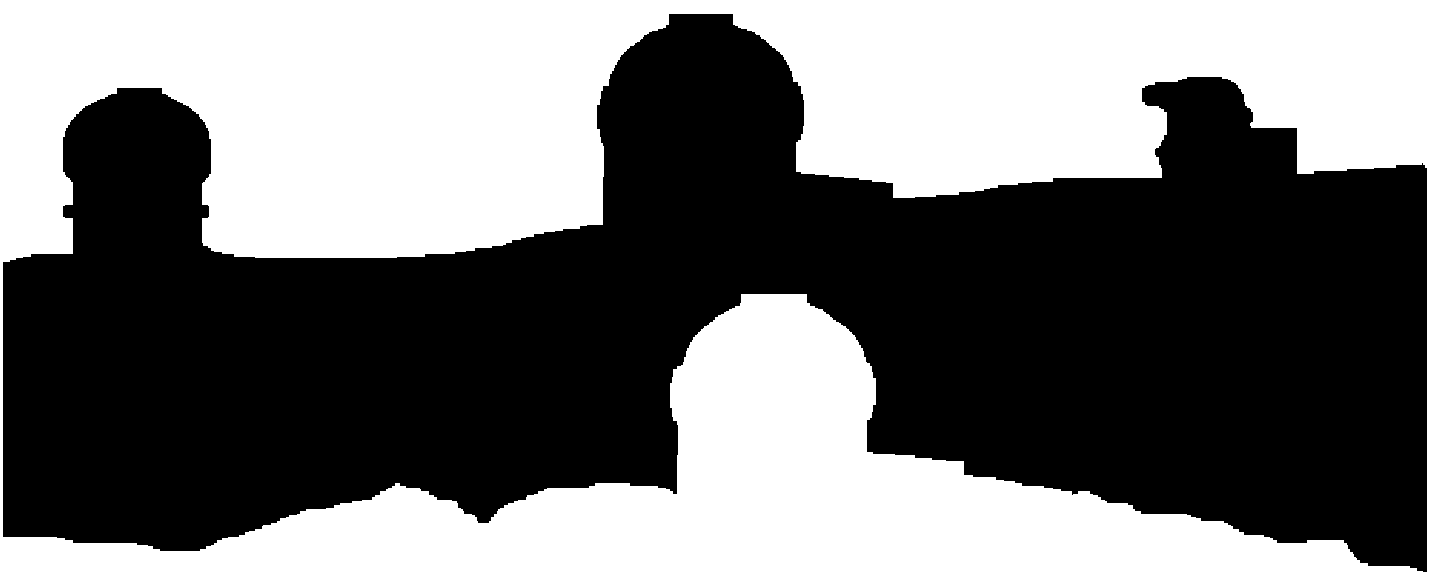

Summary

Science workshops were held throughout the Gemini partnership during the second half of 1997 with the aims of identifying and quantifying the supporting capabilities required to enhance the utility and efficiency of the Gemini 8m telescopes. These workshops, held separately in the US, UK, Canada and South America, ensured representation of a wide range of scientific interests by astronomers from the community. At each workshop many scientific programs were considered in detail sufficient to understand the requirements for their execution on Gemini as well as for any preparatory observations. The desire for wide-field optical and near-infrared imaging was frequently identified with an average of one-half to one night of these survey observations per night of Gemini follow-up. Two other common themes were high angular resolution imaging and rapid response to target-of-opportunity events.

1. Introduction

It has long been recognised that efficient and effective use of large telescopes relies on supporting observations and data from complementary facilities. A classic example is the influence of Schmidt surveys and 1-2m telescopes on the utilisation of 4m-class telescopes. These have been primary sources of interesting scientific targets as well as providing complementary observations, for example of the brighter objects in a sample, astrometry, simultaneous data, and preparatory and calibration observations. To identify and quantify these connections and understand their application to the Gemini 8m telescopes we have undertaken a study of science programs drawn from the Gemini partner communities.

To make allowance for any specific national biases of science interests or access to supporting facilities, science workshops were held separately in the US, UK, Canada and jointly amongst the South American partners. These workshops, described more fully in section 2, all followed a similar scheme that involved the examination of a number of potential Gemini science programs in detail sufficient to understand their requirements for successful execution, both for Gemini and from supporting facilities. In this context the ‘supporting facilities’ are taken to include other optical and IR telescopes, for specific targets as well as surveys, telescopes operating at other wavelengths and satellites, measuring machines, data processing systems and archives. Examples of supporting programs are identification or selection of samples of targets, calibration, accurate brightness of colour measurements and observations of the brighter members of an object list.

Analyses of the individual workshop results are presented in section 3 together with an examination of several common themes from the Gemini perspective. A brief primer on the Gemini telescopes, instrumentation and operational capabilities presented prior to, or at, each of the workshops as a context for the illustrative science programs is given in Appendix A. The programs themselves are included in Appendix B.

2. The workshop processes

2a. US

The U.S. workshop on supporting capabilities for large telescopes was held September 26 through 28, 1997 in Tucson, Arizona. Rather than being specific to the Gemini telescopes, this workshop was aimed at identifying capabilities required for the effective use of all the 6.5-10 meter telescopes available to the community. Forty-five participants representing 25 different institutions and five independent large telescopes participated. The participants were divided into eight discipline-based panels, each with two co-chairs to organize and lead the discussion. Panel subject areas ranged from Origins of solar system objects to Large Scale Structure/Cosmology.

The first part of the meeting included presentations on the capabilities and modes of operation of each of the large telescopes. In the afternoon of the second day, the group split into the prearranged panels and worked to devise one or more large observational programs in their subject area to be done on one of the large telescopes. They were then asked to analyze these programs from beginning to end, and identify all supporting capabilities required. These capabilities could include telescopes, instruments, software, surveys, operations modes, or any other aspect of infrastructure that might be needed. They were asked to consider capabilities that might be needed for sample selection, calibration, complementary or simultaneous observations, or as preparation for the large telescope observations. The entire group reconvened at the end of the first day to make sure all the panels were making suitable progress. They further developed the details of their programs through the second day and everyone reconvened at the end of the second day for final reports from the panels. In the morning of the third day, the panel co-chairs and workshop organizers met to merge the findings of the individual panels and identify the most important common requirements.

2b. UK

The UK meeting was held at University College London on 1997 October 2nd. The attendees were selected by trawling through the observing time allocations on the UK 4-m telescopes over the last 4 semesters and inviting people who are consistently awarded significant allocations. The invitees were asked to consider an observational program which would include a substantial Gemini component and develop the programme to identify the instrument configurations and estimate the observing time required on Gemini and any other facilities that would be required for the successful completion of the program. In most cases, the programs are of a similar scale to those currently allocated on the UK 4-m telescopes (i.e. programs which need a few nights on Gemini).

Before the meeting, the attendees were provided with brief descriptions of the phase I instruments and those identified as high priority in the initial phase of the ongoing instrumentation program. They were also provided with very approximate expected sensitivity calculations of generic imaging and spectroscopic instruments as a first order guide to anticipated Gemini performance.

The meeting started with an overview of Gemini instrument capabilities from Phil Puxley and a brief description of the procedures required to conduct observations with Gemini. This was followed by a summary of the interim conclusions of the UK wide-field astronomy panel presented by Jim Emerson. The attendees then described the science programs that they had developed, including the scientific aims, instrument requirements, and observing time required on Gemini and any other telescopes. Brief discussions held immediately following the individual presentations were followed by a more general discussion after all the programs had been presented. The general discussion concentrated initially upon the observing requirements with 2 to-4-m telescopes, and then moved on to consider the implications for the UK telescope time allocation process. A dozen people attended the meeting and a list of participants and sample Gemini programmes is provided in Appendix B2.

2c. Canada

The Canadian Gemini supporting capabilities workshop was held as part of the 7th annual meeting of the Canadian Gemini Science Steering Committee (CGSSC) at the Herzberg Institute of Astrophysics in Victoria, British Columbia on August 1 and 2, 1997. The discussions on the supporting capabilities took place during the afternoon of the first day of meeting and the morning of the second day.

The workshop was attended by about 20 government and university researchers and included radio astronomers. Ground-based and space facilities of interest to Canadians were reviewed, and support capabilities Canadian astronomers would need to prepare and to conduct their scientific programs with the Gemini Telescopes were defined. The attendees were fairly representative of the community of heavy users of existing large facilities, and were certainly among those keenest to use the Gemini Telescopes to pursue their scientific programs.

A subtle bias was probably introduced by the fact that participants were 'forced' to think about supporting observing programs and required facilities to conduct them. A few of the participants first said that they would shift all their observing efforts to Gemini and that they would not need smaller telescopes anymore; in the end they provided a support capability program! Consequently the number of support nights on other telescope may be slightly inflated. However this is possibly compensated by other researchers who may have underestimated their need of supporting observations in the various wavelength domains. This is especially true in the context that observers may wish to complement optical or infrared observations with millimetre observations, e.g. with the SCUBA imager on the James Clerk Maxwell Telescope.

Ten of the attendees were specifically requested to propose in writing one or more Gemini science programs (including the Gemini instrument(s) needed) and to define the supporting observations needed to conduct or complete the Gemini science. They were requested to identify the needed telescope facilities (existing, planned or desired) or archives. Exchanges were continued electronically after the meeting to clarify issues and to quantify the required amount of telescope time. These science programs are included in Appendix B3.

2d. South America

The South American Gemini workshop was held in Florianopolis, Brazil, on 1997 December 8-10th. Fifty-five participants from Brazil representing seven institutions, ten from Argentina representing four institutions, and two from Chile attended the meeting. One CTIO staff member, one ESO staff member, two Gemini staff members, one NSF representative, and one invited speaker from USA also attended the meeting. The organizers had aimed to invite a larger number of other partner members and also a larger number of participants from Chile, however there were several withdrawals in the last weeks before the meeting.

Doug Simons and Phil Puxley gave extensive presentations on Gemini instrumentation, capabilities, queue observing modes and other matters. Wayne van Citters discussed the Australian participation, in discussion at that time. These talks promoted very active discussions. A total of 31 scientific oral talks and 27 poster papers were presented. The proposals were, in most cases, presented by the PI of small groups. During the meeting several ideas for joint programs were conceived. Full (280 page) proceedings of the meeting are being produced in book form. Its editors are B. Barbuy, E. Lapasset, R. Baptista, R. Cid Fernandes, and the publishers are

Universidade Federal de Santa Catarina/Universidade de Sao Paulo. Abstracts for the oral presentations, titles for the poster presentations and their Gemini instrument requirements are included in Appendix B4.

3. Analysis of workshop results

3a. US perspective

All the panels identified multi-band imaging surveys as essential, principally for sample selection. The detailed parameters (bandpasses, survey areas, limiting magnitude, and precision of photometry and/or astrometry) of the required surveys varied from program to program. Bandpasses ranged from U to L with some programs desiring photometry in Stromgren or Washington (narrower band) systems. Survey areas ranged from ten to a few hundred square degrees, and limiting magnitudes and precisions were appropriate for medium aperture (2.5-4m) telescopes.

Subsequent to the workshop, an attempt was made to examine the required survey capabilities in the context of a uniform set of assumptions about telescopes and instruments. The parameters of each survey were used to determine the number of nights required to carry out each survey on each one of four telescopes – a 2.5-meter telescope with 1 arcsec images and 10% emissivity, a 2.5-meter telescope with 0.5 arcsec images and 3% emissivity, and two 4-meter telescopes with the same values of image quality and emissivity. In all cases, wide field imagers using currently available detectors were assumed. This analysis showed that most of the surveys could be done on 2.5-meter telescopes with some preference for a telescope with better performance. The surveys each typically required a few tens of nights to be completed. The two surveys that came from panels working on high redshift problems required an unreasonable number of nights in all cases. For these surveys to be practical, further progress on detectors, particularly in the IR, is necessary.

In addition to the physical infrastructure, the panels noted that development in other areas related to undertaking such surveys would be beneficial or essential. As mentioned above, development of larger format detectors for both optical and IR imagers provides an increase in efficiency proportional to the number of pixels. Standardization of software for pipeline data reduction, archive access, and observing protocols would make the results of surveys more readily useful to the entire community. Additionally, it was recognized that sociological issues must be addressed to balance the desirability of taking on the effort of a survey with the guaranteed community return. Finally, a desire for specialized operations modes was expressed, including specifically, mechanisms that would allow target-of-opportunity and synoptic observations.

A number of biases are evident due to the individual participants as well as the process itself. There was relatively little connection with other wavelength regions or space-based observations. The panels were told to “think big” in order to identify the most important problems and commonly required supporting capabilities. As a result, some panels may have developed programs that are too ambitious to ever be undertaken with the facilities under consideration. Many subject areas were inadequately represented. Still it was an interesting and informative exercise, and well served the additional purpose of initiating community acknowledgment and discussion of the need for facilities to support effective use of the largest telescopes.

Participants in the workshop included James Elliot (MIT), Jane Luu (CfA), Phil Nicholson (Cornell), John Spencer (Lowell), James Liebert (U. Arizona), Neill Reid (Caltech), Chuck Claver (NOAO), Chris Clemens (Caltech), Todd Henry (CfA), Ted von Hippel (U. Wisconsin), Andrea Dupree (CfA), Chris Sneden (U. Texas), Mark Giampapa (NOAO), Douglas Gies (Georgia State), Artie Hatzes (U. Texas), Larry Ramsey (Penn State), Dimitar Sasselov (CfA), Charles Lada (CfA), Stephen Strom (U. Mass.), Michael Meyer (U. Arizona), Joan Najita (CfA), Bruce Wilking (U. Missouri), Erick Young (U. Arizona), Rob Kennicutt (U. Arizona), Sylvain Veilleux (U. Maryland), Jay Elias (NOAO), Joseph Shields (Ohio U.), Tom Soifer (Caltech), Dennis Zaritsky (UCSC), Bruce Carney (UNC), Ken Freeman (Australian National U.), Taft Armandroff (NOAO), Heather Morrison (CWRU), Mike Rich (Columbia), Ata Sarajedini (SFSU), Richard Elston (U. Florida), Matt Bershady (U. Wisconsin), Jane Charlton (Penn State), Ruth Daly (Princeton), Arjun Dey (NOAO), Michael Strauss (Princeton), Hans-Walter Rix (U. Arizona), Ken Lanzetta (SUNY), Ray Carlberg (U. Toronto), Tod Lauer (NOAO), Ann Zabludoff (UCSC), Phil Puxley (IGPO), John Huchra (CfA) and Todd Boroson (NOAO). Hugh Van Horn (NSF) also attended the workshop.

3b. UK perspective

The major conclusions from the UK meeting can be summarised as follows:

i. Most programmes presented are extensions of projects being conducted on 4-m telescopes; it is probable that actual Gemini applications will exploit more fully the advantages of an 8-m telescope. The UK meeting was held shortly after the deadline for telescope proposals, and it is likely that people naturally developed ideas that were fresh in their minds.

ii. The advantages of Adaptive Optics are only partially represented in most of the programmes; as more experience of AO is gained, it is likely that projects which exploit its advantages will be devised.

iii. A wide variety of supporting observations is required, covering optical and infrared spectroscopy and imaging, and access to existing data and archives, as well as satellite data at other wavelengths. The observing time required on 2-4-m telescopes in support of Gemini is dominated by programs that need wide-field optical/near-IR imaging to survey substantial areas of sky for target selection.

iv. There is a large spread in the ratio of observing time required on Gemini relative to that needed on the 2-4-m telescopes, but overall, a ratio close to 1 : 1 is probably representative with large variance over the programmes and large uncertainties.

v. There is a clear requirement for a rapid response mechanism to allow effective measurement of targets of opportunity.

vi. The telescope time allocation structure in the UK may need to be revised to allow more efficient completion of highly-rated programmes that require time on more than one telescope.

The programs presented are unlikely to be representative of the actual programs that will be conducted on Gemini for several reasons. The people invited to the meeting represent only a small fraction of the active UK community and are biased towards the heaviest users of the UK 4-m telescopes; those who get either smaller or less regular time allocations were not represented. It is well known that new capabilities and instruments stimulate observers to develop new approaches to formulating their scientific research projects – this will happen with Gemini.

Attendees were: Pat Roche, UKPS, Phil Puxley (IGPO), Roger Davies (Durham University), Richard McMahon (IoA, Cambridge), Ian Crawford (UCL), Phil Charles (Oxford University), Mike Bode (Liverpool John Moores University), Mike Edmunds (University of Wales, Cardiff), Rachael Padman (MRAO Cambridge), Jim Emerson (QMWC London), Alan Coates (PPARC)

3c. Canadian perspective

(i) Major capabilities identified

The main facilities of interest to Canadians astronomers in the Gemini era are the Canada-France-Hawaii 3.6m Telescope for the optical and infrared domain, the James Clerk Maxwell Telescope for the sub-mm and mm range and the Canadian Astronomical Data Center (CADC) for archives.

New imaging capabilities at 350 and 850 microns with SCUBA-JCMT offer attractive new capabilities that were mentioned several times. This illustrates the many common links between the science that will be conducted from Gemini and from cm, mm and sub-mm radio telescopes in areas like star forming regions, active galaxy nuclei and distant galaxies. Some support projects would make use of the deep narrow-band imaging capability of the 1.6m telescope of the Mont Megantic Observatory. Various archives such as HST, ROSAT and CFHT are in high demand, and the Canadian Astronomical Data Center (CADC) is recognised as a unique and most powerful facility.

Because Canada does not own any large telescope in the Southern Hemisphere (except Gemini South when available), better access to optical and infrared facilities in the south is obviously needed.

The main demand is for high quality 'large' field (10 to 30 arcmin) BVRIJHK imaging with 4-m class telescopes in both hemispheres. Because of the paucity of JHK images (especially of survey type) and the short history of good detector availability, the need for imaging in the near infrared is particularly flagrant. Approximately 20% of the CFHT support was for Adaptive Optics bonnette work.

The 13 'submitted' Gemini science proposals corresponded to a total number of 46 'requested' Gemini nights. In terms of support, this leads to 58 'CFHT' nights, 15 nights on a 2-m class telescope and 6 JCMT nights. This translates into the following approximate equivalence: 1 Gemini night 'requires' 1.3 night of 4-m class telescope, plus 0.3 night of 2-m class telescope, plus 0.1 radio telescope night.

We consider these figures only as indicative; nevertheless they illustrate that the Canadian astronomical community will wish to keep access to some high-performing smaller telescopes in the Gemini era. It is certainly fair to conclude that one Gemini night will require approximately one night on another facility.

(ii) Selection and scale biases

The main directions of astronomical research in Canada were quite well presented among the proposed illustrative science cases. However a few more cosmology 'proposals' would probably better reflect the trends of present and future research by Canadian astronomers.

An interesting aspect of the proposed supporting observing programs to be conducted on 4-m class (or smaller) telescopes is the relatively high percentage (20%) requesting the use of the CFHT Adaptive Optics bonnette. This can be probably explained by the availability of such an instrument to Canadian astronomers and by the fact that the AO bonnette is recognised as a reliable and well-performing instrument.

Participants to the Canadian Workshop were as follows: David Hanes (Queen's University), Bill Harris (McMaster University), Jaymie Matthews (UBC), Simon Morris (HIA), Jean-Rene Roy (Universite Laval -- Canadian Gemini Project Scientist), Nicole St-Louis (Universite de Montreal), Michael West (St Mary's University), Tim Davidge (HIA), Don Morton (HIA), Andy Woodsworth (HIA), John MacLeod (HIA), Paul Feldman (HIA), Daniel Durand (HIA), Russell Redman (HIA), David Schade (HIA), David Crampton (HIA), John Hutchings (HIA), Jim Hesser (HIA), Greg Fahlman (UBC) and Gordon Walker (UBC).

3d. South American perspective

The approach by Chile is different from that of Argentina and Brazil, given the difference of number of nights available per astronomer. A "typical" Chilean proposal was presented by L. Campusano consisting of a large survey for QSO detection. Argentinian and Brazilian proposals showed the characteristic of having well-defined targets to observe with Gemini. Preparation of observations with smaller telescopes is clearly necessary since the available observing time with the 8m telescopes will be so small. We note that the existing principal facilities in Argentina and Brazil are respectively a 2m and a 1.6m telescope. Astronomers from these two countries have been able to obtain observing time in Chile (CTIO and ESO) over the years, but of course in a limited way. Therefore particularly with respect to Brazil, some proposals may be suited to be shared between the Soar 4m telescope and Gemini, recalling that Soar is expected to be compatible with Gemini in many respects. The Gemini instrumentation required for the proposed programs was distributed as follows: 39% GMOS (1/5 of these using IFU), 19% HROS, 18% GNIRS, 3% Phoenix, 17% NIRI, and 4% mid-IR imaging. 13% of the proposals need AO. These fractions are only approximate since in some proposals, the needs (for example for AO) were not clearly stated.

3e. Overall Gemini perspective

(i) Analysis of program content

Before analysing the workshop results it is first necessary to understand if the ensemble of science programs is truly representative of "Gemini science". In Table 1 we present a summary of the programs sub-divided according to the Gemini telescope and instrument capabilities they would seek to exploit. (Note that because the US workshop was concerned with science programs on all of its 8m-class telescopes, and not just Gemini, not all of the US science programs match to specific Gemini capabilities. Where it was feasible, instrumentation on these other telescopes has been mapped to their nearest Gemini equivalent).

There are several interesting aspects to this collection of science programs. Firstly, differences in the science interests of the communities are evident, for example the extensive interest in high resolution spectroscopy amongst the various South American partners. Secondly, it appears that appreciation of several of the technical areas that Gemini has been designed to excel in (i.e. high resolution images and a low thermal infrared background) is yet to impact the science interests of the wider community. Thus there is a paucity of programs using the mid-IR instrumentation (Michelle and MIRI) and a relative lack of programs which would make use of the Gemini AO system to further improve the image quality. It is noteworthy that principal amongst requests for GAOS are the Canadian programs (e.g. Can1, 2, 9 and 12) presumably due to that communities exposure to one of the first common-user AO systems (the AOB on CFHT). Nevertheless, the workhorse imagers and spectrometers are called upon by the majority of science programs and explore the wide range of modes and capabilities offered. Therefore we interpret this ensemble of programs more as a modest extension of on-going optical and near-infrared imaging and spectroscopic studies.

The programs cover a very wide range of science interests from solar system studies to the distant universe. In the US case this arises from the subject-oriented approach to the workshop organisation (see section 2a) but is more generally due to the involvement of a wide range of telescope users.

In Table 2 we highlight another aspect of the programs which is their overall scope expressed simply as the Gemini time required to carry out the observations. The most obvious feature is the great variety amongst small and large programs again reflecting the structure of the separate workshops with presentations either by individuals or by larger groups instructed to be ambitious.

We conclude that the programs summarised in Tables 1 and 2 provide a representative snapshot of science interests amongst the wider Gemini community circa 1997, albeit one that will surely change over next few years as Gemini moves into its operational phase. Nevertheless we believe that the top-level supporting capabilities identified below are of such generic importance that they are likely to be applicable for many years.

Program Reference	GAOS	NIRI					NIRS					GMOS				Michelle			HROS			MIRI		Phoenix
		JHK & nb 0.02, 0.05	LM & nb 0.02, 0.05	JHKL & nb 0.11	JHK grism	coronograph	JHK spec	LM spec	cross-dispersed	IFU JHK	IFU LM	imaging	long slit	MOS	IFU	10-20um imaging	low & med res spec	high res spec	long-slit	cross-dispersed	MOS	10-20um imaging	spectroscopy	1-5um spec
US1				■								■												
US2a		■											■											
US2b													■	■										
US2c							■						■											
US3a																				■				
US3b																				■				
US4a							■	■										■						■
US4b							■			■														
US5	■	■												■										
US6a														■										
US6b														■										
US6c														■						■				
US7				■			■							■	■									
US8				■			■																	
UK1														■										
UK2				■									■											
UK3													■											
UK4																		■						■
UK5																				■				
UK6												■												
UK7	■					■																		
UK8	■									■														
Can1	■	■					■																	
Can2	■									■														
Can3															■									
Can4				■																				
Can5					■					■							■						■	
Can6				■																				
Can7														■										
Can8														■	■									
Can9	■									■					■									
Can10				■																				
Can11														■										
Can12	■	■								■														
Can13														■										

Table 1a: Use of the Gemini initial instrument complement by the example science programs.

Program Reference	GAOS	NIRI					NIRS					GMOS				Michelle			HROS			MIRI		Phoenix
		JHK & nb 0.02, 0.05	LM & nb 0.02, 0.05	JHKL & nb 0.11	JHK grism	coronograph	JHK spec	LM spec	cross-dispersed	IFU JHK	IFU LM	imaging	long slit	MOS	IFU	10-20um imaging	low & med res spec	high res spec	long-slit	cross-dispersed	MOS	10-20um imaging	spectroscopy	1-5um spec
SA1									■					■										
SA2									■				■											
SA3							■						■											
SA4																				■				
SA5													■							■				
SA6	■	■																						
SA7																				■				
SA8																				■				
SA9												■								■				
SA10																				■				
SA11										■														
SA12	■	■																						
SA13																				■				
SA14	■	■							■															
SA15																								
SA16														■										
SA17																				■				
SA18													■						■					
SA19														■										
SA20															■									
SA21	■				■				■						■									
SA22	■	■														■								
SA23															■									
SA24														■										
SA25	■	■								■														
SA26		■										■			■									
SA27														■										
SA28				■										■										
SA29	■	■								■					■									
SA30	■	■				■				■														
SA31	■														■									
Totals by	16	12		8	2	2	7	1	4	10		4	9	17	10	1	1	2	1	12			1	2
instrument (/65)	16	24					22					40				4			13			1		2

Table 1b: Use of the Gemini initial instrument complement (continued).

Program Reference	Gemini Time Required (hours)	Time on Supporting Facility (hours)						
		optical imager		infrared imager		opt/UV spectr.	IR spectr.	radio & mm
		wide FOV	narrow	wide FOV	narrow			
US1	600	1100						
US2a	3000					250		
US2b	300	100						
US2c	400	100		120				
US3a	150	400						
US3b	30							
US4a	1500			1000			500	
US4b	1000	50		700			(same as 4a)	
US5	730	50			300	450		160
US6a	500	320						
US6b	1000	600						
US6c	480	180				120		
US7	2450	1350		v. large (see text: 3a)				
US8	1300	600		3000				
Total time	13440	4850	0	4820	300	820	500	160
Hrs wrt Gemini (excl US7)...		0.32	0.00	0.44	0.03	0.07	0.05	0.01
UK1	350		20					
UK2	90		5		30			
UK3	25	200						
UK4	75				10		60	
UK5	30							
UK6	60	80						
UK7	25		5		5	10		
UK8	50							
Total time	705	280	30	0	45	10	60	0
Hrs wrt Gemini...		0.40	0.04	0.00	0.06	0.01	0.09	0.00
Can1	60				60			
Can2	40		20					
Can3	20	60						
Can4	10							
Can5	20			60				
Can6	40		30					30
Can7	60	60						
Can8	20				40			
Can9	40							
Can10	40		150					
Can11	50	150				60		
Can12	50			20				20
Can13	80			60				
Total time	530	270	200	140	100	60	0	50
Hrs wrt Gemini...		0.51	0.38	0.26	0.19	0.11	0.00	0.09

Table 2: Time usage on Gemini and generic telescopes providing supporting capabilities for the example science programs.

(ii) Support capabilities identified

In Table 2 we include a summary of the supporting facilities identified in each program which incorporate use of another telescope. (The programs from the South American workshop did not identify this information). For the cases of optical and infrared imaging it was generally assumed that supporting observations would be made on either a 2.5 or 4m telescope with the latter used principally for IR imaging and spectroscopy and narrow-band optical imaging. To derive time estimates it was further assumed that the optical imaging would be carried out with a large format, mosaic CCD camera (e.g. CFHT Megacam, NOAO mosaic camera, INT prime focus camera). Specific details of the supporting observations may be found in Appendix B.

As to be expected, the wide variety of science areas have a range of supporting requirements, however there is a striking interest in wide field (30 arcmin or greater) optical and near-infrared imaging surveys across the community. These surveys would be used to construct large multi-colour databases to identify suitable candidates for spectroscopic or high-resolution imaging observations with Gemini.

Whilst the amount of time requested for these surveys shows large variance, on average a 'typical' night of Gemini follow-up requires between one-half and one night of supporting observations. It is also apparent that this ratio is approximately constant between the countries and applicable equally to large and smaller scale programs.

Imaging with good angular resolution (~0.2 arcsec or better), though less frequent, is another common theme. Into this category fall preparatory observations with ground-based telescopes and AO systems as well as the HST and its archives. The number of example Gemini programs concerned is too small to derive reliable statistics. Another enabling capability identified in a few programs and essential to their execution is quick-response access to Gemini to follow-up an external event triggered by a variety of telescopes and satellites. The Gemini Science Operations Plan supports these non-traditional operational modes.

Appendix A: Gemini capabilities primer

(a) Initial Instrument Complement

The initial instrument complement for the Gemini North telescope is provided by NIRI (near-IR imager), NIRS (near-IR spectrograph), GMOS (optical multi-object spectrograph and imager), Michelle (mid-IR spectrograph and imager, shared with UKIRT) and GAOS (natural guide star AO system).

The initial instrument complement for the Gemini South telescope is provided by GMOS (optical multi-object spectrograph and imager), HROS (high resolution optical spectrograph), MIRI (mid-IR imager) and Phoenix (high resolution near-IR spectrograph, shared with CTIO).

Three science instruments plus facility calibration unit and AO can be mounted on either telescopes' cassegrain rotator at any one time. The top-level capabilities of each instrument are summarised below:

(a-I) Near Infrared Imager

- Detector: 1024x1024 InSb array with 27 µm pixels
- 1-5.5µm wavelength coverage
- High throughput
- Three plate scales:

Pixel Size	Field of View
0.02"	20.5"
0.05"	51"
0.12"	123"

- Filters: 20-30 slots for filters, grisms, and polarisers
- Grism mode, JHK wavebands, slit widths 0.04-1 arcsec.
- Coronagraphic mode
- On-instrument near-IR wavefront sensor with 3.5 arcmin FOV (no on-axis guiding)
- Polarising prism.

(a-II) Near Infrared Spectrograph

- Detector: 1024x1024 with 27 µm pixels
- Wavelength coverage: 0.9-5.5 µm
- High throughput
- Spectral resolution: R ~ 1800, 5400 & 18000
- Pixel scales: 0.05 & 0.15 arcsec/pixel
- Slit widths: 2 to n pixels.
- Slit lengths: 50 or 100 arcsec
- Cross dispersion (1-2.5 µm)
- Integral field mode (approx. 0.03 and 0.12 arcsec sampling giving 2 and 12 arcsec FOV).
- On-instrument near-IR wavefront sensor with 3 arcmin FOV (no on-axis guiding)

(a-III) Multi-object Spectrographs

- Two Instruments: Gemini North and Gemini South

- Detector: three EEV CCDs with 2048x4608 13.5 µm pixels
- Image scale: 0.08 arcsec/pixel (5.5 arcmin FOV)
- Wavelength range: 0.36-1.10 µm
- Slit sampling: 2.5 times the image pixel scale
- Imaging mode: designed to support MOS mask production
- Spectral resolution: 500 - 10,000 with various gratings
- Integral field mode: 0.2 arcsec sub-apertures with 8 arcsec FOV
- Visible on-instrument wavefront sensor with 5 arcmin FOV

(a-IV) High Resolution Optical Spectrograph

- Detector: Two EEV CCDs with 2048x4608 13.5 µm pixels
- Throughput is highest priority, particularly in UV
- Requirement: >10%; goal 20%
- Resolution: ~50,000
- Sampling: 3 pixels per resolution element
- Slit: width 0.6"@ R=50,000; length up to 1'
- Wavelength coverage: ~0.3 - 1.0 µm total with essentially all of this range covered in a single exposure
- Stability: Cassegrain mounted - <0.05 resolution element in one hour
- Visible acquisition camera (1 arcmin FOV) and reflective slit jaws.

(a-V) Mid-Infrared Imager

- Highest priority for this instrument is broad-band ~10 µm diffraction limited imaging
- Must fully exploit high background characteristics of mid-infrared arrays
- Array: ~256x256 Si:As IBC
- Wavelength range: ~5 to 25 µm
- High throughput
- Plate scale: 0.09 arcsec/pixel
- Instrument background: < 1% effective emissivity
- Filter requirements: cold filter wheel with 20-30 slots for filters, etc.
- No on-instrument wavefront sensor

(a-VI) Michelle

- Based on ~256x256 Si:As IBC Array
- Long slit spectroscopy, 8-25 µm range
- R~200: 8-13 µm window in a single exposure
- R~1000: optimum detectivity of narrow ionic and molecular emission lines
- R~30,000: velocity resolved observations of narrow emission lines
- Pixel scale: 0.18 arcsec
- Slit width: 0.36 arcsec
- Diffraction limited imaging
- Pixel scale 0.10 arcsec
- Background limited sensitivity under all of the above conditions
- Shared UKIRT/Gemini use
- No on-instrument wavefront sensor

(a-VII) Phoenix

- Based on 1024x512 InSb array
- 1-5 µm high resolution echelle spectroscopy
- Resolution: R~100,000 (2 pixel) or 67,000 (3 pixel)
- Pixel scale: 0.09 arcsec
- Slit width: 0.17 arcsec (2 pixel) or 0.26 arcsec (3 pixel)
- Slit length: 14 arcsec
- Spectral format:: single echelle order displayed, band pass = 1500 km/s
- Guiding - visible light (30 arcsec FOV) sent to port for tip/tilt sensor
- Infrared direct imaging and pupil imaging
- NOAO plans call for KPNO/CTIO shared use

(a-VIII) AO

- Mauna Kea baseline system is NGS with LGS upgrade path
- Optimised for 1.0-2.5µm
- Feeds any instrument at Cass with corrected 2 arcmin FOV:
  - Preserves plate scale and image plane location of basic telescope
  - Optical throughput of AO unit ~90%
- H-band strehl of end-to-end *system* ~40%, for:
  - Bright star
  - 45° from zenith
  - Median seeing

(a-IX) Calibration Unit

- Arc and flat field lamps, colour balance and ND filters.
- Wavelength range 0.3-5µm.
- Field flat to ~3% over 5 arcmin field.

(b) Telescope Performance

In this section we summarise the pointing, tracking and guiding performance of the telescope. For most parameters both the requirement and goal are presented with the current (end-1997) best estimate of the final value highlighted in italic font.

- Absolute pointing (zenith distance < 60°):
  - *2 arcsec rms.*
  - Goal: 1 arcsec rms.
- Tracking and guiding:
  - *Open loop: consistent with pointing and sufficiently stable for guide star acquisition.*
  - “Slow” correction (e.g. PWFS)
    - Requirement: 100 mas rms in 10 min., 250 mas in 1hr.
    - *Goal: 20 mas in 10 min., 50 mas in 1hr.*
  - “Fast” correction (e.g. OIWFS)
    - Requirement: 10 mas rms in 1hr.
- Slewing times:

1 sec for offsets of up to 5 arcsec.
5 sec for offsets of up to 60 arcsec.
30 sec for 10 degree slews; max 300 sec between any two positions.

- Offsetting accuracy:
  Open loop:
    Requirement: 100 mas over 10 arcmin offset.
    Goal: 50 mas over a 10 arcmin offset.
  Closed loop:
    10 mas over a 10 arcsec offset.
- Secondary Articulation
  The telescope secondary is articulated to provide image motion compensation (with error signals combined from on-instrument and peripheral wavefront sensors) and chopping. For square-wave two-position chopping the allowed chop throw and frequency are shown in Figure A1. The chop duty cycle is 80%.

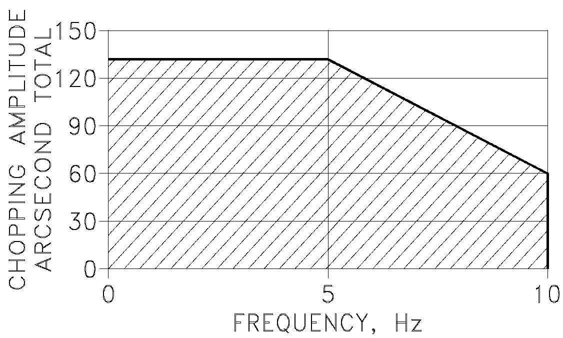

Figure A1 : Maximum chop throw as a function of chop frequency. Note that the chop amplitude is given in mirror space; divided by four to get the chop throw on the sky.

(c) Gemini Observing Modes and Observing Conditions

The Gemini telescopes can be operated in different modes:

- Queue
  Individual observations within programs are defined by the applicants and executed by a Gemini staff scientist and system support associate (SSA). Scheduling attempts to optimise the match to site conditions, scientific ranking and efficient use of telescope time.
- Classical
  Scheduled in blocks mod 0.5 night. Visiting observers support by SSA and a Gemini staff scientist (typically for the first night only).

A (partner optional) quick-response mechanism will further allow insertion of programs into the classical schedule or queue at short notice during the semester e.g. for targets of opportunity, with or without external triggers.

In queue mode the desired image quality must be selected by the applicant. Observations will not be executed under poorer image quality than that requested. The delivered image quality principally depends on the intrinsic seeing, guide star availability (in PWFS, OIWFS and AOWFS FOVs), guide star magnitude and off-axis angle, wind speed and direction and observing wavelength. The on-instrument and AO WFS fields of view are given in section (a) above. The two peripheral WFSs are located within the instrument support structure and patrol fields of diameter 14 and 12 arcmin, respectively.

The decision-making process by an applicant might typically be:

- Decide what image quality is required for the science.
- Determine guide star availability and properties for the target fields (using the *guide star selection tool*, part of the Phase I software; see section (e))

  For reference a sky coverage of 90% translates into guide star magnitudes of R=18.1, or H=16.5 and a coverage of 99% into R=19.7. The principal Gemini Guide Star Catalogue (GSCII, under joint-development with STScI) has a limiting mag ~20 (at the Galactic pole).
- Given wind speed and natural seeing distributions, select an image quality from one of the percentile bins:

  ❍ 20%-ile ❍ 50%-ile ❍ 90%-ile ❍ don't care

Models of the entire system performance have been generated to examine the dependence of the delivered image quality on the various parameters which affect it. An example is shown in Figure A2.

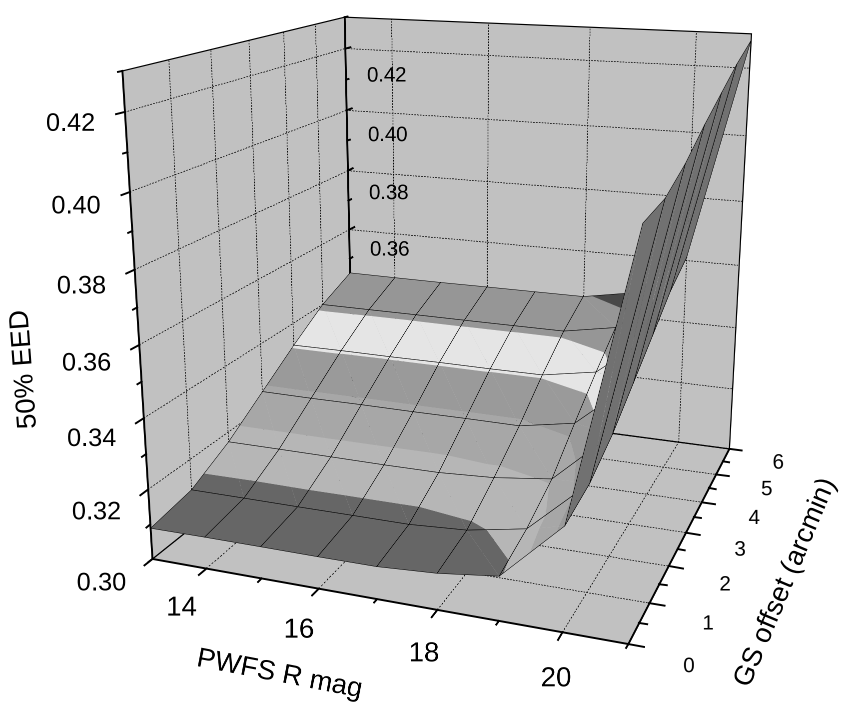

Figure A2: Delivered image quality (in arcsec, vertical axis) as a function of guide star magnitude (R mag, horizontal axis) and guide star off-axis angle (arcmin) for a wavelength of 10μm, 10%-ile best natural seeing and 20%-ile best wind.

All of the models have the same characteristic form with only a weak dependence on guide star magnitude until a 'knee' whereupon the wavefront sensor starts to run out of photons. The image quality percentiles translate into specific values as a function of wavelength. Examples are shown in Tables A1-3 for visible V-band, near-IR K-band and 10µm wavelengths. The table entries give the 50% EED and (in parentheses) the guide star mag given at the performance ‘knee’.

		wind		
		good	median	poor
seeing	good	0.27 (20^m)	0.28 (20^m)	0.30 (18^m)
	median	0.48 (20^m)	0.49 (20^m)	0.51 (18^m)
	poor	0.65 (20^m)	0.66 (20^m)	0.68 (18^m)

Table A1: Image quality estimates in the V waveband assuming an OIWFS(optical) or PWFS. There is a degradation of ~1%/arcmin for off-axis guide star angle of 0 out to 6 arcmin and an improvement of ~10% for guide stars brighter by 1 mag.

		wind		
		good	median	poor
seeing	good	0.20 (21^m)	0.22 (21^m)	0.27 (20^m)
	median	0.34 (21^m)	0.35 (21^m)	0.38 (20^m)
	poor	0.46 (21^m)	0.47 (21^m)	0.48 (20^m)

Table A2: Image quality estimates in the K waveband assuming an OIWFS(IR). There is a degradation of ~2%/arcmin for off-axis guide star angle of 0 out to 6 arcmin and an improvement of ~10% for guide stars brighter by 1 mag.

		wind		
		good	median	poor
seeing	good	0.33 (20^m)	0.34 (20^m)	0.35 (18^m)
	median	0.39 (20^m)	0.40 (20^m)	0.43 (18^m)
	poor	0.39 (19^m)	0.40 (19^m)	0.41 (17^m)

Table A3: Image quality estimates at 10µm assuming a PWFS. There is a degradation of ~3%/arcmin for off-axis guide star angle of 0 out to 6 arcmin and an improvement of ~10% for guide stars brighter by 1 mag.

The results from these models may be concatenated to produce a translation between the frequency of occurrence (i.e. image quality bin) and the image quality itself. This translation is shown in Table A4.

Frequency of occurrence	V 50% EED	K 50% EED	10µm 50% EED
20%-ile	0.30	0.22	0.33
50%-ile	0.50	0.35	0.36
80%-ile	0.70	0.50	0.40

Table A4: Translation between image quality (50% EED in arcsec) and its frequency of occurrence for three wavelengths.

There are other site conditions that need to be defined in an application. These are yet to specified in detail but include:

- Lunar phase (for both classical and queue programs), choice of:
  ❍ dark ❍ grey (classical only) ❍ bright
- Infrared background (queue programs only), choice of:
  ❍ 20%-ile ❍ 50%-ile ❍ 90%-ile ❍ don't care
- Cloud cover (queue programs only), e.g. choice of:
  ❍ photometric ❍ don't care

The effectiveness of AO systems also depends on the natural seeing (see Figure A3) and, for natural guide systems, on the guide star brightness (see Figure A4).

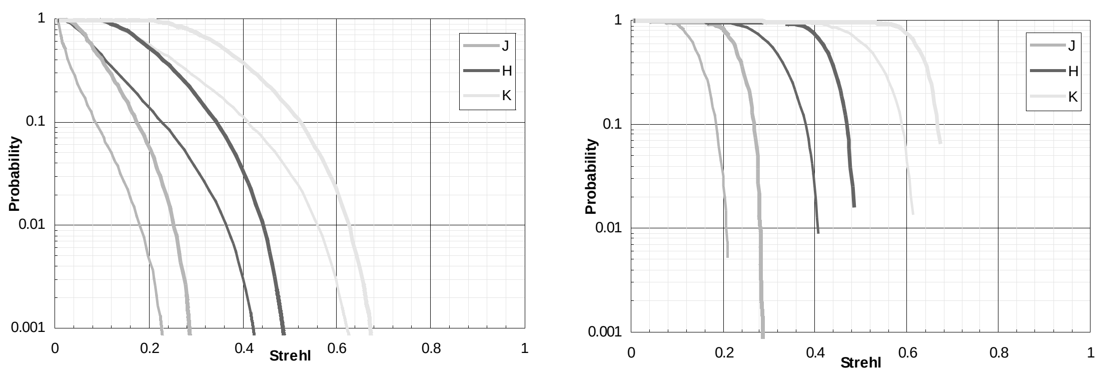

Figure A3: Predicted Strehl as a function of sky coverage for (left panel) natural and (right panel) laser guide star AO systems on Gemini. Three sets of curves are shown corresponding to the near-IR J, H and K wavebands for good (thick lines) and median (thin lines) natural seeing.

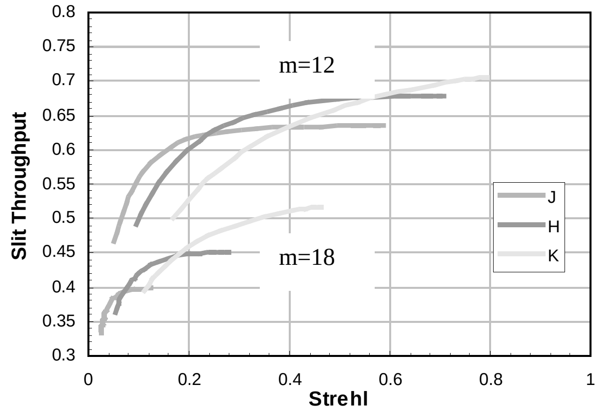

Figure A4: Throughput of the near-IR spectrograph with a 0.1 arcsec slit and natural guide star AO system for bright (m=12) and faint (m=18) guide stars at near-IR J, H and K wavebands.

(d) Target Acquisition

The facility acquisition and guide unit includes a CCD camera with 2 arcmin FOV. This camera, or any of the instruments in their imaging configurations, may be used for acquisition of the science target. Several acquisition modes are available, depending on the precision required, brightness of the target and reference stars, and the accuracy of astrometric information.

If precision is of utmost importance then the target must be visible with in images taken with the science instrument or, spectroscopically, with slit peak-up. In this case the accuracy is expected to be about 10mas and is dominated by the relative offsetting accuracy of the telescope over small offsets (see section (b) above).

If precision is less important then there are several options, each of which should result in an accuracy of about 25mas. The first option requires a nearby (several arcmin) reference star visible to PWFS or the science instrument in its imaging mode, and an accurate star-target vector. The procedure would be to place the star on some fiducial point, close the loop around the PWFS and reverse the known offset using the PWFS. A section option, if the target is visible to the acquisition camera, would be to retract the science fold mirror and/or deploy the acquisition camera, depending on which instrument port was being used, place the target on a fiducial, retract the acquisition camera and/or re-deploy the science fold. In this case the positional uncertainty arises from the combination of small throw offsetting, acquisition camera probe motion and science fold motion errors. A third option needs a nearby (several arcmin) reference star visible to the acquisition camera and an accurate star-target vector.

(e) Telescope Applications and Observation Planning Tools

The Gemini telescope application process has two phases. In Phase I, applications are submitted to National Time Allocation Committees (NTACs) which are responsible for scientific and technical assessment. The NTACs produce separate lists of classical and queue programs, ranked according to merit, and forward these lists to the Gemini observatory together with the recommended programs transmitted electronically in a pre-defined format. A Phase I software tool will be provided by Gemini for automatic submission of proposals in the required format. The lists of queue and classical programs will be merged by Gemini to produce a final classical schedule and integrated pool of queue programs.

In Phase II of the application process, approved programs undergo definition of telescope and instrument configurations and sequencing, acquisition instructions and on-line data processing needs using software referred to as the Observing Tool (OT). Use of the OT for observation pre-planning is mandatory for queue programs and expected for classical programs. The OT software has several features designed to make it straightforward to use by potential Gemini observers: being written entirely in Java it is platform independent and will be widely distributed, it's graphical user interface is designed to allow construction of complex programs from simple components (see Figure A5) and it includes a "library" of commonly executed configurations, sequences and calibrations which may be cut-and-pasted or edited as desired.

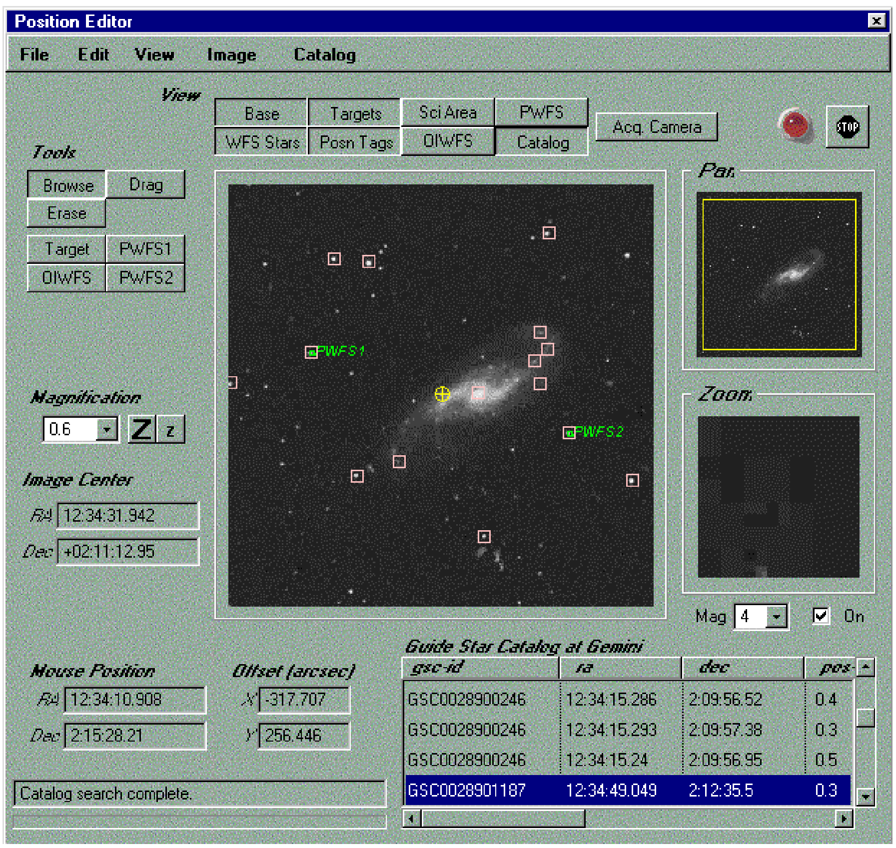

Figure A5: The Position Editor component of the Observing Tool allows visual representation of the telescope pointing, wavefront sensor and guide star positions, user-defined offsets and images of the field (e.g. from the digital sky survey or images taken by the telescope).

Appendix B. Illustrative science programs

1. US sample scientific programs

Program group: Origins of Solar System objects
Program reference: US1
Co-investigators: Jane Luu, Jim Eliot, Phil Nicholson, John Spencer
Title: Physical and Population Studies of Kuiper Belt Objects

1. Define a Scientific Program

To carry out physical and population studies of Kuiper Belt objects (KBOs). These trans-Neptunian objects are the most primitive solar system material known, and their physical and dynamical characteristics have important implications for formation of planetary systems - our own and perhaps others, if circumstellar disks around main sequence stars can be interpreted as Galactic analogs of the Kuiper Belt.

We propose to study the surface composition of KBOs (via optical color and near-IR spectroscopy), measure their sizes (via occultations and space-based infrared observations), shapes and rotational properties (via lightcurves), dynamical characteristics (via high precision astrometry), and, if possible, to resolve the largest KBOs via speckle interferometry. We also propose to search for faint (red magnitude m_R ~ 27) KBOs to constrain the small size end of the size distribution.

2. Define How Target Lists Will be Assembled

(a) What can extant surveys provide? How and why do they need to be supplemented?

Existing surveys have not yielded enough KBOs for statistical studies (~50 are known currently). Existing surveys also do not provide enough regular astrometry to keep the KBOs from being lost (due to uncertainties in orbital elements). Larger and more systematic surveys are needed to rectify these two problems.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

We need 2 preparatory surveys to yield enough KBOs for physical and population studies:

(i) a survey to m_R = 24 to obtain 1000 KBOs. We estimate that this can be achieved with 80 nights/yr over 5 yrs on a 4m telescope, with a wide-field imager (FOV 0.5 sq. deg.). This will produce enough KBOs to permit meaningful statistical studies of their properties with large telescopes. An extra 20 nights/yr is also needed to provide regular astrometry (twice a year per object) to keep the 1000 KBOs from being lost.

(ii) a complete 10,000 sq. deg. survey of the ecliptic to m_R = 21 to find the largest KBOs (radius >= 500 km). This survey can be done on a 1m-class telescope with a wide-field imager. The number of the largest KBOs is needed to constrain any accretion model of the outer solar system, thereby constraining the mass of the outer solar nebula. These largest objects will also provide the best and most interesting targets for detailed physical studies.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

None

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

We need a net of faint photometric standards and faint solar analogs (both $m_R > 15$) for spectroscopic and flux calibration. We also need faint astrometric standards ($17 < m_R < 21$). These stars should distributed around the sky, especially near the ecliptic.

4. Define Preparatory Observations

List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

Preparatory observations consist mainly of regular astrometry of known KBOs (twice per year for each object, over 5 yrs) in order to refine their orbits (see #2 under "How Target Lists Will Be Assembled").

(a) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

The same instrument set-up used for the 1000-KBO survey (a 4m-class telescope with a wide-field imager) is good, but the wide field capability is not essential.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

The most direct means of measuring the sizes of KBOs is via occultation of bright stars, which can be observed with a network of small, portable telescopes. Model-dependent sizes can also be determined from thermal measurements of these objects at wavelengths >30 micron.

(a) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

The occultations of bright (~ 14th mag stars) can be done with small, portable telescopes once accurate orbits are available. Thermal measurements at wavelengths longer than 30 microns will necessitate space-based observations (e.g., SIRTF) or observations with SOFIA.

6. Define Observations Requiring the Large Telescope

List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

The first goal, physical studies of KBOs, can be achieved with the following observations:

Optical and near-IR colors/spectra to study the surface composition of KBOs. Broadband colors (optical and JHK) are needed to estimate fluxes for low-resolution spectroscopy, and to identify objects with interesting surface compositions. Spectroscopy of KBOs (m_R > 21) can only be done with large telescopes, while broadband colors are best done with large telescopes to cover large samples in a reasonable time.

- Lightcurves to obtain shapes and rotational properties of KBOs; the distribution of rotation periods will help determine their collisional evolution. Once the rotation period is determined, we will also search for color variations as a function of rotational phase to look for signs of albedo variations across the object's surface. Companions may also be revealed via eclipses.
- Deep imaging to search for KBO companions.
- High accuracy astrometry to pinpoint the orbital elements of dynamically interesting KBOs. For example, KBOs near resonances with Neptune need to have very accurate orbits in order to determine whether they are actually trapped in the resonances. Resonance populations have important implications for the formation and dynamical evolution of outer solar system bodies.
- If it is possible, speckle observations to resolve the largest KBOs during stellar appulses.

The second goal, population statistics of small (diameter = 35 km) KBOs, can be achieved with a deep survey of the ecliptic to m_R = 27. A wide-field imager like MegaCam (FOV 0.16 sq. deg.) on a 8m class telescope can cover ~ 100 fields to this limiting magnitude in 60 nights and might yield ~ 1000 objects, although this extrapolated number is very uncertain.

(a) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

Any Kuiper Belt survey will need a wide-field imager. Approximately 60 nights with a wide-field imager like the MegaCam of the MMT are needed to determine the size distribution in the 30-km diameter range. Spectroscopy of any KBO requires image acquisition capability, i.e. the ability to image the target and position it in the slit before taking a spectrum.

Finally, high precision non-sidereal tracking AND GUIDING is absolutely CRUCIAL to all non-survey KBO observations.

Addendum: other capabilities for planetary observations

1) Moving object tracking and guiding

2) Need large telescope for
   (a) high spectral resolution (R ~ 10^6)
   (b) high spatial resolution in near-IR

3) Chop throw of 40 - 50" (e.g., thermal IR observations of Jupiter)

4) Efficient nodding (short settling times for telescope)

5) Sub-frame readout of CCD imagers and near-IR cameras at rates of 10 Hz (for occultations). Occultations will also require absolute timing of order ~ 1 ms and control of dead time between exposures (ideally less than a few % of the duty cycle).

6) Access for visitor instruments

7) Large community participation in design and development of new instruments (e.g., via a science team)

8) Automation: script control of telescope pointing and focus in conjunction with instrument commands

9) Ability to do rapid instrument changes during the night

10) Support periodic monitoring programs (short observing times at intervals of days-months) for: eclipses, occultations, seasonal and weather changes (e.g., Mars, Jupiter) ==> QUEUE OBSERVING GOOD

11) Real-time "data reduction" capability (photometry of point sources, simple spectral reductions)

Program group: Extrasolar planets/brown dwarfs/faint white dwarfs
Program reference: US2a
Co-investigators: James Liebert, Neill Reid, Chuck Claver, Chris Clemens, Todd Henry, Ted von Hippel
Title: Three Ages of The Mass-Luminosity Relation

1. Define a Scientific Program

The goal is to determine mass-luminosity relations (MLRs) for low mass stars and brown dwarfs in the Hyades and Pleiades. When combined with the MLR in the solar neighborhood, the cluster MLRs will be used to convert LFs to MFs over a range of ~100 in age (0.07 to 5 Gyr), thereby allowing astronomers to discover the effects of age on the MLR and, ultimately, to weigh the galaxy. Emphasis is on objects with masses less than 0.2 Msun, with special attention to determining brown dwarf masses.

This program can be used as critical step toward direct detection of extrasolar planets given the low luminosity of brown dwarf companions. This program is exceptional in that it utilizes the full diffraction limit capability of 8m telescopes. (They're not just light buckets!)

Program Goals include:

- 4 objects each in the Hyades and Pleiades with masses less than 0.08 Msun and determined to 10%, probably as companions in ...
- 10 binaries each in the Hyades and Pleiades with masses less than 0.2 Msun and determined to 5%.
- 10 binaries each in the Hyades and Pleiades with masses 0.2-1.0 Msun determined to 5%.

2. Define How Target Lists Will be Assembled

(a) What can extant surveys provide? How and why do they need to be supplemented?

STEP I - Determining Cluster Members

Requires faint members of Hyades (100 mas/yr) and Pleiades (36 mas/yr) to be determined with high confidence. Multi-epoch sky surveys with moderate astrometric accuracy (0.1") in the regions of interest are required. Some are done now; some are needed.

For reference, the end of the main sequence falls at Mv~20, Mi~15, Mj~11, Mk~10, 0.08 Msun.

Hyades (50 square degrees)

> [end of main sequence V~23.5, I~18.5, J~14.5, K~13.5]
>
> An optical survey has been done almost to sufficient depth by Reid (V~20), which corresponds to ~0.1 Msun, though not 0.08 Msun.
>
> A second epoch infrared survey will be done to sufficient depth by 2MASS (K~14.5).

Pleiades (10 square degrees)

> [end of main sequence V~25.5, I~20.5, J~16.5, K~15.5]

An optical survey has been done to sufficient depth by Rebolo (I~22).

A second epoch infrared survey is needed to reach K~15.5. 2MASS will not reach sufficiently faint.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

A second epoch survey is needed for the Pleiades, requiring a wide-field infrared camera. 2MASS should be supported for the Hyades.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

(none)

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

Calibration binaries are needed to calibrate detector plate scale. These targets will account for ~20% of the observing program, or ~4 nights/year (see below).

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

Optical and infrared wide-field surveys described above will provide necessary fluxes and positions.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

STEP II - Finding Cluster Binaries

A 2m class telescope radial velocity program is needed to reveal binaries with periods less than 10 years and primary masses > 0.6 Msun. Many of these systems have already been identified by the CfA radial velocity group.

A 4m class telescope radial velocity program is needed to reveal binaries with periods less than 10 years and primary masses < 0.6 Msun. These systems have not yet been identified, but in this step only the variables need to be flagged. Given a multiplicity rate of 1/3 for red dwarfs, with only 1/5 of those in the appropriate period regime (corresponding to ~1-10 AU), ~15 red dwarfs must be observed to find each appropriate system for the MLR program. 300 in each cluster must be observed to find 20 systems.

In both cases, 200 m/s precision is required. A spectrograph sensitive at red wavelengths (0.6-1.0 microns) with a resolution ~5000 should be sufficient.

These observations will require ~25 nights of 4-metre time, spaced over a period of 1-2 years.

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

Two observational programs are required:

I. High resolution imaging

Orbits of binaries with periods less than 10 years will be mapped using 8m class telescopes. Infrared speckle imaging has been proven to be a viable, productive method for this type of work. Speckle imaging is accomplished by obtaining ~5000 frames 100 ms in duration on a target and a similar number on a point source, interspersed with sky frames. Speckle imaging takes advantage of the full resolving capability of the
telescope, unlike adaptive optics.

To reach 5% mass errors, relative separations must be measured to 2 mas accuracy, roughly twice a year. Faint objects will be targeted, primarily at J where brown dwarfs are brightest. Diffraction-limited resolution on an 8m (NOT ADAPTIVE OPTICS WITH A PRECISION OF "ONLY" 250 mas) at J is 32 mas. Superresolution data reduction techniques will allow even a low mass binary Pleiad (0.15 + 0.05 Msun) to be mapped, but adaptive optics will be insufficient. Targets with K~10 can now be observed on a 2m class telescope to magnitude differences of 4. Speckle sensitivity does not scale directly as other observing techniques because of the increased number of speckles. Anticipating observable primaries with K~12, we could reach to K~16 for companions which is past the end of the main sequence in both clusters.

This program would not have to be done on a specific 8m telescope, and queue scheduling is certainly possible.

Instrument requirements:

infrared camera (256 X 256 sufficient)
fast readout (5-500 ms range)
small pixels (Nyquist sampled at 16 mas/pixel)

Time:

20 binaries in Hyades + 20 binaries in Pleiades	= 40 targets
10 calibration binaries	= 10 targets
2 observations each per year	= 100 targets
2 hours/observation	= 200 hours
10 hours/night	= 20 nights/year

note: 10 year program needed!

Software:

Either PI responsible for all software, or a fast computer capable of Fourier analysis is required. "Fast" means reducing 256 X 256 frames at a rate of ~1/second to reduce data for a single object in 3 hours.

II. Radial velocities

The same binaries will be followed with radial velocity techniques to improve orbital elements and measure fractional masses in the system. Roughly 50 observations over the full period are adequate to define an orbit with confidence. Given the relatively long periods for the systems, typically 5-10 years, only 5-10 observations are required per year. The moderate precision of the required velocities (200 m/s) does not drive the velocities to high spectral resolution. However, faint targets near the end of the main sequence do require an 8m telescope.

Instrument:
red sensitive CCD
echelle covering 0.6-1.0 microns with R~5000

Time:
1 hour integrations for program and standards = 100 hours
= 10 nights/year

Software:
nothing special

Required precisions for the two programs are:

	0.55 + 0.05 Msun		0.15 + 0.05 Msun	
	sep	reflex	sep	reflex
SOLAR NEIGHBORHOOD	391 mas	1.9 km/s	271 mas	4.1 km/s

HYADES	82 mas	1.9 km/s	57 mas	4.1 km/s
PLEIADES	31 mas	1.9 km/s	22 mas	4.1 km/s

Program group: Extrasolar planets/brown dwarfs/faint white dwarfs
Program reference: US2b
Co-investigators: James Liebert, Neill Reid, Chuck Claver, Chris Clemens, Todd Henry, Ted von Hippel
Title: Age of the Galactic Disk

1. Define a Scientific Program

This project seeks to measure the disk white dwarf luminosity function (WDLF) below log(L/Lsun)~-3 from a magnitude limited sample, giving a measurement of the age of the galactic disk and constraining the physics of white dwarf cooling.

The chronology of star formation is recorded in the white dwarf luminosity function. White dwarf structure implies a relatively simple connection between luminosity and age. First attempts to exploit the white dwarfs as chronometers have come from Liebert and collaborators (Liebert, Dahn, and Monet 1987, ApJ, 332, 891 LDM, Winget et al. 1987, ApJ 315 L77). They showed that the white dwarf luminosity function was a map of the history of star formation in the disk, and that there was a significant shortfall of low-luminosity degenerates---the inevitable consequence of the finite age of the disk. The shortfall near log(L/Lsun)~-4.3 implies a disk age between 6-9 Gyrs (Wood 1992, ApJ 386, 539). More recently the white dwarf luminosity function from wide common proper motion binaries (Oswalt, Smith, Wood and Hintzen 1995, Nature 382, 692) does *not* show the shortfall seen by Liebert, Dahn, and Monet. The Oswalt et al. luminosity function suggests that the disk is at least ~9.5 Gyrs old and is consistent with arbitrarily old models at the 2 sigma level. Both the Liebert, Dahn, and Monet and Oswalt, et al. luminosity functions for white dwarfs were derived from proper motion catalogs, hence may be affected by significant kinematical bias as well as incompleteness in the parent sample. The simple fact is, the faintest, age dependent, end of the white dwarf luminosity function is not yet reliably determined.

Along with the shortfall from the finite age of the galactic disk, the WDLF should also exhibit structure related to the physics of white dwarf cooling. A well-defined observational WDLF will not only yield the age of the disk, but will also show whether phase transitions occur in high density white dwarf interiors. Theoretically proposed transitions include crystallization and chemical separation, both of which would release latent heat, prolong the cooling process, and create a local excess in the WDLF at the temperature where the phase transitions occurs. Measuring or constraining the size of this excess is important, both for learning about Coulomb interactions at high density, and for improving the precision of white dwarf age estimates.

2. Define How Target Lists Will be Assembled

(a) What can extant surveys provide? How and why do they need to be supplemented?

The Texas Deep Sky Survey (TDSS; Claver 1995, PhD Thesis, U. Texas) uses broad and intermediate band photometry to V=22 to select cool white dwarf candidates from field stars. This survey will detect a sample equal in size to that which defines the WDLF of Liebert, Dahn, and Monet (1988). This does not represent a significant improvement to the precision with which we can estimate the WDLF.

It is important to improve measurements of the WDLF, because the recently published WDLF derived from white dwarfs in common proper motion binaries (Oswalt et al. 1995, Nature, 382, 692) gives a luminosity cutoff, and hence disk age, different from Liebert, Dahn, and Monet.

Furthermore, a large magnitude limited sample will avoid the problems of kinematical bias that affect both of these published luminosity functions. The broad-band component of this survey could be taken in part from the NOAO Deep Wide-Field Survey.

In order to realize a true measurement of the age of the Disk, the sample of cool white dwarfs needs to be enlarged by an order of magnitude - to approximately 500+ objects. A deeper survey (or one covering a much larger area) will accomplish this task.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

A multicolor (wide and narrow band filter) survey complete to V=24 will discover approximately 40 white dwarfs per square degree. Of these 3-4 will be fainter than the estimated WDLF downturn at log(L/Lsun)=-4.3, which implies that a survey of 20 square degrees is needed to sufficiently improve the statistics in the faintest bins of the WDLF. If this survey incorporates the data from the NOAO Deep Wide-Field Survey, it would only require observing with the narrow-band (MgH and CaH) filters in the same fields.

In this survey the primary contaminant at faint magnitudes will be unresolved background galaxies. Follow-up spectroscopy with larger telescopes (4-8m) will confirm the identities of the white dwarf candidates.

To complete the photometric survey in a realistic amount of time and acquire data that are of sufficient quality to throw out most of the contaminating galaxies (by PSF shape evaluation) requires wide-field 4m imaging. For example, with the NOAO/KPNO Mosaic camera and the same filter scheme as the TDSS, such a survey would require approximately 120 hours of clear weather exposure time, or roughly 20 clear nights, half this amount if the NOAO Deep Wide-Field Survey is incorporated.

Alternatively, survey on a 1M class telescope covering 300 square degrees to a depth of V=22 would yield a similar sample.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

Deep IR wide field images to roughly J,K=23 would assist in determining the physical parameters of cool white dwarfs. In addition, deep IR imaging along with R and I measurements would yield a secondary component to the proposed survey to search for very cool white dwarfs belonging to the Halo.

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

Photometric calibration of the 4m survey field should be done on 1m class telescopes, where time and instrument stability are available. This would require photometric imaging at the intersection point of adjacent fields in the survey.

For the classification and analysis of the new discovered white dwarf stars a grid of high quality spectra of known cool white dwarfs would be required. These would serve as identification templates for an automatic classification process. This would require a standard Cassegrain low-resolution spectrograph on a 4m-class telescope. The estimated time to observe a the 40+ known cool white dwarfs in the WDLF would be 6 nights.

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

The survey and calibration observations provide the necessary preparatory data required. Current and accurate astrometric standards are necessary within the survey area to derive positions for the follow-up spectroscopy.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

The candidates brighter than approximately 21 magnitude could be followed up either individually or with multi-object spectroscopy on 4m class telescopes.

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

Completing this project requires low-resolution optical spectra of the faint candidate white dwarfs at sufficient signal to noise to distinguish between a true white dwarf and potential contaminates (i.e. metal poor subdwarfs and faint galaxies). Furthermore, the spectra should determine whether the white dwarfs have Hydrogen, Helium, or peculiar atmospheric compositions. The temperature and luminosity are estimated once the composition is known from modeling the broad-band BRIJHK flux points.

It would improve observing efficiency to have a spectrograph simulator to choose integrations times. By observing zero noise spectra through the simulator, and comparing the output to our template spectra, we could measure the integration time required to minimize incorrect identifications.

The estimated number of targets in the survey will be between 1000-2000, depending on the contamination rate. This implies a target surface density of 50-100 per square degree, which is a reasonable match to multi-object fibre-spectroscopy modes (Hectospec). Given that the faintest candidates will have R~24, integration times of several hours are required for each field. Hence, a total of ~20-30 nights will be required for these observations. It may prove necessary to supplement these fibre observations with single/multislit observations of the faintest candidates.

Program group: Extrasolar planets/brown dwarfs/faint white dwarfs
Program reference: US2c
Co-investigators: James Liebert, Neill Reid, Chuck Claver, Chris Clemens, Todd Henry, Ted von Hippel
Title: Variations in the sub-stellar mass function

1. Define a Scientific Program

The goal of this project is to use surveys of young (50-100 Myr) and intermediate-age (600 Myr) open clusters to determine the mass function to mass limits significantly below the H-burning limit. Selecting young clusters maximises the chances of detecting brown dwarfs, since those objects are still relatively luminous and have not yet cooled substantially; dynamical evolution has not yet had sufficient time to produce substantial mass segregation and evaporation; and the objects have known age and abundance.

A related project, surveying old open clusters to determine the extent and evolution of dynamical effects, would require similar facilities for preparatory and complementary observations.

2. Define How Target Lists Will be Assembled

Targets: Alpha Per, IC 2602, IC 2391, Pleiades (ages 50-100 Myrs) distances 110 to 150 parsecs;
Hyades (age 600 Myrs) distance 50 parsecs

(a) What can extant surveys provide? How and why do they need to be supplemented?

POSS II/UK Schmidt surveys provide a database for astrometric identification of candidate cluster members to R~20th magnitude.

2MASS provide additional photometric data (and hence membership indicators) to J ~ 16, R~20.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

We require optical (R=6000 A; I=8000A; z=9000 A: standard filters) and near-infrared (J=1.2 micron) surveys of ~10 square degrees in the young clusters; and of ~50 square degrees in the Hyades. The expected surface density of sources is a few x 10**4 per square degree. It will be essential to have software capable of determining reliable photometric and image-shape parameters for those data; and for correlating the catalogue lists produced by the separate instruments. The latter demands astrometry to 0.5-1.0 arcseconds precision.

These observations are discussed in more detail below.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

AXAF observations will be useful in confirming cluster membership for lower main-sequence stars (and for determining whether brown dwarfs are coronally active!)

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

General requirement:

A small automated photometric telescope could greatly enhance efficient use of 4m and 8m class telescopes by reducing their calibration overhead. In the simplest scenario a single automated telescope would be responsible for calibrating the atmosphere at a given site over time periods as short as a few hours, leaving the large telescopes responsible only for the telescope and instrument calibration. For photometry this would often mean determining only a zero point, as color terms are generally very stable. An automated photometer could also perform simultaneous photometry of the sources on which the larger telescopes were performing spectroscopy. This may be especially useful for variable objects. Another form of support would be the creation of secondary standards within the field of the large telescope programs. This could occur before, during, or after the large telescope observations, depending on the science requirements. Given the high pressure on large telescope time it is likely that such an automated photometer would not only increase the efficiency of large telescope use, but it would also increase the photometric accuracy of the data as many large telescope observers perform the minimum of atmospheric calibration. Additionally, the large telescope archives that had such a homogeneous and external photometric calibration would be more valuable.

Specific to this project:

An accurate mass-luminosity relation as a function of age is required to transform a luminosity function to a mass function. See our mass-luminosity proposal.

Many of these clusters already have accurate phyotometry for known cluster members. Additional photometry (to ~19th magnitude) can be obtained on a 1-metre telescope. These data do not need to cover the entire survey area, so 1 week of photometric time per cluster should suffice.

The response function/colour terms of the 4-metre optical systems should be characterised in a reliable fashion.

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

Young clusters: optical photometry is the simplest means of identifying candidate cluster members. The brown dwarf candidates in the Pleiades (Teide 1 etc) have M(I)~14.5, and current models predict that as 0.05 M(sun) brown dwarf has M(I)~16, or I~22 in Alpha Per etc. The clusters are ~15 pc in diameter, so a 10 square degree survey covers ~40% of the cluster and one expects 20-50 candidate members per square degree.

A 4-metre telescope can obtain 5% photometry to R~24, I~22, Z~21 in ~1 hour of total telescope time. ~2000 seconds for R, ~180 secs R and I. Short exposures (20 sec, 10 secs) to tie in to brighter calibrators.

Hyades: the Hyades, at (m-M)=3.33, has been well-surveyed to V~20. At an age of 600 Myrs, ~0.05 M(sun) brown dwarfs should have cooled to below 2000K and have M(I)~16.5; 0.04 M(sun) objects have 1200/1300K M(bol)~15.5, M(H)~15. These objects may be cool enough that methane dominates the near-infared spectrum.

One can use custom-built IR filters to detect this feature: we propose splitting the H-passband into H(short) and H(long). The full cluster covers ~200 square degrees, with an expected surface density of at most a few very low-mass objects per square degree. Hence we require a survey of at least 50 square degrees to detect significant numbers of candidates.

Based on the KPNO survey currently underway, an HgTeCd IR CCD can reach H~19 with 20% accuracy in ~10 minutes on a 2-metre class telescope. Coupled with the optical data, H(S) and H(L) magnitude to this precision are sufficient to identify candidate methane dwarfs (objects detected in J(S) but invisible in H(L). One expects (I-H) colours of 5.5 and (I-Z) colours of 1-2 magnitudes - so these objects may be detected only in the z-band in the optical survey.

Requirements:

- a wide-field (at least 0.5 x 0.5 square degree) optical imaging system on a 4-metre telescope. [A 1 square degree optical array can cut the observing time by at least x3.]
- a wide-field (0.5 x 0.5 square degree) HgTeCd IR imaging system on a 2-metre telescope [4 x 1K IR array with 1 arcsecond pixels.] The main advantage offered by the 2-metre is the plate scale, and hence larger areal coverage for an array of given physical size.
- custom-built H(short), H(long) filters
- a data reduction system capable of producing object catalogues with accurate parameters in a rapid (few days after observation) time scale.

Telescope time: approx 5 nights optical time per young clusters approx 25 nights optical, 12 nights IR for Hyades

Total of ~50 nights 4-metre class telescope time

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

AXAF follow-up observations of candidate cluster members: young stars are expected to be both chromospherically and coronally active.

Multi-object spectroscopy at low resolution on 4-metre class telescopes to use H-alpha detection/non-detection to confirm or deny membership.

Follow-up astrometric observations of confirmed photometric and spectroscopic candidates to confirm astrometric membership.

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

(i) Intermediate-resolution spectroscopy to characterise spectroscopic features as a function of age/mass. The surface density of good candidates is likely to be so low that multi-object observations are precluded. We would expect 20-30 candidates per cluster to R~24 and would expect exposure times of 1-2 hours each. These observations would require 10-15 nights.

(ii) High-resolution (~30,000) spectra of candidate very low-mass object for lithium, caesium detection etc. Since these observations demand integration times of 10-20 hours per object, we anticipate including only a few stars from each cluster in this phase of the programme. ~10-15 nights.

(iii) Near-infrared spectroscopy of candidate methane dwarfs. If any candidates are detected, they will demand adequate follow-up spectroscopy. Anywhere from 0 to 10 nights.

Program group: High resolution studies of stars
Program reference: US3a
Co-investigators: Andrea Dupree, Chris Sneden, Mark Giampapa, Douglas Gies, Artie Hatzes, Larry Ramsey, Dimitar Sasselov
Title: Physical Parameters of Luminous Stars in Extragalactic Environments

1. Define a Scientific Program

The new generation of large telescopes offers the means to study the individual brightest stars in nearby galaxies. A survey of high dispersion (R~30000) optical spectroscopy of several dozen targets in each galaxy (LMC, SMC, M31, M33, IC 1613, NGC 6822) will address three broad subjects:

(i) Galactic abundance gradients. The luminous stars are young (<30 Myr), and measuring the abundances of key species of C, N, O, Mg, and Fe will show how chemical enrichment has progressed in different locations throughout the galaxy.

(ii) Fundamental physical parameters for each star (effective temperature, surface gravity, atmospheric turbulence, projected rotational velocity) in addition to detailed abundances. These parameters make the targets especially useful as standard candles. For example, the B and A supergiants shed matter in a stellar wind which follows a well-defined wind momentum - luminosity relation, and by modeling of the H-alpha emission profile, the wind strength can be determined and the true luminosity estimated. The survey will also include photometric and spectroscopic observations of a small sample of Cepheids for each galaxy, and their distance would be estimated individually using the Baade-Wesselink method, which is a direct single-step determination.

(iii) The interaction of the stars and the interstellar medium. The winds of the stars evacuate large bubbles in the local ISM, and the observations will help establish the current wind mass loss rates and velocities.

2. Define How Target Lists Will be Assembled

(a) What can extant surveys provide? How and why do they need to be supplemented?

Some photometric surveys exist of bright stars in local group galaxies. However, they are limited in areal coverage and in (brightness) depth. For example, in order to successfully identify a reasonably complete sample of Cepheids in M31, a large area of that galaxy to well below V = 20 is necessary, and those studies are not available.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

A wide-angle deep photometric survey of local group galaxies needs to be undertaken to feed well-understood candidate stars for spectroscopy with the 8 m telescopes. At a minimum, VI photommetry should be done; BVRI is greatly preferred. The limiting magnitude should be V~23. It would be highly desirable to also have JHK photometry for a subset of the fields. These observations should also have high astrometric accuracy (see the section on preparatory observations).

As an estimate of required photometry, about 10 square degrees total would cover the sky areas of interest. Assuming that a 2 m imaging telescope is used with coverage of 0.25 square degrees per frame (0.3 arcsec pixels), then 40 fields will need to be imaged. Roughly 15 minutes per exposure and 4 filters (BVRI) per field need to be gathered.
To identify and properly classify Cepheids, 10 exposures spaced over time are required. Thus approximately 40 nights of 2 m time will be needed to create a well formed target list for 8 m high resolution
spectroscopic observations.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

For prior surveys in preparation for the 8 m spectroscopy, no observations at other wavelengths are needed.

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

(i) spectroscopic observations of hot, rapidly rotating ("featureless") stars for removal of telluric line contamination in the program stars. These observations of course should be done with the same large-telescope spectrographs as are used for the program stars. However, many of the well-known rapid rotators may be too bright for the 8 m spectrographs, and they are too widely separated in the sky for efficient employment in this project. Thus, it is strongly recommended that new spectroscopic surveys to identify many more rapidly rotating hot stars should be undertaken with 2 m class telescopes. This survey will benefit many 8 m spectrographic studies.

(ii) spectra of radial velocity standard stars. The lack of such may not be critical for the success of this program but would certainly increase the reliability of program-star radial velocities.

There are no special software requirements or preferred operation modes for this program.

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes

Preparatory observations are simply those photometric observations which have astrometric accuracies of 0.1-0.2 arcsec RMS. This then becomes no special requirement here, but care should be taken that the photometric observations not neglect the need for good positions.

We foresee no need for adaptive optics for this program. Targets from fields that are especially crowded and have potential for source confusion will simply be dropped from candidate spectroscopic lists.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

For the Cepheid star observations, further photometric data should be obtained contemporaneously (here, no further removed from the spectroscopic observations than 1 year). These new photometric data will significantly augment the phase coverage (the 10 observations needed for Cepheid identification are hardly sufficient for detailed studies of the Cepheid parameters).

For the supergiants, it would be very desirable to have high resolution observations of atomic transitions in the satellite UV, where signatures of wind outflows commonly occur. HST is just too small a telescope for this to be realistic now, but should be kept in mind for future space missions.

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

This project requires resolutions no less than R=30000. An octave of spectral coverage (4000A to 8000A would be best) is needed to capture features of enough different elements to do meaningful chemical composition analyses. It would be even better if the spectra stretched to 3900A to observe Ca II H&K, and to 8700A to observe the Ca IR triplet.

In a given galaxy, one would like to have high resolution spectra of about 20 supergiants (to trace the galactic abundance gradient), and about 5 Cepheids observed at five different phases. In M31 for example, a few supergiants are as bright as V=16, while the Cepheids are V=20-21. As a rough estimate, to obtain S/N of at least 30 for supergiants and Cepheids, an average integration time of 3-4 hours is needed. This translates into perhaps 150 hours of 8 m high resolution spectrograph time.

Of particular concern for this project is the estimation of galaxy background contaminating light. A "long-slit" of perhaps 10-15 arc-sec would be desirable. This project would be less well suited to fiber-fed high resolution spectrographs that have only 1-3 input fibers. Admittedly this problem can be attacked only statistically, but it is essential to sample a 3-5 "off-source" regions to try to guess the background light.

It important that 8 m high resolution spectrographs be accessible to the national community in both southern and northern hemispheres for this project to be completed.

Program group: High resolution studies of stars
Program reference: US3b
Co-investigators: Andrea Dupree, Chris Sneden, Mark Giampapa, Douglas Gies, Artie Hatzes, Larry Ramsey, Dimitar Sasselov
Title: Gravitational Microlensing

1. Define a Scientific Program

This is a new technique for studying the surfaces of distant stars by gravitational microlensing, with the unique ability to provide center-to-limb variations of spectroscopic diagnostic lines. Such variation maps into a variation with depth in the stellar atmosphere; spectral lines provide a large choice of center-to-limb variations. One can measure the depth-dependence of temperature, pressure, and Doppler broadening in the lensed star's atmosphere; such information is ONLY available for the Sun. Red Giants' model atmospheres are constructed without such input. The dynamics and 3-D structure of their atmospheres are poorly known and affects the color-Teff calibrations, bolometric corrections, etc. (e.g. stellar ages, etc.)

Stellar microscopy on red giants in the bulge of the Galaxy is now feasible and a proof-of-concept was accomplished on MACHO event M95-30. The rate of such giant lensing events (a dark lens crossing a giant's disk) is ~4%*(Mlens/(0.1Msun))**-0.5, a large fraction given the current rate of ~100 bulge microlensings detected per year. The amplification brightens a typical giant to ~13th mag.

The lensed image sweeps through the solar system at a transverse velocity which will introduce a time delay between Cerro Pachon and Mauna Kea of ~2-5 minutes, called microlensing parallax.

Analysis of such observations will provide: (1) unique constraints for red giant atmosphere models; (2) the lens mass & distance, and its transverse velocity - valuable information for characterizing dark matter in our Galaxy.

2. Define How Target Lists Will be Assembled

(a) What can extant surveys provide? How and why do they need to be supplemented?

The targets will be identified by the MACHO, EROS2, and OGLE2 programs.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

Finding charts will be provided by the MACHO, EROS2, and OGLE2 programs.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

Not applicable for this program.

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

We need spectra of resolution R ~ 30000 to 60000 of a target star when it returns to the original faint magnitude (V~16-17) that it possessed prior to the lensing event.

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

Not applicable for this program.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

Simultaneous low-resolution observations by HST for chromospheric UV flux measurements are desired. Time-resolved spectra would be desirable, as strong variations are expected in the UV flux.

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

THIS IS A TARGET OF OPPORTUNITY (TOO) OBSERVATION! The TOO will be triggered ~1-2 weeks in advance by alert networks.

Spectroscopy of R~30000 to 60000 is needed before, during, and after disk crossing. Also, sample at critical identified times of limb-crossing. Several short exposures (30 min) spaced over the ~100 hour event are needed.

Microlensing parallax effects can be observed if both GEMINI-N and GEMINI-S are used simultaneously in spectroscopic mode. For a typical lens trajectory, and transverse velocity of 10-50 km/s, the time delay between Mauna Kea and Cerro Pachon amounts to 3-5 minutes, and can be detected. This will require spectra of R~20000 and exposure times of <~2 minutes, for equivalent width measurements. Spectroscopy should be done continuously for three hours on both GEMINI telescopes.

Program group: Young stellar objects and physics of star formation
Program reference: US4a
Co-investigators: Charles Lada, Steve Strom, Michael Meyer, Joan Najita, Bruce Wilking, Erick Young
Title: The Nature of Protostars

1. Define a Scientific Program

Investigate in detail the earliest phase of the star formation process, i.e., the physical properties of protostellar objects and their circumstellar environments.

High resolution spectroscopy (R=5000-100,000) will be used to (1) determine the effective temperatures, surface gravities, masses, luminosities, rotation rates, veilings, etc. of protostars from studies of their photospheres, (2) provide unique constraints on the physical, chemical, and dynamical properties of their surrounding accretion disks, associated winds and jets, and infalling envelopes.

High resolution spectroscopy in the near- to mid-IR takes advantage of the large aperture, IR optimization, and excellent angular resolution (smaller slits mean more compact instrument design) offered by the new generation of large telescopes.

2. Define How Target Lists Will be Assembled

(a) What can extant surveys provide? How and why do they need to be supplemented?

Existing infrared and millimeter-wave surveys provide a good list of protostar candidate sources within the nearest (d<150 pc) clouds. However, the rarity of protostars (typically a few % of YSOs) requires that a considerably larger volume of space be surveyed in order to assemble a statistically significant sample of protostellar candidates that cover, for example, a range of stellar masses and formation environments. To obtain a sample of a few 100 protostars requires surveys of star forming regions out to ~ 1 kpc or more. Systematic surveys for protostars at distances beyond 150 pc have not yet been attempted.

All-sky and pointed far-infrared surveys (IRAS, ISO, SIRTF, and WIRE) will be used to identify active star forming regions and isolated protostellar candidate sources. Since these surveys are typically low spatial resolution photometric surveys, follow-up ground-based near and mid-infrared imaging will be used to resolve spatial confusion (particularly important for the more distant star forming regions) and obtain accurate source positions.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

JHKL survey of depth sufficient to reach 0.1 Msun for stars with ages t < 3 Myr, Av < 3 mag. Must provide fluxes accurate to 10% and relative positions to 0.1". Requires ~100 nights on a 2.5m class telescope.

Survey provides (a) basis for selecting target protostellar objects; (b) a "Guide Star Catalog" for selecting WFS and AO "reference" stars, (c) astrometric reference stars.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radiotelescopes) or by space-based facilities in defining the sample.

Far-infrared surveys and pointed observations (IRAS, ISO, SIRTF, WIRE) will provide initial lists of star forming regions to be observed.

Observations of protostars with SMA and MMA will probe structure and dynamics of outer envelopes and complement infrared spectroscopic studies of inner envelopes/disks.

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

Establish grid of spectroscopic standards for spectral classification, for cross correlation to derive rotation velocities, and in order to select surface-gravity sensitive indices required to enable sorting between PMS and field populations. Requires R ~ 20000 spectra (R/I band echelle; JHK band) with S/N ~ 100/resolution element.

Sample: field stars (luminosity class I, III, IV and V); Luminosity class IV stars will be drawn from a sample of nearby PMS stars with no/little accretion located in clouds of well-known distance; selection of accreting PMS stars).

Requires ~ 50 nights of time on a 4-m class telescope.

Standard star grid provides a valuable resource for a wide range of other astrophysical problems, e.g., stellar populations synthesis, etc.

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

Fluxes and positions of candidates that are selected by (K-L) colors will be obtained in the initial imaging ssurvey. Expect sample of 300 candidates.

Additional follow-up observations of protostar candidates at N will be conducted at a 4-meter telescope with tip-tilt capability. Estimate 50 hours to reach N=8 with S/N of 10 sigma.

Spectroscopic observations with R=1000 in the 1-5 micron region of 300 candidates to identify sources with photospheric features and assess veiling.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

N/A

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

High spectral resolution (R~10,000 - 100,000) observations of ~100 protostellar objects between 1-20 microns wavelength to study photospheres and circumstellar material (winds, disks, infalling envelopes). The 1-2 um region may be best for photospheres; longer wavelengths (3-20 um) may be better for disks and envelopes.

Instrument: high resolution near- and mid-IR spectrographs; e.g., cross-dispersed echelle. Need internal lamps with capability of measuring lots of spectral lines for accurate wavelength calibration, esp. at very high resolution.

Time: A typical low-mass protostar at 1 kpc might be M=8 (extrapolating from the Taurus population). S/N=100 on the 5um continuum will require a 5 hr integration with a fiducial Gemini + 1-5um high res spectrograph (R=50,000-100,000). Requires 1000 hours to observe 100 protostars on a 8-10-meter aperture telescope.

Using tip-tilt, mid-infrared spectroscopy with R=100,000 of absorption lines to map kinematics of outer envelopes. Estimate 5 hours per source. Requires 500 hours to observe 100 sources.

The large time investment per grating setup makes prepatory observations critical (i.e., accurate protostellar candidate identification; detection of emission lines of interest; determination of robust photospheric diagnostics to investigate based on spectral templates).

Software: N/A

Operations modes: TBD

Additional support capabilities of possible interest:

Queue scheduling: The study of variability in young stars is a powerful tool (e.g., as a probe of stellar surface structure) that is rarely used due to the difficulty of obtaining a consistent set of data over long timescales. The possibility of allocating partial nights via queue scheduling might make time variability studies more practical. In addition, having multiple instruments available per night would make it possible to study optical and IR properties concurrently.

Archiving would enable more complete use of data, effectively wider access to national facilities.

Program group: Young stellar objects and physics of star formation
Program reference: US4b
Co-investigators: Charles Lada, Steve Strom, Michael Meyer, Joan Najita, Bruce Wilking, Erick Young
Title: Determining the Initial Mass Function in Nearby Star Forming Regions

1. Define a Scientific Program

Goal: Determine the IMF in multiple star-forming regions to learn whether it is universal, and if not, it depends on initial or environmental conditions.

Approach: Establish the shape of the IMF in all molecular clouds (~10) within ~1 kpc with sensitivity sufficient to detect objects well below the hydrogen-burning limit. Requires a complete photometric and spectroscopic inventory of PMS star population in each cloud.

2. Define How Target Lists Will be Assembled

(a) What can extant surveys provide? How and why do they need to be supplemented?

2MASS provides targets to limiting magnitude 14.5 at JHK with position accuracy of 0.5". IMF program requires 10% photometry to K ~ 17, H ~18, J~ 18.5 and relative position accuracies of 0.1".

ROSAT provides a list of x-ray bright candidates. Survey sensitivity is insufficient (by >10x) to select target selects for rapidly rotating objects (discrimates against older, slowly rotating, and lower mass stars).

Mm-wave molecular line surveys provide extinction maps which guide survey boundaries and depths.

Extant JHK surveys. These are of limited areal coverage and in most cases, of sensitivity insufficient for a complete survey of of the IMF.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

(i) CRITICAL ENABLING SURVEY

RIJHKL survey of depth sufficient to reach 0.1 Msun for stars with ages t < 3 Myr, Av < 3 mag. Must provide fluxes accurate to 10% and relative positions to 0.1". Requires ~100 nights on a 2.5m class telescope. RI-band imaging must have ~30'x30' FOV with 0.5"px to enable tie-in with Hipparchos system. JHK imager must have ~15'x15' FOV.

Survey provides (a) basis for selecting target PMS objects; (b) a "Guide Star Catalog" providing fluxes and astrometric positions for WFS and AO "reference" stars.

(ii) POSSIBLY CRITICAL COMPONENT IN STRATEGY TO DISCRIMINATE PMS OBJECTS
FROM FIELD STARS IN LOWER DENSITY CLOUD REGIONS

Variability survey to I ~20

Survey provides the basis for selecting candidate PMS stars (irregular variables among accreting population; rotationally-modulated variables among the non-accreting PMS population). Requires extensive access to a 1-m class instrument equipped with a wide-field CCD imager

(iii) DESIRABLE COMPLEMENTARY SURVEY

Halpha surveys to R ~ 18 (sufficient to identify candidate accreting objects for stars with M < 0.3 Msun and Av < 5 mag).

Requires access to a 1-m class instrument equipped with wide-field CCD imager + narrow-band filters or a Schmidt equipped with an objective prism and a CCD mosaic enabling wide field spectroscopy

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

WIRE *may* provide target lists of *isolated* PMS stars still surrounded by accretion disks and/or envelopes and a finding list for candidate embedded clusters and aggregates VLA *may* provide target lists of (a) accreting stars; (b) stars with active chromospheres.

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

Establish grid of spectroscopic standards in order to establish quantitative spectral classification criteria (Teff, log g) for YSOs. These will be particularly critical for discriminating between PMS and field populations. Requires R ~ 20000 spectra (R/I band echelle; JHK band) with S/N ~ 100/resolution element.

Sample: field and nearby PMS stars spanning all spectral types and luminosity classes I, III, IV and V.

Requires ~ 50 nights of time on a 4-m class telescope.

This standard star grid will provide a valuable starting point for a variety of other studies (stellar populations; population synthesis; etc).

4. Define Preparatory Observations

List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

(i) JHKL imaging survey is REQUIRED in order to provide positions, fluxes, candidate WFS/AO reference stars.

A wide-field JHKL imaging capability (10-15 arc minutes) on a 2-m class telescope is required. It is highly desirable that JHKL observations be made simultaneously (time requirements; image registration; source variability; all dictate simultaneity).

(ii) Deep, high angular resolution JHKL imaging to establish source positions (accurate to 0.1") and fluxes (accurate to 10%) in source/background-confused regions.

4-m class telescope with tip-tilt correction will be required. Estimated observing time: 10-20 nights (depends on survey results).

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

Spectroscopic observations (R ~ 5000) at I-band and JHK- band for the brighter sources, lower extinction sources (K < 13 mag; I < 17.5 mag), comprising our total sample of ~10^4 YSOs.

I-band spectra with multi-object spectrograph on 4-m class telescopes

JHK-band spectra with spectrograph (multi-object highly desirable; multi-slit required in source- and background- confused regions)

NB: MULTI-OBJECT NIR capability on 4-m class telescope represents a highly desirable option that would enable important complementary YSO spectroscopic surveys provided that spectral coverage covers most of
the H-band.

Observing the requisite (many)x10^3 stars will require time comparable to 8-10m class program (estimated to be ~ 100 nights).

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

Deep spectroscopic observations aimed at sampling the IMF for stars with masses M < 0.3 Msun. Requires JHK spectroscopy at R ~ 5000 and relatively high S/N to establish accurate spectral types for stars 13 < K < 17 mag.

At a distance of 1000 pc, a star of 0.1 Msun will have a K-band magnitude of 15 at an age of 1 Myr and 17 at 10 Myr if Av ~0; for a more typical Av ~ 10, the corresponding predicted K-band magnitudes are 16 and 18 respectively.

Sample sizes: several thousand stars in order to enable comparison of IMFs in clouds exhibiting differing initial (molecular cloud densities; sound speeds) and environmental (rich cluster; isolated) conditions.

Time requirements: ~ 100 nights

Addendum: additional desirable capabilities

In high density cluster regions, high angular resolution (< 0.2") is required in order to separate sources.

Multi-slit IR spectroscopic capability in high density regions (often characterized by high and variable nebular background).

Multi-object capability at J- and H- band (extension of GMOS to infrared).

Near-simultaneous imaging (probably a "snapshot") is desirable in order to determine current-epoch flux values (sources are variable) and to search for binaries (this may require tip-tilt image at K-band).

Program group: Star formation and other activity in nearby galaxies
Program reference: US5
Co-investigators: Robert Kennicut, Tom Soifer, Jay Elias, Phil Puxley, Joe Shields, Sylvain Veilleux, Dennis Zaritsky
Title: Cosmological Evolution of Starburst Galaxies

1. Define a Scientific Program

With the advent of two major space infrared missions in the next 4 years, WIRE and SIRTF, it will be possible to directly study the cosmological evolution of starburst galaxies, and the corresponding evolution of the cosmic star formation rate based on infrared-selected samples of galaxies.

The WIRE mission will perform moderate and deep surveys at 12 and 25um over 100's and 10's of square degrees respectively to levels 500-1000 times deeper than the IRAS all sky survey. This will permit the detection via the infrared emission of starburst galaxies to redshifts in excess of 1 with the mean redshift of the WIRE deep survey targets expected to be ~.5.

The goal of this project is to perform a comprehensive optical and near-infrared follow-up survey to the WIRE mission, and address the following issues:

(i) Determine the evolution of the starburst galaxy population over the redshift range 0.2 - 1. The WIRE sample will allow us to probe this evolution as a function of bolometric luminosity, and will constrain the role of galaxy interaction in triggering starbursts.

(ii) Derive the star formation rate for the WIRE sources, and determine from that comparison the star formation rate in IR luminous starbursts for $z<0.2$. Compare these rates with those determined from UV/Optical selected surveys spanning the same range in redshift.

(iii) Clarify the nature of the AGN's detected in the sample. Determine the fraction of BAL AGN's selected from WIRE, compare with opt/UV selected samples.

The observational stategy to reach these goals will be to

(i) perform optical/radio identifications of WIRE detected targets with positional accuracies adequate to perform followup redshift surveys with multiobject spectrographs

(ii) perform a redshift survey of the identified targets

(iii) Classify the identified targets as AGNs/starbursts

(iv) explore the oddballs, find dusty protogalaxies in the WIRE sample for z up to 3.

2. Define How Target Lists Will be Assembled

The initial target list will be all sources detected in the WIRE deep survey. For the (conservative) no-evolution model this will be ~5,000 sources over 8 sq. degrees. at a flux level of 0.25mJy at 25um. We adopt this sample as our nominal sample for the following Science program.

WIRE positional uncertainties are 2" 1 sigma radius, so a 95% confidence search circle for identifications is 4" radius. The WIRE deep survey will be spread over the N and S polar caps in blocks ~1/2x2 deg on a
side, 6 in the N cap, and 2 in the south (for a 15 Sep 98 launch).

(a) What can extant surveys provide? How and why do they need to be supplemented?

Everything.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

All of the requirements of our program can be met with currently available capabilities.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

Deep imaging of the WIRE fields with the VLA can detect a source at 10uJy in 4 hours at 20 cm. The primary beam of the dishes is ~.5 deg, so that to cover 1 sq deg. requires 20 hr, or 160 hrs to cover 8 squ degrees. Positions need to be determined to =/-0.3" to permit accurate source location for followup multislit spectroscopy. A array is needed for source position locations.

At this level there will be radio counterparts for ~75% of the WIRE sources, using the radio/ir relation derived from IRAS.

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

The program observations will not, in general, require special calibration observations. It is however worth noting that in the infrared the standard stars needed to flux-calibrate spectra on 8m-class telescopes do not yet exist, and significant effort will be required to supply them. This work would presumably be done on smaller (2 to 4-m) telescopes.

Some special calibration in the form of re-measurement of spectra of "local" examples of different galaxy types may be needed in cases where observations in the literature are not well-matched to the data. We expect this will not require significant amounts of telescope time (e.g. a few nights on 2-4-m class telescopes with appropriate spectrographs).

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

Optical imaging in R and B is required for identification as well. R 100min/field or 400 min/square degree. Thus 8 sq. deg. corresponds to 50 hrs. At B, we require similar exposure times to reach S/N = 10 for galaxies with B-R of 1mag.

Position accuracies are the same as for the VLA observations.

For ~75% of the source there should be a unique opt/radio counterpart to the WIRE source, for the rest there will be ~2-3 candidates/WIRE source.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

Redshift survey of all ~10,000 candidates within the WIRE error ellipses using a multi-fiber spectrograph on a 4-meter class telescope. This survey will require multi-object spectroscopy over a wide FOV (of the order of a degree).

R = 500 - 1,000
lambda = 4,000 - 8,000 (observer's frame)
t(exposure) = 4 hours

Assuming 1,400 candidates per sq-degree (about half of which are the actual sources) and a MOS with 300 fibers (e.g, Hectospec or 2dF), we will get the spectrum of 200 galaxies per setup. This will require 50 setups or 25 nights. With Hydra, the required observing time would at least double.

Higher resolution spectrophotometry for ~400 bright low-z objects for spectral classification purposes using a slit spectrograph on a 4-meter class telescope.

R = 1,500 - 2,000
lambda = 3,600 - 6,800 (rest-frame)
S/N(continuum) >~ 20
t(exposure) = 1 hour

This program will target 200 fields. A typical field will contain a second galaxy of comparable brightness. If multi-slit capability is also available, fainter WIRE targets in the field will be observed in the same exposure. This program will require 20 nights.

K-band imaging of ~200 faint high-z candidates on a 4-meter class telescope

K = 22
t(exposure) = 1.5 hours

This program will require 300 hours or 30 nights.

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

(i) Redshift determination of the ~10% of WIRE sources not measurable by wide-field fibre spectroscopy. These are likely to be the higher redshift, and perhaps most interesting, objects in the sample.

Optical multi-object spectroscopy (e.g. GMOS) to R=24-25mag requiring 1hr integration. For 500 WIRE sources, i.e. 1000 optical candidates, with typically 2 sources per GMOS field, this requires 250 Gemini pointings. Total time is 250hr.

(ii) Optical spectra for discrimination between starburst galaxies and AGN, and for analysis of emission line ratios to derive gas excitation properties, abundance estimates etc.

GMOS spectra of 200 WIRE sources (typically one per field) in highest redshift bin (z=0.6-1). These 5 arcmin fields will also allow measurement of ~1000 WIRE sources near the peak of their redshift distribution (z=0.3-0.5). Integration times of 1-3 hrs per field, requires total of 400hr.

(iii) AO images to study redshift evolution of morphology (merging etc.).

Natural guide star AO is OK (can select targets having a suitable guide star from the sample list). Take images at J (of sources in lowest redshift bin, z~0.2), at H (of intermediate redshift bin, z=0.3-0.5) and at K (of highest redshift bin, z=0.6-1). This provides images with Strehl 0.2-0.5 of sources at a similar rest-frame wavelength (lambda~1um). Imaging of 100 starburst galaxies (~30 per redshift bin), with integration time of 45min each, requires 75hr.

Addendum: desired capabilities not currently available

(1) Detectors with broad wavelength sensitivities out from visible to 1.5 um.

(2) AO capabilities on 2-to-4 meter class telescopes

(3) wide-field near-infrared imaging on 2-to-4 meter class telescopes (desired but not essential for this program)

Program group: Stellar populations in nearby galaxies
Program reference: US6a
Co-investigators: Bruce Carney, Ken Freeman, Taft Armandroff, Heather Morrison, Mike Rich, Ata Sarajedini
Title: A Spectroscopic and Imaging Survey of Halo Populations in the Local Group

1. Define a Scientific Program

We propose a spectroscopic and imaging survey of halo populations in the Local Group. Specifically, we want to investigate the metallicity and velocity distributions of stars in the outer halos of M31, M33, NGC 205, NGC 147, and NGC 185. We also want to investigate the shapes of these stellar halos as a function of
metallicity, and the shape of the dark halos as well.

The scientific aims are:

(i) to quantify the fraction of halo stars that may have been contributed by the disintegration of dwarf spheroidal galaxies, which may vary as a function of parent galaxy mass, Hubble Type, or environment; In particular, M31 has 3 dwarf spheroidal companions of its own (And I-III) which have lower metallicities than the surrounding halo field stars, and which also may have their own population substructures.

(ii) To measure the abundance distribution function and compare that to chemical evolution models. Using new techniques that have been developed for abundance analysis of low S/N spectra, we aim to measure [alpha/Fe] for target, small subsamples of stars.

(iii) To use the kinematics to investigate abundance/kinematics correlations, and to constrain measurements of the dynamical mass. On the major axes of M31 and M33, the potential gradient is given by the HI rotation curve. On the minor axis, these new data will give an estimate of the vertical potential gradient and hence of the shape of the dark halo.

(iv) Radial velocities with a 10 km/sec precision could be used to discover ghost dwarf spheroidals (i.e. Sgr dwarf-like systems) in the course of this survey.

(v) Variable star populations are a useful diagnostic of characteristics such as age and metallicity, and are related to issues of importance in stellar populations e.g. the second parameter problem. We propose to use imaging on 4m telescopes to discover these stars.

2. Define How Target Lists Will be Assembled

Ground-based broad band imaging Johnson-Cousins V,I, with a 4-m class telescope, in 0.5" seeing, will provide the input catalog. It may also be desirable to use other filter systems, such as Washington photometry, to improve abundance estimates for the giants from photometry.

The data reduction steps are: 1. Photometry from the images will identify the candidate giants. 2. Astrometry is done for the sample of stars to be observed. The positions are fed into the multi slit mask generation software.

(a) What can extant surveys provide? How and why do they need to be supplemented?

Nothing, except for some archival HST data. The fields of the HST images are too small (hence poorly matched to the GMOS field) and their coverage too patchy to be useful.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

PI filters for wide field imagers may be required for a number of programs and due to their large size, will be costly; we flag the need to include these items in the operating budget.

As is the case for many programs, the input catalog need 4-m class telescopes with wide fields (approximately 30 arcmin or greater) and excellent images, and a consistent photometric solution with no spatial variations exceeding 0.02 mag, over the whole field.

Need excellent relative astrometry (~0".2): larger astrometric errors will induce radial velocity errors.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

It would be essential to have the best possible deep velocity fields of the neutral hydgrogen in M31 and M33, using VLA, Green Bank Telescope.

HST imaging can give targets in small fields, from archival data. Contiguous strips of imaging could also be a source of targets.

In specific fields, long integrations with HST using STIS or the Advanced Camera will reach the old main sequence turnoff point, at V=29 for M31. This would enable us to also have the age distribution for small regions in our halo fields.

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

Calibrate Johnson-Cousins V, I photometry obtained with the wide field imager. Calibration must be uniform to +/- 0.02 mag over the entire field of view. If other filter systems are used, these will require additional calibrations.

Metallicity indices derived from the spectroscopy of the stars must also be calibrated

We need a data pipeline to reduce the large mosaics for the photometry, and for astrometry of our sample.

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

Assuming a 30X30 arcmin imager, we estimate the following times for the survey. Assume 2 hrs in each of V, I for each field [7000 sec, V=25,S/N=50, 4m telescope, 0.5" seeing, dark moon, using NOAO exposure calculator]. We explored how to set up a minimum grid on M31, assuming the need to reach slightly beyond 3 deg = 40 kpc from the nucleus. 20 fields are need for this minimal survey. For M33, a similar effort requires 10 fields, while NGC 185 and 147 each require 4 fields; NGC 205 could be done in conjunction with the M31 survey. This adds to roughly 160 hours, including overheads, which converts to 20 nights with 0.5 arcsec seeing. The Washington photometry needed for the photometric metallicity estimates requires another 20 nights of 4-m time. About 8 photometric nights on a 1-2-m class telescope would be needed to get photometric zero points for the fields.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

See above.

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

Multislit spectroscopy of the candidate giants. The most important features are CN 3880, Ca HK, Mg, Fe 5270, 5328, Na D, and Ca triplet. Central region is 3800-6000AA and it would be desirable but not essential to get the Ca triplet at 8600AA.

Using a preliminary GMOS time estimator, we found at R=22, 5000AA, R=1000, S/N=10 per pixel in 1 hr. We also checked Cohen et al. (1997) who used LRIS on Keck and obtained very similar results. Our sample will include brighter giants, for which we can observe several masks per night. However we need to reach down to R = 24, and for these stars at least one night per slit mask is needed. We are aware that our program is demanding and it is possible that we could get by with low S/N ratio spectra for velocities alone, using broad band Washington photometry to estimate the metallicities. Or we could only work in the red, using the Ca triplet, where the faintest stars would be I=23.

For GMOS, we assume about 40 objects per mask. As a first cut program, we would look at 5 fields in M31 and one field in each of the other galaxies: this would take a total of about 10 nights. A more fully developed study to probe the velocity fields adequately would be about 5 times more extensive, for a total of about 50 nights.

Program group: Stellar populations in nearby galaxies
Program reference: US6b

Co-investigators:	Bruce Carney, Ken Freeman, Taft Armandroff, Heather Morrison, Mike Rich, Ata Sarajedini
Title:	Galaxy Formation and Evolution

1. Define a Scientific Program

We seek to understand galaxy formation and evolution in the simplest systems that have had multiple generations of star formation: dwarf spheroidal galaxies (dSph). Examples of the fundamental questions that we plan to investigate are: What are the star formation, chemical enrichment, and kinematical histories of dSph galaxies? For example, what are the age-metallicity relations and kinematics-age relations for dwarf spheroidals. How are these different between different parts of the same dSph galaxy? How are these different between a dSph such as Carina, which has had episodic star formation, and Fornax, which has had more continuous star formation? These are the simplest systems with extended star formation and chemical enrichment histories, and thus provide a crucial test of galaxy formation models.

How do we address these questions? With the new generation of large telescopes, for the first time we can measure spectroscopic abundances and radial velocities for stars with unambiguous age information. Recent results have shown multiple generations of star formation in several dwarf spheroidals. We plan to survey the entire population of Milky Way dwarf spheroidal galaxies, and determine the star formation histories of each of these. Follow-up spectroscopy of selected populations will yield information on the evolution of abundance and kinematics with age.

2. Define How Target Lists Will be Assembled

(a) What can extant surveys provide? How and why do they need to be supplemented?

The brightest giants in the Galactic dwarf spheroidals are barely detected in extant sky surveys. The turnoff stars are much fainter of course.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

Not applicable.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

None.

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

We plan to measure metal abundances for the dSph stars using three techniques: 1) Ca II H & K strength in stars near the main-sequence turnoff; 2) the Laird/Carney/Latham high-resolution low-S/N [Fe/H] methodology around 5000 A for main-sequence and subgiant stars; 3) the Ca II triplet for giant-branch stars. All of these techniques require calibration using stars in globular and open clusters. We require a spectrograph on a 4-m class telescope that yields similar spectral resolution and wavelength coverage as our planned GMOS observations (R=10,000). Approximately 10-15 clusters with a range of metallicity, and ideally age, would be needed, and 10-20 stars per cluster would be needed to bracket the temperature and surface gravity interval.

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

Extant color-magnitude diagrams show that the Galactic dSph have a variety of star formation histories. However, the current data lack the photometric precision, field coverage, and community-accessible astrometry needed. The photometric precision and areal coverage also vary greatly between galaxies. We need the photometry to be sufficiently accurate to isolate subgiant stars from the various star formation episodes, and also to determine the temperature information needed in the abundance analysis. Also, substantial areal coverage is required in order to investigate these scientific issues as a function of position within the dSph.

Deep wide-field photometry and astrometry in BVRI. We require 1% photometric precision at the turnoff of the oldest population (V ~= 24.5 in Fornax). Coverage beyond the tidal radius to background fields is needed (tidal radius = 71 arcmin for Fornax). This survey would require 60 nights of 4-m telescope time to cover 10 Milky Way dwarf spheroidals. The imager would need to produce astrometric positions of sufficient accuracy for GMOS. In addition, proper motions would be very important for removing non-members over a baseline of ~5 years. This membership issue is particularly important for increasing the yield of the spectroscopic observations, and for the science in the outer regions where contaminants exceed members. We imagine that these requirements could be fulfilled by a 4-m class telescope with excellent image quality (~0.5 arcsec FWHM, with the goal of a constant point spread function over the field) and a wide-field CCD imager (~40 arcmin field with good sampling of the 0.5 arcsec images). Excellent CCD response over the BVRI filters is important.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

For determining the dSph metallicity distribution, the Ca II triplet spectroscopy of giant-branch stars more luminous than the horizontal branch could be carried out on 4-m telescopes with good image quality and an efficient spectrograph.

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

We require spectroscopy of stars in dSph galaxies, particularly stars on the subgiant branch near the main-sequence turnoff. These stars will be chosen from our sample of 4-m observations which will provide age information, and cover the bulk of each galaxy. A spectral resolution of R=10,000 is needed to achieve our velocity accuracy goal of 1 km/s. In order to measure metal abundances from the two techniques described above, wavelength coverage from 3500 to 5500 A is needed. In the magnitude range V=23-24, the predicted exposure times based on the GMOS Web page are 6-8 hours per multislit mask. For observational efficiency, we require this multi-object capability (as in GMOS). We envision about 500 stars being needed per galaxy in order to adequately sample the distribution over age and spatial extent. This would require 5-10 nights per galaxy chosen for detailed study. Thus, 50-100 nights would be needed for the entire project. Also, spectroscopy with GMOS of giant-branch stars at the Ca II triplet may be required for the more distant systems and the faintest giants in the nearby dSph.

Quick-look reduction and analysis at the telescope would be very valuable.

Program group: Stellar populations in nearby galaxies
Program reference: US6c
Co-investigators: Bruce Carney, Ken Freeman, Taft Armandroff, Heather Morrison, Mike Rich, Ata Sarajedini
Title: What did galactic disks look like 10 Gyrs ago?

1. Define a Scientific Program

What did galactic disks look like 10 Gyrs ago? One solution is to measure ages, velocities, and chemistry for samples of stars across the disks of the Milky Way, M31, and M33. All three require study since their differing bulge/bar-to-disk rations may imply different histories. Further, they offer differing orientations of their disks and different levels of detail.

For the Milky Way, the goal is to identify relatively large numbers of old stars with measurable ages using Stromgren photometry (i.e., subgiants). The stars should also be selected over a large range of galactocentric distance, with most of them at about 3 disk scale heights from the plane to compensate the increasing incremental volumes by the declining star densities. Radial velocities would provide the primary kinematical data, but these would be supplemented for most of the stars by proper motions. Finally, detailed element-to-iron ratios will measure the nucleosynthesis history across the disk and will enable more direct comparisons with metal absorption lines in QSO damped Lyman-alpha systems.

For M31 and M33, average age measurements can be made via very deep HST imaging down to the turnoff in selected outer disk fields. Velocity-metallicity relations for single stars can be obtained for the older populations from 8m moderate-resolution (R=3000) spectroscopy.

2. Define How Target Lists Will be Assembled

(a) What can extant surveys provide? How and why do they need to be supplemented?

Milky Way: N/A

M31/M33: Archival HST data of fields in the disks of these galaxies will provide targets for follow-up spectroscopy. These archives are likely to require supplemental observations.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

Milky Way: Completion of the POSS II survey with proper motions to V = 19-20 is essential.

M31/M33: N/A

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

N/A

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

Milky Way: Ages are estimated from comparison of Stromgren c1 (Balmer jump) vs. b-y (temperature) indices. For metal-rich stars, this will require photometric precision of 0.005 mag or better. Thus flat fielding
to 0.5% or better over a large field of view (1 sq. deg.) is required. To calibrate the age determinations and tie the results to clusters, observations of carefully-selected open and globular clusters will be necessary. A 4m with very good image quality (FWHM < 0.5" and constant PSF across the field) is best suited to the cluster work, and will require 10 nights of photometric conditions.

M31 and M33: The brighter red giants in M31 and M33 can be observed at R=3000 at signal-to-noise of 15 in a night-long exposure with GMOS. We need to measure the precision of metallicity measurement from such spectra using observations of galactic globular and open clusters. We assume for the rest of the proposal that sigma([Fe/H]) of 0.15 can be achieved at this S/N. This should only take a few nights on a 4m telescope.

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

Milky Way: To study the outer disk, fields near l = 180 at b = 6, 8, 15, and 90 should be observed. To obtain comparable and adequate numbers of subgiants, field sizes of 1, 1, 4, and 10 sq. deg. should be observed. A wide-field (1 deg) 4m with good image quality (0.5" - 0.8") seeing is sufficient. Toward the bulge, observations loward l = 15 will provide the best kinematic discrimination between bulge and disk stars. An additional 1, 1, and 4 sq. deg. should be observed at b = 6, 8, and 15, respectively. A total of 40 photometric nights will be required to achieve the precision in the c1 index at V = 18-19.

M31 and M33: Where HST archival data is not available in low-reddening fields across the disks of these galaxies, HST snapshot images in the crowded regions and 4m imaging with superb image quality in the outer regions will provide red giants for follow-up spectroscopy.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

Milky Way: To obtain the third velocity component, radial velocities must be measured for all the age-dateable subgiants. A wide-field (1 deg) 4m multi-object spectrograph operating at moderate resolution (R =
3000) will suffice. We estimate two nights per field, or 40 nights total.

M31/M33: A separate program on the M31 spheroid will help distinguish spheroid stars in our disk fields.

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

Milky Way: To optimize the precision of the relative ages of the disk and bulge stars, to determine the nucleosynthesis history across the disk, and to compare the history of the Milky Way's disk with the observations of metal lines in damped Lyman-alpha systems, we must determine element-to-iron ratios for many elements in a subsample that spans differences in age, metallicity, and galactocentric distance. We estimate 300 stars will be required, many of them faint (V=17-18), and that a single-object, high-resolution (R > 30,000) spectrograph on an 8m telescope can provide the data in about 30 nights.

M31 and M33: Due to crowding limitations, we will focus on major axis fields at distances of more than 10 kpc from the galaxy's center. Large samples (several hundred in each of 3 fields per galaxy) are needed to measure velocity dispersion for different metallicity ranges. A multi-object moderate-resolution (R = 3000) 8m spectrograph is needed for adequate metallicity measures. Giant branch tip stars (V= 22.5) will require exposures of 3 nights per field with several hundred fibers available per field.

Program group: Galaxy formation and evolution
Program reference: US7
Co-investigators: Richard Elston, Matt Bershady, Jane Charlton, Ruth Daly, Arjun Dey
Title: The Formation and Growth of Galaxies

1. Define a Scientific Program

The overall goal is to study the formation and growth of galaxies by following the evolution of their gas, stellar, and dark matter content from$1<z<3$. This includes:

(i) Determination of the luminosity function (LF) and galaxy-galaxy correlation function on < few Mpc scales down to present M*+2 as a function of environment, galaxy type, mass, and redshift.

(ii) Detailed evolution of stellar populations, morphology, star-formation rate, chemical abundance, and dust content.

To achieve these goals, the sample will be selected (for the usual reasons) in the near-infrared based on wide-field imaging surveys using 4m-class telescopes, and followed up with high resolution spatial imaging and spectroscopy with 8m-class telescopes using multi-object and integral field optical/near-IR spectrographs.

The survey will have the following structure:

(i) An imaging survey on 4m-class telescopes covering 5x1 deg^2 for selection of 200,000 targets to K<21 (imaging to K<23 at 5 sigma and commensurate depth in UBRIJH). Fields will be chosen to correspond to deep fields surveyed at x-ray, mid-infrared, and radio wavelengths at high galactic latitude and low extinction.

(ii) Optical/NIR MOS on 8m-class telescopes of 1000 galaxies to calibrate photometric redshifts for subsequent target selection and for LF studies.

(iii) Selection of subsamples of roughly 1000 galaxies (each) for detailed spectroscopic follow-up to address the following issues:

(a) H-alpha rotation curves for disk galaxies for internal velocity -luminosity relation study (NIR);

(b) Stellar populations in red-envelope galaxies (OP/NIR);

(c) QSO absorption line-selected samples to study abundances, dust and kinematics;

(d) Radio, x-ray, and mid-infrared selected samples to correlate with dust, activity, star formation, etc.;

(e) Variability selected targets (extended sources) to study the evolution of the faint end of the AGN LF and its relation to the global galaxy LF.

2. Define How Target Lists Will be Assembled

(a) What can extant surveys provide? How and why do they need to be supplemented?

We will pick five 1 square degree fields distributed over a range in RA to aid efficiency in observing / schedulability. Some of the target fields will be selected based on bright quasar pairs and groupings. These may be provided by existing quasar surveys or by the Sloan Digital Sky Survey. For our galaxy evolution studies, fields will be selected on the basis of low cirrus emission (i.e., based on the IRAS / SIRTF / WIRE 60-100 micron maps) and low HI column density (i.e., based on existing HI surveys of the Galactic plane and the Rosat All Sky Survey).

The primary research goal is to investigate the global properties of galaxies in a variety of environments and at redshifts z>1. Selecting such galaxy samples requires deep optical and near-IR imaging surveys. None of the extant surveys are complete to the required depths, especially at near-IR wavelengths.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

Overview:

The imaging survey proposed here requires a three-tiered approach:

(i) The first tier comprises of a very wide-field survey covering areas at least 25 degrees^2 (each) in size in order to place the galaxies in the context of their large-scale structure environments and to sample size-scales comparable to the clustering scales in the local Universe.

(ii) The second tier of the project is the primary observational requirement for the science proposed here. We will survey five 1 square degree regions of the sky at both optical and near-IR wavelengths and which will enable selecting sub-L* galaxies out to redshifts z~3. Subsequent follow-up on a yearly basis will provide provide accurate relative astrometry (including proper motions) and information on variability.

(iii) The third tier is an extremely deep, very high spatial resolution complement. For this portion of the study, we will obtain K images of 12'-15' sub-fields of (2) using the Gemini Telescopes in order to determine morphologies and image structure.

Details:

1st Tier) This initial survey is designed in order to investigate gross large scale structure, and therefore does not need to reach very faint magnitudes. We envision a quick I-band survey reaching I=25 covering at least 5 degrees on a side. This can be done in 7 nights per 5x field on the 4-m using the current CCD MOSAIC camera, or a total of 35 nights for the five fields surrounding the 2nd Tier survey.

2nd Tier) This can be accomplished on a 4-meter class telescope using existing instrumentation (e.g., the CCD MOSAIC on the KPNO 4m) for the optical imaging, and a new three-channel, wide-field near-IR imager to cover the J, H and K bands.

The Gemini Telescopes will be able to obtain moderate resolution, moderate signal-to-noise spectroscopy on K=21 magnitude objects in 10h exposures. Hence, in order for our sample to be complete to this magnitude, the survey must reach at least two magnitudes fainter, or toK=23 (5-sigma, 1" diameter aperture). (K=19.3 for a unevolved L* elliptical at z=1.5). In addition to the

K-band, we require good photometry in the J and H bands in order to secure accurate photometric redshifts. In order to reach our 5-sigma (1" aperture) limits of J=26, H=24 and K=23 requires a total of 30 nights per 1 square degree field using the new multi-channel near-IR imager (pixel scale of 0.6" and FOV of 20'x20') on a 4-m class telescope , or a total of 150 nights for all five fields.

The reddest populations at z>1 may have R-K~6. Hence, the optical portion of the survey will be carried out to a depth of U=B=V=R=I=27 AB magnitude; this requires 25 hours per field, or, using the CCD MOSAIC on the 4-m, 15 nights per square degree, or 75 dark nights for all 5 fields.

3rd Tier) This high-spatial resolution portion can be carried out exclusively on Gemini using AO to obtain <0.3" image quality. It may also be carried out using the Advanced Camera on HST.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radiotelescopes) or by space-based facilities in defining the sample.

Ground-based:
Tying the optical data to an absolute reference frame can be accomplished using a deep, high-spatial resolution radio interferometric survey. The optical/near-IR survey proposed here, in combination with existing radio surveys of the sky (e.g., the VLA FIRST survey) will provide unique information regarding the nature of the faint radio source populations. In addition, faint, distant radio sources have been successfully exploited in searches for distant clusters. Future surveys with the currently planned millimeter and sub-mm arrays in our optical survey fields will be of great importance in studying the evolution of the star-formation rate and dust content in high-redshift systems.

Space-based:
Existing ROSAT data will be valuable for identifying high redshift AGN. The planned deep AXAF images will provide information both about the distribution and temperature of hot gas (intracluster medium, X-ray halos and AGN) in our survey fields. The SIRTF surveys will be sensitive to dusty and actively star-forming systems. SIRTF observations can yield information on dust and old stellar populations in high redshift galaxies, and in particular will enable us to understand the biases involved in selecting galaxies at optical/near-IR wavelengths.

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

Near-IR spectro-photometric and telluric standards near program fields.

Instrument/Telescope: single-object R=10000 NIR spectrograph on 2-4m telescope.

Time: 10 nights

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

Wide field optical and NIR survey to K<23 (5 sigma detection in 1 arcsec diameter aperture):

- Astrometric Calibration:

Relative astrometry to 0.03 arcsec for MOS positioning over 10 arcmin MOS.
Absolute astrometry to 0.2 arcsec for multiwavelength comparison.

Observations: Repeated observations (yearly) for determination of proper motions down to guide-star limit on 8m-class telescopes; astrometric calibration of wide-field imagers by observing astrometric standard fields.

- Photometric calibration and precision:

Relative calibration within and between fields < 0.02 mag
Absolute calibration < 0.05 mag

Obervations: Observe standard photometric calibration sequences in optical and near-IR during acquisition of wide-field imaging -- one epoch only.

Telescopes/Instruments/Time: 150 nights WF NIR (simultaneous JHK over 20x20 arcmin FOV) imaging on 4m telescope; 75 nights optical WF imaging (8Kx8K UV-sensitive) on 4m. See above for details.

- Software:

(i) Pipe-line reductions of survey data

(ii) Archiving of images and photometric and astrometric catalogues.

(iii) Target, guide-star selection, MOS preparation and planning software for 8m-class telescope.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

Wide field optical and NIR MOS to K<17 using high-throughput imaging spectrographs.

Telescopes: 4-6m class.

Instruments: WF (30 arcmin FOV) optical imaging MOS with HIGH throughput and R>5000; NIR MOS (>5 arcmin FOV) with high throughput and R>5000.

Time: TBD

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

- High spatial resolution imaging (FWHM<0.3 arcsec) at 2.2 microns to a depth of 24 mag per arcsec^2 at 1 sigma over selected subfields containing 5000 target galaxies for subsequent spectroscopic follow-up. (50 nights)

- R>5000 Optical and NIR MOS with 10 arcmin FOV with ability vary slit orientations; FWHM < 0.3 arcsec. Software for reduction of spectra taken with variability tilted slitlets. (150 nights)

- R~10000 Integral field spectroscopy for 100 galaxies for rotation and H-alpha (star formation) studies with AO (Strehl > 30%). Software for reduction of IFU spectra. (30 nights)

- R = 500,000 of bright (B<17) QSOs in target fields at S/N of 15 per resolution element. (5 nights)

- R = 20,000 of B<20 QSOs in target fields at S/N of 30 per resolution element. (10 nights)

Total Time: 245 nights

Program group: Large scale structure/Cosmology
Program reference: US8
Co-investigators: Michael Strauss, Hans-Walter Rix, Ray Carlberg, Ken Lanzetta, Tod Lauer, Ann Zabludoff
Title: Large-Scale Structure at High Redshifts

1. Define a Scientific Program

We wish to study large-scale structure at high redshifts. The redshift range 1-5 is quite feasible to study with wide-field imaging surveys and spectroscopic follow-up on the 8-m class telescopes, while beyond remains quite speculative at this time. We are interested in the evolution of large-scale structure. On large scales, the evolution of clustering is strongly Omega-dependent; clustering evolves rapidly in a flat universe, while it is frozen in at a high redshifts in a low Omega universe. On small scales (100 kpc-10 Mpc), the study of LSS is intimately tied to the formation of galaxies, and galaxies in formation are likely to exhibit a strong bias. Hence, an imaging survey that defines samples for studying the evolution of structure beyond z = 1, must be defined broadly enough to explore the variation in clustering properties with galaxy type, luminosity, and environment.

For scales >>10Mpc, the galaxy-galaxy correlation, itself, falls to low amplitudes, making less it effective as a diagnostic of power on large-scales. Constraining both the form and amplitude of the mass-spectrum on large scales is important, however; this can be provided by the cluster-cluster correlation function, the void-probability function, as well as topological measures such as the genus-number of the 3D distribution of galaxies in redshift and the two transverse spatial dimensions. The scale length of the cluster-cluster correlation function is ~20Mpc at z=0, and voids, “great walls,” and so on, are observed to have ~100Mpc scales, thus observing the evolution of large scale structure at z>1 on the very largest scales important at this epoch requires that the parent image survey cover several contiguous square degrees. For example, 100Mpc subtends ~1deg at z=1-4 (almost independent of z!) thus the imaging survey must cover this angular scale in one-dimension at least to provide a fair sample of the ancient universe. Furthermore, the geometry of the survey cannot be too anisotropic lest improper sampling of the structure in the short dimension alias measurement of structure sampled by the long dimension.

Galaxy clusters are of particular interest as tracers of large scale structure; however, the surface density of rich clusters is relatively low - typically ~10 abell-like clusters of richness 1 are seen per square degree for 0<z<1, with the richest clusters (such as Coma), at least an order of magnitude rarer still. Clusters at z>>1 have been seen in only a few special cases and can only be detected in general with deep IR-imaging - again a large area is required.

We only have upper limits at present on the number density of z >5 galaxies, from the photometric surveys that have been done (HDF, etc.). Yet, for the mission of NGST, a large-scale exploratory survey is of utmost
importance.

The deep imaging survey proposed below can address a large number of other cosmological questions:

(i) Surveys for z ~2 supernovae, for determination of Omega and Lambda separately;

(ii) Gravitational lensing studies, both weak and strong;

(iii) QSO absorption line studies, the power spectrum of absorption from the IGM, and the correlation between the IGM and the galaxy distribution.

In order to meet these goals, we propose two photometric surveys with 4-meter class telescopes:

(i) 10 square degree multicolor (UBVRIJHK) survey to 5% precision at $K_{AB} = 23.5$ (comparable limits in the other bands);

(ii) 0.5 square degree multicolor survey to $K_{AB} = 25.0$.

We will do a complete spectroscopic survey of $z > 2$ galaxies selected from the first photometric survey, covering roughly 1 square degree, and containing 20,000 galaxies.

These surveys will provide:

- photometric redshift estimates ($\sigma_z = 0.07$)
- a measure of the luminosity functions for galaxies of different types at different redshifts
- a basis for "galaxy-type" selection of samples
- a sample of galaxy clusters for follow-up
- samples of rare objects (QSOs, low luminosity AGNs, LENSING)

2. Define How Target Lists Will be Assembled

(a) What can extant surveys provide? How and why do they need to be supplemented?

There is really nothing on a large enough scale that is deep enough for our purposes. SDSS covers 10,000 square degrees, but is quite shallow for our purposes, and does not extend to the near-IR. However, it will be a useful source of tight groups of quasar targets on the sky for high-resolution spectroscopy.

The NOAO Deep Survey (9 square degrees, UBVRIJHK) is not deep enough to select representative galaxies beyond redshift 2.

(b) Describe the requirements of any new surveys that may be required along with the generic telescope/instrument/operations/software needs of the program to achieve necessary flux and position accuracies.

The SED of a typical galaxy peaks beyond 1 micron in the rest frame. Current search techniques for high-z galaxies (e.g., Steidel et al.) rely on rest-frame UV emission. Therefore, in order to obtain a more representative sample of galaxies z =1-5 we would like to select galaxies longward of rest-frame 4000A, i.e., K-band. Based on the Hubble Deep Field, we require photometry from 3600 A to 2.2 microns to determine photometric redshifts in this range. U band and JHK imaging will be by far the most time-consuming aspect of this.

We will do two surveys, as mentioned above.

- Survey 1: 10 square degrees; near-equatorial to be observable from both hemispheres 2-4 Right ascension chunks to be observable all year. The depth goal set by the K band: rest B-band L* galaxies at z=3-4 have $K_{AB}=23.5$. This coverage gives us ~ 100 clusters in a low-Omega universe (velocity dispersion > 450 km/s) beyond redshift 1.

We scale from the JHK HDF survey at the KPNO 4-m (Connolly et al 1997 to a 4-m at a better site (2 magnitudes fainter background, seeing better by factor 1.4), we find we require 8 hour exposure to get 5% photometry at K_AB = 23.5. 1024x1024 chips with 0.3" pixels. This covers 225 square arcminutes.

⇨ 1 square degree in 15 nights on a 4m

⇨ 150 photometric nights in K at a 4meter for 10 square degrees.

Note that it takes a comparable time to do H and J (taken together)

- Survey 2: One square degree to K_AB=25 (5% photometry). This requires 16 times longer per unit area ==> 120 nights for 1/2 sq degree (K only). Given current upper limits on the number density of z > 4 galaxies, this survey could contain up to 3000 galaxy candidates.

(c) Describe the role played by ground-based facilities operating at other wavelengths (e.g. cm- and mm- wave radio telescopes) or by space-based facilities in defining the sample.

Although not necessary for the purposes of this *survey, it would be very interesting to correlate this with surveys carried out with:
(i) The VLA (FIRST, at 20 cm);
(ii) SIRTF (especially in the thermal infrared)
(iii) SCUBA and the upcoming submillimeter arrays

3. Define Required Calibration Observations

List type of observations, numbers of observations, need for simultaneity, etc. List generic instruments and estimate time on "appropriate" telescopes. Are there special software requirements or desirable operations modes/requirements (e.g. ensuring availability of simultaneous observations).

N/A. The observing on the 8-meter is quite straightforward, requiring no need for standard stars, and nothing more than the usual flats and arc calibrations. The astrometry requirements on the parent catalog are quite severe, of course, in order to place slitlets down; with 0.4" slitlets, we need astrometry good to 0.1" or better. This may require (annual?) recalibration of the position of guide stars, if there is an appreciable delay between the photometric survey, and the start of the spectroscopic survey.

4. Define Preparatory Observations

(a) List observations required to determine accurate fluxes, positions, slit position/orientation for targets objects, along with requirements for acquisition, guiding and adaptive optics observations.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes?

N/A.

5. Define Complementary Observations

(a) List observations critical to the program but which could best be carried out on telescopes of smaller aperture.

(b) What instrumentation/telescope configurations are required in order to provide required observations? What are the estimated time requirements? Special software or operations modes? Need for simultaneity with large telescope observations?

See the description of the 4-m imaging survey described above.

6. Define Observations Requiring the Large Telescope

(a) List observations which must be carried out with a large telescope and indicate what characteristics of the large telescope (sensitivity; angular resolution; low emissivity) are required to enable those observations.

(b) What instrument/telescope configurations are required? What are the estimated time requirements? Special software or operations modes?

Addressed with photometric redshifts alone, spectroscopic observations redshifts are absolutely necessary for a number of aspects of this work:

1. Calibrating the photometric redshift relation;
2. Mapping out the detailed topology of the large-scale structures (voids and walls);
3. Measurements of clustering on small scales, including the effects of redshift distortions (from peculiar velocities and cosmology);
4. Measuring spectroscopic properties of the galaxies themselves.

We imagine defining a complete sample over one square degree of objects with photometric redshift $z > 2$ and $K_{AB} < 23$. Estimates from the Hubble deep field are that there are roughly 5 such objects per square arcminute, consistent with the K-band number counts of Gardner et al (1993). We need to select the redshift range in order to keep the number of objects down, and to make sure that spectroscopic features fall into the (relatively narrow) near-IR windows we are exploring.

With a near-IR spectrograph with a 10' field of view, we could observe as many as 60 objects with multi-slits, giving 10" per slitlet. We imagine using tip-tilt, but not full adaptive optics, which of course would be impossible over such a large region. We assume that for bulge-dominated galaxies, we could put most of the light down a 0.4" slit. We would need $R \sim 5000$, to be able to resolve out the OH emission.

We estimate that for an eight-meter class telescope, we could measure spectra good enough for a redshift in roughly 2-3 hours for an L* elliptical at $z = 2.5$, near our photometric limit. With an average of two or three such exposures per night, we could observe 150 objects/night. Thus a survey containing a square degree would require 130 good nights.

2. UK sample scientific programs

Program reference: UK1
Name: Roger Davies
Title: Galaxy Scaling Relations in clusters at intermediate redshift

Summary:
The MOS capability on Gemini is ideally suited to the study of the scaling relations of galaxies in intermediate redshift (z=0.5) clusters imaged by HST. We propose to measure the velocity dispersions of early type galaxies to probe the Faber-Jackson and Fundamental Plane relations in clusters surveyed extensively by HST. We will use measurements of metal absorption lines to investigate the relationship between the kinematics and stellar population that is so tight in local galaxies (e.g. the MgII, sigma relation). Together with measurements of the H beta line strength the metal lines will let us explore the evolution of galaxies in age and metalicity. By observing large and representative samples of galaxies, we will measure the evolution of the early-type galaxy population in rich clusters over the last ~5 Gyrs.

Gemini instrument(s): *Instrument, configuration - slit width, resolution, field, filters*:

GMOS, grating H, R=1000, slit width = 2 times the seeing, say 1"

Approx mag or flux of targets: R=21.5, V=23, B>24 mag.

Required S/N or Photometric accuracy: S/N = 40/ Å

Astrometric accuracy: 0.1"

Spectral range: 5500-8100 Å

Image quality *(FWHM in arcsec):* < 0.7"

Sampling - *spatial and/or spectral*: 0.08"; 1 Å

Field : 5.5'; 20-30 objects per mask
3-4 masks per cluster. Total of 1 night per mask.

Observing Conditions required (*image quality, cloud, water vapour requirements):*

No special requirements

Scheduling Constraints *(Phase of moon, simultaneity, periodicity, external triggers)*: DARK

Any unusual telescope acquisition requirements:
(e.g. blind pointing, stringent guiding precision (e.g. for precise radial velocities))
Requirements for relative co-ordinate of science objects with respect to Gemini guide stars : none other than those required to set up a MOS mask on target (ie. acquire fiducial stars and blind offset)

Required photometric or spectrophotometric calibrations:
(any unusual demands on flat fields etc.)
Wavelength calibration, lamp flat fields (colour balancing filters?),

Observation of zero redshift stars through offset slits: how do we acquire these? Need to observe zero redshift stars trailed diagonally across a long offset slit and raster them across and down the slit.

Supporting Programme(s) on other Telescopes or Satellites

Objectives: (*target selection, complementary or simultaneous observations of an object or sample, calibrations etc.)*

Requires GMOS images > 1 month prior to observing.

B, R, I - band imaging for colours on WHT.

R-band HST images for morphology and radii (many in archive already).

Instruments and configurations
(Fields, Resolutions, Slit Widths, Filters, Wavelength or Frequency)

WHT: 7' FOV, B, V, R-bands.

Telescope aperture

Observing Time

Scheduling relative to Gemini Programme *(e.g. must imaging data be collected and analysed before starting a Gemini spectroscopic programme?)*

Colours and HST images need to be in hand to enable objects for spectroscopic study to be selected.

Magnitude Range, Sensitivity

Supporting ''Facilities'', e.g. Archives, Measuring Machines

Maskmaker.
HST archive.

Program reference: UK2
Name Phil Charles, Astrophysics, Oxford University
Title Accurate Compact Object Masses

Summary:

Determining how neutron stars and black holes form can only come from an accurate knowledge of their masses and other properties. By performing optical spectroscopy and IR photometry of quiescent X-ray transients it is possible to completely solve for the binary system parameters. However, the brightest of these systems are around V=17 and most are much fainter, so large telescopes are required. The current status of mass measurements (essentially the limit of what we can do at present) is summarised in the accompanying figure. Note that this technique could also be applied to old, short period white dwarf binaries whose companions could now be brown dwarfs. These are even fainter and so Gemini observations will be essential to take this further.

Gemini instrument(s): *Instrument, configuration, slit width, resolution, field, filters, etc.*

GMOS, single object, 0.5" slit, R ~5000
NIRI, JHK

Approx mag: R =20-23, K =17-20 mag

Required S/N or Photometric accuracy

Astrometric accuracy: 0.5"

Spectral range: GMOS 0.5-1.0 micron
NIRI 1-2.5micron

Image quality *(FWHM in arcsec):* < 1"

Sampling: GMOS 0.5Å per pixel
NIRI 0.1" per pixel

Field: < 2'

Observing Conditions required *(image quality, cloud, water vapour requirements):*
GMOS <1 " seeing, non-photometric OK
NIRI " "

Scheduling Constraints *(Phase of moon, simultaneity, periodicity, external triggers):*
GMOS dark
NIRI any (need not be simultaneous with GMOS)

Any unusual telescope acquisition requirements:
(*e.g. blind pointing, stringent guiding precision (e.g. for precise radial velocities)*)

Requirements for relative co-ordinate of science objects with respect to Gemini guide stars:

Unusual requirements: crowded field acquisition, high time resolution

Required photometric or spectrophotometric calibrations:
(any unusual demands on flat fields etc)

Supporting Programme(s) on other Telescopes or Satellites

Objectives *: target selection, complementary or simultaneous observations of an object or sample, calibrations etc.*

Supporting programmes:
GRO, XTE transients in outburst, small telescope follow-up for identification.
1-4m telescopes adequate (Robotic Telescopes ideal) for ToO in both northern and southern hemispheres.
Possible that some IR ellipsoidal curves of the brighter objects are achievable with IR cameras on 4m telescopes (but the spectroscopy will definitely require Gemini to get the rotational broadening)

Instruments and configurations
Fields, Resolutions, Slit Widths, Filters, Wavelength or Frequency

Telescope aperture

Observing Time

Program reference: UK3
Name: M.F. Bode,
Astrophysics Research Institute, Liverpool John Moores University
Title: Gemini Spectroscopy of Classical Novae in External Galaxies

Summary:

Classical Novae (CN) are important objects to study in the contexts of mass accretion onto compact objects; the physics of thermonuclear runaways, and dust formation in stellar ejecta. They are also an important distance indicator. It is estimated that there are 30 - 50 CN outbursts in our Galaxy per year. Of these, approximately 3 per year are actually observed and distance determinations for these are fraught with complications.

A core programme of the Liverpool Telescope (LT) currently being considered is the search for, and follow-up of, CN in external galaxies from the Local Group, out to as far as the Virgo Cluster. The primary aims of the programme would be

(i) to provide a much-improved Maximum Magnitude - Rate of Decline (MMRD) relation for use in distance determination;

(ii) to investigate the relationship between galaxy type/stellar population and the type and frequency of CN outbursts, and

(iii) to determine the distribution of speed class for CN down to the very slowest novae. Our scientific objectives are therefore to improve the accuracy with which CN can be used in distance determination, and to increase our understanding of their progenitor systems and the circumstances of their outbursts.

The use of Gemini for spectroscopic follow-up of the CN we initially discover with the LT adds a further valuable dimension to our work. Few extragalactic CN have been observed spectroscopically before. Spectroscopic observations covering approximately 400-700nm with R around 10,000, made within a few days of discovery, will allow us to

(i) confirm the outburst stage of the nova explosion (particularly important if the maximum has been missed);

(ii) (ii) explore the expansion velocity - speed class relation with a large sample of objects in a consistent fashion, and

(iii) (iii) investigate correlations of stellar population/speed class with ejecta abundances. It is currently anticipated that the LT will provide around 1 target per week for spectroscopy. Although spectroscopy could be carried out for the brighter targets on 4m-class telescopes (e.g. WHT) even for these Gemini is preferred because (a) it offers queue-scheduled observing and (b) GMOS is likely to be available on one or other of the Gemini telescopes most of the time.

Gemini instrument(s) *Instrument, configuration - slit width, resolution, field, filters, etc*

GMOS, 0.25 arcsec slit, R approx. 10,000 (5,000 would be the minimum)

Approx. mag or flux of targets 16 < V < 21 mag

Required S/N or Photometric accuracy S/N > 10

0.1 arcsec astrometry (?)

Image quality < 1 arcsec

Sampling - spatial and/or spectral

Field :

Observing Conditions required (*image quality, cloud, water vapour requirement):*

Scheduling Constraint (*Phase of moon, simultaneity, periodicity, external triggers):*
Observations triggered by discoveries on LT. Expect 30-50 targets per year.
Observations within 3 days if possible.

Any unusual telescope acquisition requirements:
(e.g. blind pointing, stringent guiding precision (e.g. for precise radial velocities))

Requirements for relative co-ordinate of science objects with respect to Gemini guide stars
LT CCD discovery images can be supplied to Gemini if required
(FOV of LT CCD will be about 5 arcmin)

Required photometric or spectrophotometric calibrations:
(any unusual demands on flat fields etc)

Supporting Programme(s) on other Telescopes or Satellites

Objectives: *target selection, complementary or simultaneous observations of an object or sample, calibrations etc*

Liverpool Telescope (the search and follow-up programme would take a few hours per week of time on this telescope).

Pipelined images will be provided to Gemini within 1 to 2 days.

NB: This programme has many parallels to other ToO programmes. For example the distant supernova programme of the Berkeley group. The follow-up spectroscopy they require relates to id of the targets as Type Ia. Even more challenging is the gamma-ray burst follow-up where one may only have a few hours advance warning.

Instruments and configurations
Fields, Resolutions, Slit Widths, Filters, Wavelength or Frequency
CCD Imager

Telescope aperture 2.0m

Program reference: UK4
Name: P.F. Roche, Astrophysics, Oxford University
Title: Molecules in the Interstellar Medium

Summary

High spectral resolution, high signal-to-noise ratio observations of heavily obscured objects will allow measurement of absorption band depths, and hence the abundances, of important molecular species lying in and behind molecular clouds. The measurements of column densities along pencil beams through molecular clouds will allow the abundances of different species along sightlines towards both embedded and background objects to be determined. This will lead to greatly-improved estimates of the 3-D structure of the chemistry of cold materials to be developed. Lower resolution observations will quantify the absorption from species condensed in icy mantles and in dust cores. Comparison of abundance variations (e.g. of CO, SiO, CH_4, NH_3 etc relative to H_2) along sightlines with very different amounts of volatile material in the condensed phase, will provide constraints on the composition of the ices.

Many of the absorption bands, and particularly those of H_2, are very weak. Indeed H_2 absorption has only recently been detected towards NGC 2024 with an optical depth estimated at 0.16 at the line centre (and a line width of 1 km s^{-1}). The extinction towards this source is estimated at A_V ~ 21 mag. Phoenix and Michelle on Gemini will have the sensitivity and resolution to measure many transitions towards a large number of obscured objects. The Serpens, Chamaeleon, Corona Australis clouds contain a substantial number of bright compact YSOs which are suitable targets for a detailed studies of nearby star-forming regions.

Gemini instrument(s): *Instrument, configuration - slit width, resolution, field, filters :*

Phoenix R= 100,000. 2 µm < lambda < 5 µm
Michelle R=~30,000
usually single objects

Approx mag K= < 10-12 mag
Estimate a S/N ratio of ~100 in 1~hr for K= 12mag; implies 1-3 hr per H_2 line, a few minutes for CO.
Total of about 3--4 hr/object with Phoenix + similar time with Michelle.
Need 10 nights for a reasonable first sample.

Required S/N or Photometric accuracy
Need S/N of up to 1000 for high resolution detections of H_2 (source-noise limited)
S/N ~100 for low resolution observations

Astrometric accuracy
Need to be able to peak up accurately in narrow slits at high spectral resolution.

Image quality *(FWHM in arcsec)*
Flux down slit is critical: slit width =0.17 arcsec for R=100,000
Need to be competitive against 4-m telescopes with 0.3 arcsec slit implies LGS AO in dark clouds

Observing Conditions required (*image quality, cloud, water vapour requirement):*

Low water for some observations; may need scheduling to avoid telluric lines.

Any unusual telescope acquisition requirements: *(e.g. blind pointing, stringent guiding precision (e.g. for precise radial velocities))*
In Dark Clouds

Required photometric or spectrophotometric calibrations:
(any unusual demands on flat fields etc)
Precise flat-fields and very high S/N standard star spectra. Probably more than one standard star per science observation to eliminate photospheric contamination of IS lines.

Supporting Programme(s) on other Telescopes or Satellites

Objectives : *target selection, complementary or simultaneous observations of an object or sample, calibrations etc*

Some targets picked up from 2MASS, Denis etc., but want compact star-forming regions, so images over a few armin suffice. Do not need to go very deep.Say K of 16, but will be fainter at J,H (+ HST ?). Would like to identify binary pairs for detailed study.

Low spectral resolution studies possible on smaller telescopes. Studies of ice and dust bands, and perhaps some molecular species.

Instruments and configurations
Fields, Resolutions, Slit Widths, Filters, Wavelength or Frequency

R ~1000, 2μm < lambda < 20 μm spectroscopy
Broad band photometry from surveys, dedicated fields.

Telescope aperture: 4-m (probably limited by instruments) - not currently available in the south for thermal IR spectra.

Observing Time: Few nights imaging for target selection; complementary spectroscopy will take less time than Gemini observations.
Estimate total of 1 night on a 4-m per Gemini night.

Scheduling relative to Gemini Programme
Essential that images are taken first for target selection, not necessary generally for spectroscopy, though it may be helpful for improved target selection

Magnitude Range Same as for Gemini programme

Supporting "Facilities", *e.g. Archives, Measuring Machines*

2MASS, Denis, HST, other IR imaging surveys

Program reference: UK5
Name: I.A. Crawford ,
Dept Physics & Astronomy, University College London
Title: The age of the Galaxy from abundances in Halo stars.

Summary

The ages of metal-poor halo stars can be determined by measuring the abundance of Thorium relative to other (stable) r-process elements. Cowan et al (ApJ 480, 246. 1997) obtained an age of 17 ±4 Gyr for one 13th mag star at R=20,000 S/N ratio ~70 with an integration of about 7.5 hr. HROS on Gemini will allow higher resolution, higher S/N observations of many more halo objects. The higher quality spectra will be especially important in resolving blends and measuring weaker Thorium lines (Cowan et al used only the strongest 4019Å line). The wide simultaneous wavelength coverage of HROS will provide measurements of many other rare r-process elements

Gemini instrument(s): *Instrument configuration* **-** *slit width, resolution, field, filters, etc*

HROS

Approx mag of targets V= 14-15 mag

Required S/N ~100-200
Integration times:(S/N =150) U= 13-15mag = 0.5 to 3.5hr

Image quality *(FWHM in arcsec*)

Sampling - *spatial and/or spectral*

Sample of about 10 objects (3 Nights)

Observing Conditions required *(image quality, cloud, water vapour requirements)*

Scheduling Constraints

Any unusual telescope acquisition requirements:

Required photometric or spectrophotometric calibrations:}
any unusual demands on flat fields etc

Supporting Programme(s) on other Telescopes or Satellites

Objectives: target selection, complementary or simultaneous observations of an object or sample, calibrations etc

Surveys of candidate low-metallicity halo stars conducted at lower resolution with 4-m class telescopes (e.g. Beers et al, Ryan et al)

Instruments and configurations
Fields, Resolutions, Slit Widths, Filters, Wavelength or Frequency

Program reference: UK6
Name: Richard McMahon, Institute of Astronomy, Cambridge
Title: The Star Formation History and growth of LSS in the Universe at z>4

Summary:

We propose to derive the star formation rate at z>4 by searching for emission line galaxies using narrow band filters that have been carefully located in regions where OH emission is weak. In fact in these regions beyond 7000Å, the sky continuum is as dark as it is in the wavelength range 4000-5000Å. We aim to detect galaxies with star formation rates down to 1 Solar Mass per year independent of their continuum magnitude.

(see Hu & McMahon, Nature, 382, 231, 1996 for background)

The aim is go deeper than one can do in pure broad band redshift surveys.

This is potentially a long-term program that will evolve in a number of ways:
(i) higher redshift
(ii) lower redshift
(iii) lower fluxes
(iv) larger areas
(v) NIR wavebands for survey
(vii) Large scale structure

There will also be follow-up studies

(i) GMOS spectroscopy for confirmation and dynamics
(ii) Dynamics of individual galaxies
(iii) HST and AO for morphologies

In the first phase we propose to image 2 5min x 5min regions with Gemini i.e. 1 per semester.
The target star formation rate is 1 Solar Mass per year. This corresponds to a 5 sigma line flux limit of 10^{-17} erg cm^{-2} s^{-1}. This will require 10hrs on sky per field at three redshifts

60hrs on-sky on Gemini.

Alternatively, 2-4hrs per field and we study more fields.

Instrument: GMOS with narrow band filters

1% filters at 6750Å, 8200Å and 9250Å corresponding to Lyman-alpha redshifts of 4.55, 5.74 and 6.61.

Sub-arcsecond image quality is required since the faintest objects are likely to be small. Ideally one field would be done in best seeing. High redshift galaxies are highly likely to consist of sub-galactic sub-units e.g. say collapsing disks 5-10" in extent with Orion-like HII regions that last 10^7 years that are each 0.2" in extent.

Grey time may be OK at the longest wavelengths.

It would make planning of such observations better if there was a program that allowed one to compute the Sky Brightness between the OH lines as a function of lunar phase and distance from the moon.

Supporting Program

The highest redshift galaxies will be selected on the basis of the Lyman-alpha emission line. However, there are various other emission lines from lower redshift galaxies that will be detected and we will need to eliminate these objects on the basis of their broad band colours. Spectroscopy is inefficient.

Need broad band imaging in 4 bands VRIz

8hrs per field per band on a 4m

WHT with 2048x2048 array is sufficient. 4086^2 would be needed for the longer term plan to extend the field of view and do the evolution of LSS.

target limits:
V=27.5 (5sigma)
R=26.0 (10sigma)
I=25.0 (10sigma)
z=25.0 (10sigma) (RG850+open CCD)
[J=24.0 (10sigma) for highest redshift selection in longer term]

8hrs per band on WHT.

Therefore 40 hours/field =>10nights allowing time for bad weather and overheads

If WHT nights were allocated in 1/2 nights we would only study one field per semester. We need fields in two semesters so that project can generate science at a steady rate.

Some sharing of broadband data would be possible.

Program reference: UK7

Name Mike Edmunds, University of Wales, Cardiff

Title Surface features and environment of bright stars

Scientific aims:

Monitoring of surface features of bright stars (e.g. Betelgeuse) exploiting the 8m resolution of Gemini, and looking for local environment changes (e.g. dust formation)

Instrumentation:

(i) Private fast CCD camera for bispectrum and non-redundant masking image reconstruction;
Access to narrow-band filters (e.g. Hα)

(ii) (Environs) Natural guide-star AO with coronagraph plus imager
(IR initially (1 to 20 microns all interesting!, later optical when available)

Observing time required:

(i) Regular (e.g. weekly or fortnightly) period of 30 minutes to do targets and standards
(ii) Intensive campaign of 2 x1/2 night, then 1/2 hour per month

? (i) Could be overtaken by interferometers?

Supporting Observations

(i) Needed within 2 weeks of Gemini time

a) High resolution spectroscopy
b) ? UV spectroscopy ? and UV imaging useful HST, NGST
c) Radio continuum
d) Infrared and visual photometry

(ii)

a) IR mapping photometry with AO on smaller telescope
b) 11 micron interferometry?

Program reference: UK8

Name Mike Edmunds, University of Wales, Cardiff

Title Chemistry of Evolving Galaxies

Scientific aims:

Chemical composition, particularly gradients, from analysis of HII spectra in galaxies.

Argument:

Can analyse individual giant HII (size 200-300pc) regions if just resolved.

If galaxies at redshift ~ 3, the important lines for the "strong-line" diagnostic method of HII region abundance determination ([OII] 3727Å, [OIII] 5007, Hβ can move into H and K spectral regions. So look at z~3 galaxies with integral-field IR spectrograph (spectral resolution of ~ 500 to 1000) and laser AO. Spatial resolution would be around size of giant HII region, or starburst areas of galaxies. Line fluxes would be down on current optical observation of nearby galaxies because of

(i) IR not as sensitive due to thermal emission, atmospheric lines and detectors

(ii) cosmic dimming

BUT up because of

(i) efficient 8m telescope and

(ii) fluxes stronger from starburst regions.

Spectral observations of Lyman-break galaxies with UKIRT (M. Pettini, private communication) indicate fluxes will be sufficient. Integral field unit will be well matched to size of galaxy, so just "point-and-go" - no need for detailed positional information on the individual HII regions.

Science: Observations of chemical abundances and gradients at a fraction of the age of well-studied nearby galaxies. Heavy-element and star-formation history.

Observing Time Required:

A few hours for each galaxy. Initial sample of ten suggested, after proving the technique on one. But project could extend to all types of early galaxies found in surveys, provided they show emission regions.

Supporting Observations:

Discovery of suitable target galaxies (need suitable redshift)- will come from current work on finding Lyman-break galaxies.

3. Canadian sample scientific programs

Program reference: Can1
P.I.: Jaymie Matthews (UBC)
Title: Searching For Undetected Protostellar Companions To Late-B Rosat X-Ray Sources

Summary

The ROSAT all-sky survey has revealed high X-ray fluxes (up to 10^{31} erg s^{-1}) in 68 B7 - B9 dwarfs which should be devoid of X-rays according to earlier surveys and most plausible emission mechanisms. Of the sample, 17 are visual binaries, 26 are spectroscopic binaries (SB) and 23 are velocity variables; however, in only a few cases can the X-ray emission be ascribed to the known secondary or any cold dwarf in the system. The most likely culprit is a third companion: a cool active pre-main-sequence star lurking undetected photometrically or spectroscopically. We propose to search for such close companions directly; NIRI will allow us to detect companions as close as 0.05 arcsec (corresponding to orbital separations as small as 2-3 AU for the closest candidates).

As a follow-up for those systems with positive detections, NIRS could be used in queue mode to obtain velocity curves to determine masses and look at spectral indicators of coronal and chromospheric activity.

Gemini instrument: NIRI + GAOS, NIRS + GAOS (6 nights)

Gemini requirements:

Requirements for absolute astrometry: 0.1 arcsec

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: 0.1 arcsec for NIRS

Requirement for relative co-ordinate of science objects with respect to Gemini guide stars: the science objects are the AO guide stars!

Required photometric or spectrophotometric calibrations : Calibrated JHK fluxes should yield spectral types and angular diameters to confirm the PMS nature of the X-ray source.

Supporting Program

Title: JHK survey of ROSAT X-ray sources

Objectives: This survey will search for possible companions with separations of 0.2 - 1 arcsec.

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}): K~9-10

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} arcsec^{-2}):

Photometric accuracy: 0.1 in K

Astrometric accuracy: Bright B primary will be used for pointing; no need for astrometry

Spectral range, band: JHK

Image quality (FWHM in arcsec): 0.15 arcsec

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R): 0.02 arcsec/pix

Field (total or individual (e.g. deg, arcmin, arcsec)): 5 arcsec/field

Supporting 'Facilities', Archives

Existing: ROSAT archive; CFHT + AOB + KIR - 6 nights

Planned:

Desired:

Program reference: Can2
P.I.: Simon Morris (HIA-NRC)
Title: Velocity Dispersions in the Core of Elliptical Galaxies

Summary

We propose to measure stellar velocity dispersions in the core of elliptical galaxies with the highest spatial resolution achievable in order to derive reliable Black Hole masses. We note that "cuspy" profiles, although they are indicative, do not mean the existence of a central massive black hole; also gas dynamics is not as reliable as stellar dynamics.

Gemini instrument: NIRS + IFU + GAOS (4 nights)

Gemini requirements: If with IFU, astrometry requirements are minimal; if long slit, one wants slit width ~< 0.1 arcsec. Once on slit, we also need ability to offset by 1 slit width with an accuracy to 1/10 of a slit width, i.e. ~<0.01 arcsec!

Requirements for absolute astrometry: 0.1 arcsec

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: 0.01 arcsec

Requirement for relative co-ordinate of science objects with respect to Gemini guide stars:

Required photometric or spectrophotometric calibrations : Metal rich G-K giants for X-correlation. Hot stars (WD or O stars) for calibration of atmospheric bands. Velocity dispersion standard galaxies to check measurements.

Supporting Program

Title: CFHT OSIS or HST archive of Elliptical galaxies to check for "cuspiness"

Objectives: In order to choose targets, we will do CFHT SIS imaging or search HST archive for cuspy nuclei. We will also search the USNO catalog and Skycat for guide stars (AOWFS or OIWFS). We will use the data base of ROSAT and VLA surveys. Multicolour photometry would be conducted with CFHT.

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}):

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} $arcsec^{-2}$): ~22 per $arcsec^2$

Photometric accuracy: 0.1 mag

Astrometric accuracy: 0.1 arcsec

Spectral range, band: I (+K if available)

Image quality (FWHM in arcsec): 0.3 arcsec

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R): 0.05 arcsec

Field (total or individual (e.g. deg, arcmin, arcsec)): 5 arcmin/field

Supporting 'Facilities', Archives

Existing: CFHT-OSIS, HST-WFPC2 and HST archive at CADC - 2 nights

Planned:

Desired:

Program reference: Can3
P.I.: Jean-Rene Roy, Laurent Drissen (U Laval), Francois Legrand (IAP)
Title: Wolf-Rayet Stars in Galaxies - The Case of I Zw 18

Summary

Legrand et al. (1997) have found the presence of WR stars in the metal-poor galaxy I Zw 18 (D ~ 10 Mpc; m - M = 30) from a 15 hour exposure longslit spectrum (CFHT). WR range typically -3.5 ≤ M ≤ -7.5, but the I Zw 18 WR appear to be of WC type, i.e. M ~ -3.5. Observed in their emission line, WR in I Zw 18 would be about m ~ 23. The binary channel helps to account for the presence of WC stars in a 1/40th solar Z environment.

Gemini Observations: Measure spectroscopically (R ≥ 3,000) periodicity (from several days to a few weeks) in the position of the WR emission bump. Better the astrometry will be the smaller the slit will be to reduce galaxy stellar background and improve S/N and velocity resolution.

Gemini instrument: GMOS (IFU would make observation less risky if astrometry was “poor”). (2 nights)

Gemini requirements:

Requirements for absolute astrometry: 0.1 arcsec

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: 0.01 arcsec for wavelength stability

Requirement for relative co-ordinate of science objects with respect to Gemini guide stars: 0.1 arcsec

Required photometric or spectrophotometric calibrations: standard

Supporting Program

Title: Broad and narrow band imaging at 4686 Å of nearby star-forming galaxies

Objectives: Positions of WR could be obtained from deep λ4686 Å on- and off-band imaging with HST-WFPC2, or with a fine scale imager on a 4-m class telescope at an excellent site in both hemispheres. The full project would involve a WR imaging survey of a large number of nearby star-forming galaxies (D ≤ 10 Mpc) encompassing a range of metallicities from a few times solar (e.g. center of M 31) down to 1/50th solar (e.g. I Zw 18).

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}): V=24

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} $arcsec^{-2}$):

Photometric accuracy: 0.2

Astrometric accuracy: 0.1 arcsec

Spectral range, band: Redshifted λ4686 Å, Δλ 30 Å, and adjacent continuum Δλ = 100 Å

Image quality (FWHM in arcsec): 0.5 arcsec

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R): 0.2 arcsec/pix, 30 Å

Field (total or individual (e.g. deg, arcmin, arcsec)): 2-10 arcmin/field

Supporting 'Facilities', Archives

Existing: HST archive, CFHT mosaic CCD imaging - 6 nights

Planned:

Desired: Large narrow band filter mosaics appropriate for the on- and off-band imaging

Program reference: Can4
P.I.: Michael West (St Marys' University)
Title: Search for Intergalactic Globular Clusters

Summary

We propose to obtain deep infrared observations of the cores or rich clusters of galaxies in the redshift range z = 0.02 to 0.06 in order to search for an expected population of intergalactic globular clusters (IGCs) which are not bound to any individual galaxy. We choose clusters in which the brightest member galaxy is significantly offset from the X-ray centroid, as we expect the IGCs to trace the same dark matter distribution traced by the hot H-ray gas, and thus their distribution should peak around the X-ray centroid. We require that the brightest member galaxy be offset from this location so that its intrinsic globular cluster population will not be confused with the IGCs that we are searching for. Gemini will allow us to observe more distant clusters than are feasible with CFHT, which to date has limited number of good candidates.

Note: at z = 0.06, 1 arcmin corresponds roughly to 50 h^{-1} kpc.

Gemini instrument: NIRI (1 nights)

Gemini requirements:

Requirements for absolute astrometry: minimal

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: minimal

Requirement for relative co-ordinate of science objects with respect to Gemini guide stars: minimal

Required photometric or spectrophotometric calibrations: reach K ~ 23±0.2; control of contamination by distant galaxies or foreground stars

Supporting Program

Title: X-ray imaging of galaxy clusters

Objectives: Provide a selected sample of rich galaxy clusters for imaging in the near-infrared. The selection will be based on the X-ray luminosities of the clusters.

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}):

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} arcsec^{-2}):

Photometric accuracy:

Astrometric accuracy:

Spectral range, band:

Image quality (FWHM in arcsec):

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R):

Field (total or individual (e.g. deg, arcmin, arcsec)):

Supporting 'Facilities', Archives

Existing: Existing Einstein and ROSAT archival data

Planned:

Desired: Future X-ray satellites

Program reference: Can5
P.I.: Jean-Rene Roy, Laurent Drissen (U Laval)
Title: Youngest and Most Massive Stars & Dust Embedded Super Star Clusters

Summary

The lifetime of the most massive stars is so short that many may never be observable at optical wavelengths. Super stellar clusters are generally not visible in their earliest stage. SSCs are about 1-2 pc in size, i.e. ≤ 0.1 arcsec at $D \geq 3$ Mpc. The presence of dust-hidden massive clusters is implied by infrared observations of several nearby small starburst galaxies (e.g. NGC 5253, NGC 2366).

New spectroscopic diagnostics now exist to identify and classify their massive star content using infrared spectra (cf. Morris et al.). Signatures of WNL, Of, Be and LBV stars are now well-known.

Gemini Observations: H and K infrared spectroscopy ($R \geq 1000$) to search for broad H I, He I, He II and N III features associated with the massive winds of massive pre-WR stars.

Gemini instrument: NIRS (with an IFU), NIRI, MICHELLE, MIRI (2 nights)

Gemini requirements:

Requirements for absolute astrometry: 0.1 arcsec

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: 0.3 arcsec

Requirement for relative co-ordinate of science objects with respect to Gemini guide stars: 0.1 arcsec

Required photometric or spectrophotometric calibrations: standard

Supporting Program

Title: Near-IR imaging of nearby star forming galaxies

Objectives: Near-infrared JHK imaging with good spatial resolution (sampling at 0.2 arcsec) of a large number of nearby starbursts and IRAS sources. The sample should include about 20 objects over a range of metallicity, e.g. from I Zw 18 to NGC 2403. NICMOS on HST will provide a *small* sample of such objects because of the limited lifetime of the instrument. The enlarged project could include optical BVRI imaging of the same set of starbursts. The color-color BHK diagram is quite powerful in disentangling the age sequence of the various super stellar clusters of any given starburst.

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}): K=16

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} arcsec^{-2}):

Photometric accuracy:

Astrometric accuracy: 0.1 arcsec

Spectral range, band: J, H and K

Image quality (FWHM in arcsec): 0.3 arcsec

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R):

Field (total or individual (e.g. deg, arcmin, arcsec)): ≥3 arcmin/field

Supporting 'Facilities', Archives

Existing: 2MASS survey will enable identification of K ≤ 14 centers of starbursts; HST-NICMOS archive; CFHT + KIR - 6 nights

Planned: 2.5m IR imaging telescope (USA?)

Desired:

Program reference: Can6
P.I.: Michael West (St Marys)
Title: The Cluster Environment of a $Z = 2$ QSO Triplet

Summary

We propose to obtain deep infrared observations of a very unusual cluster of quasars at $z = 2$. Hoag 1, 2, 3 are three QSO's which have very similar redshifts (z = 2.048, 2.054, 2.040) and projected separations less than 200 arcsec, corresponding to physical separations less than ~ 1 - 2 h^{-1} Mpc from each other, and velocity differences less than 1000 km/s. This unique group of QSOs (the only known genuine triplet with such small projected separations) is thus an excellent candidate for a very high redshift rich cluster of galaxies. We aim to identify the cluster galaxies based on their near-IR colours. The existence of an extremely rich cluster at this redshift would pose strong cosmological constraints.

We will need to image a field of ~16 arcmin^2 with Gemini-NIRI.

Gemini instrument: NIRI (4 nights)

Gemini requirements:

Limiting magnitude 22-23 in each of J, H and K with $\pm$ few tenths.

Requirements for absolute astrometry: minimal

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: minimal

Requirement for relative co-ordinate of science objects with respect to Gemini guide stars: minimal

Required photometric or spectrophotometric calibrations: standard JHK

Supporting Program

Title: Multi-wavelength database on Hoag 1,2,3

Objectives: Establish a database ranging from X-ray, through UBVRI to mm domain of the QSO group.

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}):

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} arcsec^{-2}):

Photometric accuracy:

Astrometric accuracy:

Spectral range, band: X-ray, UBVRI, mm

Image quality (FWHM in arcsec):

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R):

Field (total or individual (e.g. deg, arcmin, arcsec)): ≤ 10 arcmin

Supporting 'Facilities', Archives

ROSAT archive will be searched for associated X-ray emission, but owing to high redshift of this QSO triplet, it is unlikely anything will be found. Complementary JCMT and CFHT observations are planned.

Existing: ROSAT archive; CFHT, JCMT - 3 nights on each telescope

Planned:

Desired:

Program reference: Can7
P.I.: David Hanes (Queen's University)
Title: The Formation of Elliptical Galaxies

Summary

We will carry out moderate-dispersion multi-object spectroscopy on samples of hundreds of globular clusters around elliptical galaxies in varied environments (Virgo core, Virgo wing, field). Positional and dynamical information (velocities) will be correlated with age/metallicity measurements determined spectroscopically, as we determine the formation/merger history of the target elliptical galaxies and the continuing dynamical importance of dark halos.

Gemini instrument: GMOS (6 nights)

Gemini requirements:

Requirements for absolute astrometry: minimal

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: 0.1 arcsec

Requirement for relative co-ordinate of science objects with respect to Gemini guide stars: 0.1 arcsec

Required photometric or spectrophotometric calibrations: usual GMOS calibrations

Supporting Program

Title: Broad-imaging of elliptical galaxies in clusters

Objectives: Large CCD mosaic imaging in broadband (B, I) will be used to define ''clean" samples of galaxies: image structure weeds out remote galaxies, as does colour, cut likewise many foreground stars. Astrometry could be used to pre-define GMOS masks.

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}): B=23

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} $arcsec^{-2}$):

Photometric accuracy: ±0.07

Astrometric accuracy: not critical if GMOS masks are made from Gemini images

Spectral range, band: B, I

Image quality (FWHM in arcsec): ≤ 0.6 arcsec

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R): 0.2 arcsec

Field (total or individual (e.g. deg, arcmin, arcsec)): ~1deg in Virgo
Supporting 'Facilities', Archives

Existing: ROSAT X-ray imaging to derive galaxy/cluster masses; CFHT + Megacam - 6 nights

Planned:

Desired:

Program reference: Can8
P.I.: Nicole St-Louis (U Montréal)
Title: Hot Massive Stars in Clusters

Summary

We propose to obtain spectroscopy of the brightest members of several clusters in the nearby galaxy M33 which contain a Ofpe/WN9 star in order to search for evolutionary links between the various types of massives stars. This would allow us to determine if these transition objects come from very massive stars (≥ 60 Msun) or lower mass stars (~ 30 Msun) or both.

Gemini instrument: GMOS (+ GAOS?) (2 nights)

Gemini requirements:

Requirements for absolute astrometry: 0.05 arcsec

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: 0.02 arcsec

Requirement for relative co-ordinates of science objects with respect to Gemini guide stars:

Required photometric or spectrophotometric calibrations: standard

Supporting Program

Title: UBV and/or JHK imaging of star clusters in M33

Objectives: We wish to obtain high spatial resolution photometry of M33 star clusters containing aOfpe/WN9 star to clearly identify the individual brightest stars for follow-up spectroscopy with Gemini-GMOS.

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}): B~20

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} arcsec^{-2}):

Photometric accuracy:

Astrometric accuracy:

Spectral range, band: UBV and JHK

Image quality (FWHM in arcsec): 0.1 arcsec

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R): 0.05 arcsec/pix

Field (total or individual (e.g. deg, arcmin, arcsec)): ≥ 20 arcsec/field

Supporting ‘Facilities’, Archives

Existing: CFHT + AOB with KIR - 4 nights

Planned:

Desired: AOB on CFHT operating as far into the optical domain as possible

Program reference: Can9
P.I.: Jean-Rene Roy and Daniel Friedli (Universite Laval)
Title: Searching for the First Barred Galaxies

Summary

The Hubble Deep Field shows a dearth of barred galaxies which constitute in the present-day universe ~2/3 of the morphological types among disc galaxies. This dichotomy may result from the difficulty of applying galaxy classification to the distant universe imaged in the standard photometric bands, or to a real lack of bars because the discs are too young. The timescale of bar formation is only a few 10^8 years, and bars can develop at later stages of galaxy evolution. We propose to use the Gemini optical and infrared optical spectrograph GMOS-IFU and NIRS-IFU to map key nebular lines across the disc of high redshift galaxies in order to derive reddening, excitation and abundance distributions. Young barred galaxies should show strong massive star formation in the bar. Furthermore the presence of young bars should be betrayed by two breaks in the radial O/H abundance distribution: the 1st break located near corotation, and the second break in the outer disc, with a rather flat abundance distribution between. The galactocentric distance of the second break and the amplitude of the azimuthal O/H abundance fluctuations would allow to date the age the bars.

Gemini instrument: GMOS+IFU, NIRS+IFU \& GAOS (4 nights)

Gemini requirements:

Requirements for absolute astrometry: 0.3 arcsec

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: 0.1 arcsec

Requirement for relative co-ordinate of science objects with respect to Gemini guide stars: 0.1 arcsec

Required photometric or spectrophotometric calibrations: spectrophotometric standards for IJHK spectroscopy

Supporting Program

Title: Deep optical and infrared imaging of high redshift disc galaxies

Objectives: In order to do spectroscopic mapping of high redshift galaxies, we need to assemble a sample of disc galaxies, seen relatively face-on ($i \leq 45$deg), at a range of redshifts $z \geq 1$ to probe bar formation and evolution over a time span of several 10^9 years. We believe that existing deep images (HST, CFHT, and Keck) provide a sufficient data base for this project.

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}):

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} arcsec^{-2}):

Photometric accuracy:

Astrometric accuracy: 0.2 arcsec

Spectral range, band: UBVRIJHK

Image quality (FWHM in arcsec): ≤ 0.3 arcsec

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R): 0.1 arcsec/pix

Field (total or individual (e.g. deg, arcmin, arcsec)): 3 arcmin/field

Supporting 'Facilities', Archives

Existing: HST archive, Keck archive and CFHT deep imaging (perhaps?) or archive

Planned:

Desired: JHK spectrophotometric standards

Program reference: Can10
P.I.: W. E. Harris (McMaster)
Title: The Age of the Galaxy

Summary

The very oldest structures in the Milky Way are probably the metal-poor globular clusters in the Galactic bulge. As yet, we do not have high quality age measurements for even a single one of these clusters. All of these clusters have large foreground reddenings and heavy contamination by bulge field stars. The one and only way to minimize these severe difficulties is to obtain photometry of the cluster stars in the near-IR, under the highest quality imaging conditions possible. We will use Gemini North with NIRI to obtain high quality, deep main sequence photometry (K = 21) for 10-12 clusters.

Gemini instrument: NIRI (4 nights)

Gemini requirements:

Requirements for absolute astrometry: minimal

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: 0.1 arcsec

Requirement for relative co-ordinate of science objects with respect to Gemini guide stars:

Required photometric or spectrophotometric calibrations: flux standardization to J, K system

Supporting Program

Title: Theoretical isochrone development, and V, V - I photometry of bulge globular clusters

Objectives: We propose to conduct in parallel a theoretical program for isochrone development of old star clusters in the K, J-K plane (for the Gemini NIRI) observations, and an observational program for V, V - I photometry of the same target clusters, e.g. CTIO and CFHT.

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}):

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} $arcsec^{-2}$):

Photometric accuracy:

Astrometric accuracy:

Spectral range, band: V, I

Image quality (FWHM in arcsec): 0.3 arcsec

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R): 0.05 arcsec/pix

Field (total or individual (e.g. deg, arcmin, arcsec)): 5 arcmin/field

Supporting 'Facilities', Archives

Existing: CTIO 4m, CFHT - 15 nights

Planned:

Desired:

Program reference: Can11
P.I.: Jean—Rene Roy, Daniel Friedli (U Laval), P. Martin (CFHT)
Title: The Chemistry of the Outer Discs of Galaxies

Summary

Do outer regions of discs obey the relationship between metallicity and stellar surface brightness as in the inner disc?

- Regions of interest: between R_{25} and $R_{Holmberg}$ of nearby disk galaxies
- Probe star formation history in low gas surface density and high gas fraction environment (≡ early stages of galaxy evolution)
- Determine gas-phase element abundances for O, N, S, Ne, and Ar from direct measurements of electron temperature based on detections of [OIII]λ4363, [SIII]λ6312, and [OII]λ7320-30
- Compare with damped Lyman α systems

Gemini instrument: GMOS (5 nights)

Gemini requirements:

Nebular optical spectroscopy 3727 - 10,000 Å at R ~2000

Requirements for absolute astrometry: 0.25 arcsec

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: 0.5 arcsec

Requirement for relative co-ordinates of science objects with respect to Gemini guide stars: 0.5 arcsec (objects are fuzzy and extended)

Required photometric or spectrophotometric calibrations: 10^{-17} erg cm^{-2} s^{-1}

Supporting Program

Title: Deep narrow-band Hα imaging of nearby disc galaxies

Objectives: Identification and astrometry of faint outer HII regions should be obtained from deep wide field Hα imaging. The full project would involve a Hα imaging survey of several large nearby disk galaxies (D ≤ 10 Mpc) corresponding to a range of morphological type (2 galaxies per type Sd, Sc, Sb, Sa, S0) with well-mapped HI discs. We will have one sample of field galaxies and one sample of cluster galaxies, i.e. 20 galaxies in total.

Requirements:

Large-field fast imager (both hemispheres) for precise narrow-band imaging spectrophotometry in optical nebular lines (≡ OMM + PANORAMIX).

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}): $0.3*10^{-17}$ erg cm^{-2} s^{-1}

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} arcsec^{-2}): 10^{-17} erg cm^{-2} s^{-1}

Photometric accuracy: 50% on the faintest regions

Astrometric accuracy: 0.2 arcsec

Spectral range, band: Redshifted Hα, $\Delta\lambda$ 10-30Å

Image quality (FWHM in arcsec): 1-2 arcsec

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R): $\leq$ 1 arcsec, 10Å

Field (total or individual (e.g. deg, arcmin, arcsec)): 10-20 arcmin/field

Supporting 'Facilities', Archives

Existing: OMM + PANORAMIX - 15 nights , CFHT-MOS - 6 nights

Planned: ?

Desired: Large field focal reducer on a 2m telescope in the southern hemisphere

Program reference: Can12
P.I.: T. J. Davidge (HIA)
Title: Probing the Stellar Content and Evolutionary Histories of the Central Regions of Nearby Galaxies

Summary

The central regions of nearby galaxies provide an important fossil record for charting the evolution of these systems. Indeed, because the central regions of galaxies lie at the bottoms of deep potential wells, they are likely locations for star formation induced by, say, interactions with neighboring large systems, the accretion of smaller satellites, or radial gas flows. In order to probe the star-formation and chemical enrichment histories of galaxy centers it is necessary to obtain spectra and broad-band colours for individual stars, and this task is greatly complicated by crowding. Moreover, data at near-infrared wavelengths are required to (1)
overcome the effects of line blanketing, which distort the spectral-energy distributions of super metal-rich stars at optical wavelengths, and (2) make direct comparisons with the Galactic Center, which can only be observed at wavelengths longward of 1μm. With an angular resolution of only 0.2 arcsec in *K*, the HST + NICMOS will not be able to resolve individual stars in the central regions of nearby galaxies, and an 8 metre aperture is essential to achieve the 0.1 arcsec angular resolution required to probe the most crowded, and also most lucrative in terms of galaxy evolution, environments. The Gemini telescopes, combined with NIRI, NIRS + IFU, and GAOS, provide unique platforms for conducting near-infrared photometric and spectroscopic surveys of the central regions of nearby galaxies.

Gemini instrument: NIRI, NIRS + IFU (Note: need IFU to do crowded field spectroscopy), GAOS (5 nights)

Gemini requirements:

Requirements for absolute astrometry: The astrometry would be done with respect to the galaxy centers, the locations of which should be known to ~0.01 arcsec

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: Blind pointing is not an issue, as snap shots would be taken to position galaxy centers on the detector. Guiding must be such that the telescope diffraction limit is not degraded by more than ~10%.

Requirement for relative co-ordinate of science objects with respect to Gemini guide stars: None

Required photometric or spectrophotometric calibrations: Nothing special - an uncertainty in the photometric zeropoint of ~0.01 mag is acceptable. Crowding will likely cause the photometric errors to be much larger than those in the zeropoint.

Supporting Program

Title: I. A Wide-Field Near-Infrared Survey of the Bulges of Nearby Galaxies; II. The Far-Infrared Properties of the Bulges of Nearby Galaxies

Objectives: I. Compare the photometric properties of stars near the centres of nearby galaxies with those seen at larger radii, and thereby place constraints on the collapse histories of these systems. This could be done with a 4 metre telescope, such as CFHT. II. Search for signs of active star formation or potential star-forming material by surveying these systems at sub-mm wavelengths. This would be done with JCMT + SCUBA.

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}): K ~ 20 - 21 (i.e. one - two mag below the RGB-tip for Local Group systems; RGB-tip for Sculptor Group systems.

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} $arcsec^{-2}$): K ~ 22 - 23

Photometric accuracy: ~ 0.01 - 0.02 mag in K

Astrometric accuracy: 0.01 arcsec , measured with respect to the galaxy nuclei.

Spectral range, band: JHK; 0.3 - 1.0 mm for JCMT

Image quality (FWHM in arcsec): A more relevant statistic is the Strehl ratio, for which will require ~0.2 or better

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R): 0.02 arcsec/pixel; R ~ 1000 for IR spectra

Field (total or individual (e.g. deg, arcmin, arcsec)): ≥ 10 arcsec

Supporting 'Facilities', Archives

Existing: CFHT, JCMT, CADC (for HST optical data) - 4 nights

Planned:

Desired: Southern hemisphere mm telescope.

Program reference: Can13
P.I.: T. J. Davidge (DAO)
Title: The Chemical Evolution of the Halos of Nearby Galaxies

Summary

Galactic halos contain some of the oldest stars in galaxies, and hence provide a means of probing the early chemical evolution of these systems. With the current generation of 4-metre telescopes, is only possible to conduct detailed studies of stars in the Galactic halo. These studies have revealed that the Galactic halo is very metal-poor, with [Fe/H] ~ -1.3, and has a non-solar chemical mixture. However, the Galactic halo is likely not representative of other systems; indeed, the M31 halo appears to be more metal-rich and, based on the strength of CN absorption, may even have a systematically different chemical mixture. I propose to survey the photometric and spectroscopic properties of halo stars in Local Group (M31 and M33) and the nearest Sculptor Group (NGC55, NGC300, NGC7793) galaxies, with the goal of determining the metallicity distribution function for each galaxy. The observations would focus on stars making the first ascent of the giant branch, and would consist of narrow-band CO imaging, to estimate [O/Fe], coupled with wider-field deep spectra of the 8600Å Ca triplet, to estimate [M/H]. These data would then be used to determine how the chemical properties of stars in halos vary with distance from the galaxy center, and change with basic galaxy properties such as Hubble type and M_B. The amount of time to conduct this program is relatively modest - for Local Group galaxies (M31 and M33) the spectra would take roughly 3 hours per field, while the deep IR imaging would take roughly one hour per field. 2 nights on GN for M31 + M33, and 6 nights on GS for the 3 Sculptor galaxies.

Gemini instrument: NIRI (CO imaging) + GMOS (8 nights)

Gemini requirements:

Requirements for absolute astrometry: 0.1 arcsec

Required Gemini telescope acquisition capabilities for blind pointing, guiding precision and chosen slit width: An arcsec. However, for the multislit spectroscopy, it will be necessary to align the stars with ~0.5 arcsec slits.

Requirement for relative co-ordinate of science objects with respect to Gemini guide stars: an arcsec

Required photometric or spectrophotometric calibrations: 0.01 mag in K

Supporting Program

Title: Wide-Field Near-Infrared Imaging of Halo Fields in Nearby Galaxies

Objectives: The main objective would be to obtain J and K photometry of moderately large halo fields in the target galaxies. These data would be used to construct moderately deep (K, J-K) CMDs, and derive the brightnesses and colors of stars with Ca triplet and CO measurements. These data could be obtained with a 4 metre class telescope equipped with a wide field IR imager.

Requirements:

Limiting mag or flux (e.g. mag, erg cm^{-2} s^{-1}): The RGB-tip occurs near M_K ~ -5.5, and accurate photometry is required 1 - 2 mag below this. For Local Group systems this corresponds to K ~ 20 - 21, while for Sculptor galaxies this corresponds to K ~ 21 - 22. For the GMOS observations, the target stars would have I between 20.5 and 21.5

Limiting (S/N=2) surface mag or flux (e.g. mag, erg cm^{-2} s^{-1} $arcsec^{-2}$): K ~ 24. For the spectra, would need S/N ~ 20 at I ~ 21.5

Photometric accuracy: 0.01 - 0.02 mag

Astrometric accuracy: Not critical

Spectral range, band: 7000 - 9000Å (GMOS); JK + 2.3μm CO (NIRI)

Image quality (FWHM in arcsec): ≤ 0.5 arcsec (GMOS); ~ 0.2 arcsec (NIRI)

Sampling (e.g. arcsec pix^{-1}, A pix^{-1}, R): 0.05 - 0.10 arcsec per pixel (NIRI + GMOS)

Field (total or individual (e.g. deg, arcmin, arcsec)): 8 arcmin (GMOS); 3 arcmin for NIRI

Supporting 'Facilities', Archives

Existing: CFHT, CADC (would use CFHT + HST archival data to select fields) - 6 nights

Planned:

Desired: Wide-field IR imager on 4 metre in South (to map out Sculptor galaxy fields)

4. South American sample scientific programs

Program reference: SA1
Investigators: J.E. STEINER
Title: THE SUPERSOFT X-RAY BINARIES AND THE V SAGITTAE STARS

Summary

Compact binary supersoft sources are systems in which stable nuclear burning occurs on the surface of a white dwarf. The result is an X-ray source with near Eddington luminosity and temperatures of 20 - 60 eV. The galactic (X-ray quiet) counterpart of these systems have been proposed as the newly defined class of V Sagittae stars. Both classes may be supernovae type Ia progenitors. Gemini telescopes may be instrumental in the study of a) the faint end of the luminosity function; b) the characterization of the objects in Andromeda and more distant galaxies; c) the characterization of the secondary stars.

Instrumentation: GMOS and GNIRS with R ~ 5000 to 10000.

Program reference: SA2
Investigators: M. P. DIAZ
Title: INTEGRAL FIELD SPECTROSCOPY OF NOVA SHELLS

Summary

The project described in this contribution aims to study the structure of nova shells and their ionizing sources. This question will be addressed by improved physical and chemical diagnostics derived from spatially resolved spectroscopic observations. New model constraints can be obtained using infrared coronal lines in addition to optical diagnostic lines sampled along the evolution of the nova ejecta.

Instrumentation: GMOS, GNIRS. Optical and infrared two-dimensional spectrographs working at low to medium resolution (R-500-2000). We plan to obtain broad IR coverage (I, J, H and K). The spectral region from 3.5 to 5 micron being desirable but not essential. A spatial resolution of 0.15 to 0.25 arcseconds (FWHM) would be sufficient. Absolute flux calibration both in the infrared and in the optical is required.

Program reference: SA3
Investigators: R. BAPTISTA
Title: ACCRETION PROCESSES ON COMPACT BINARIES WITH GEMINI

Summary

I propose and discuss a few examples of observing programs in the field of interacting binaries to explore the time domain with the Gemini telescopes.

Instrumentation: GMOS, GNIRS. Accurate timings (better than 1ms) and small time resolution (of ~ 1s, ideally 0.1s) are a must. This type of observations requires that the data acquisition system of the Gemini instruments are designed/programmed having in mind the ability to perform observations at the fastest readout modes.

Program reference: SA4
Investigators: F. JABLONSKI
Title: SPECTROPHOTOMETRY OF OPTICAL PULSATIONS IN LMXB

Summary

The optical counterpart to the pulsed flux in low-mass X-ray binaries (LMXB) is an excellent probe for the physical processes occurring in these systems. We explore the parameters related to the practical observation of the three X-ray pulsars that show optical pulsations, namely, Her X-1 equivalent to HZ Her, 4U1626-67 equivalent to KZ TrA and GX1+4 equivalent to V2116 Oph.

Instrumentation: HROS. The wavelengths of interest cover selected windows in the span provided by the instrument. The required spectral resolution is ~ 1 A. The observational characteristics to be stressed is time resolution, about 0.1 second. Not all orders of the spectrum are needed so the amount of data can be manageable even at this high time-resolution. This project is meant for image quality conditions worst than the median. There is no need for AO or special calibrations except for accurate time tags.

Program reference: SA5
Investigators: E. LAPASSET
Title: MAIN SEQUENCE STARS IN OPEN CLUSTERS

Summary

Some issues related to the lower main-sequence of open clusters require an extension of high resolution spectroscopic observations beyond the observing limits of 4-meter telescopes. Membership, binarity, rotation, chromospheric activity and light element depletion are some of these issues. Particularly, the determination of Li abundances provides an independent way to estimate minimum ages for clusters and an empirical evidence to define the limit between stellar and sub-stellar objects. We propose to observe the faintest stars probable members of the nearby open clusters.

Instrumentation: HROS with R ~ 50000 and medium image quality. GMOS with R ~ 10000 could be used as a first approach for detecting members among the faintest stars and brown dwarfs of the open clusters.

Program reference: SA6
Investigators: R. A. MENDEZ
Title: STELLAR POPULATIONS AND GALACTIC STRUCTURE FROM STARCOUNTS ON THE HUBBLE DEEP FIELD

Summary

We review recent findings on the shape of the faint luminosity function for the disk and halo of our Galaxy, and the space distribution of those stellar populations derived from starcounts on the HST Hubble Deep Field and its flanking fields. We point out the current limitations imposed by

the small samples available, and provide future directions with the help of further observations by HST and 8-m class telescopes.

Instrumentation: NIRI + AO. Obtaining samples of point-like objects at faint ($V > 20$) magnitudes requires a good image characterization (FWHM < 0.5 arc-sec). If point-like sources are obtained from deep imaging with HST on only one-passband, ground-based data are used exclusively to obtain color information, and a 2.5-m class telescope would suffice to reach $V \sim 27$. However, star-galaxy separation at $V > 20$ can only be done reliably from the ground using AO. On the HST flanking fields, mid to late M-dwarfs appear in the magnitude range $20 < V < 25$, or equivalently $15 < K < 20$. These objects could be detected \it and characterized as point-like sources through near-IR (JHK) photometry with a 4-m class telescope equipped with AO. At $25 < V < 28$, low-metallicity halo M-subdwarfs dominate the counts, and in this case an 8-m class telescope with AO would be required to produce clean samples of point-like objects with $21 < K < 24$. This will be achievable with the Northern Gemini telescope by using the Near-infrared Imager assisted by the Altair AO system.

Program reference: SA7
Investigators: H. LEVATO
Title: THE PHYSICS OF CP STARS AND RELATED OBJECTS WITH GEMINI TELESCOPES

Summary

In this review I have addressed three problems related with the understanding the physics of the chemically peculiar stars that may be studied with the new high resolution facilities that will be available at the Gemini telescopes.

Instrumentation: HROS: Wavelength range 3000 - 10000, Resolution: minimum 50,000, better 100,000 or larger, no special calibrations.

Program reference: SA8
Investigators: B. BARBUY
Title: CHEMICAL EVOLUTION OF THE GALACTIC BULGE

Summary

The presently available data on elemental abundances in bulge stars is reviewed, and the importance of spectroscopic observations with Gemini-class telescopes is shown, with the aim of better understanding the chemical evolution of the Galactic bulge.

Instrumentation: HROS for stars with $V > 16$. Lower resolution observations with GMOS and optical/IR imaging are also of interest.

Program reference: SA9
Investigators: J. J. CLARIA
Title: CHEMICAL EVOLUTION OF THE GALACTIC DISK

Summary

The question of the existence of a general relationship between metallicity, age and position in the Galactic disk is addressed by examining probably the largest open cluster sample known so far with abundances derived on a homogeneous scale. The way as this project will be extended and substantially improved using the Gemini telescopes is described.

Instrumentation: GMOS, HROS. We propose to observe open clusters with GMOS in direct imaging mode with the V,I and DDO filters. The excellent images that the Gemini telescopes will produce, together with the high spectral resolution of the HROS, will also allow us to obtain high resolution spectra not only from faint cluster giants but also from main sequence stars in open clusters

Program reference: SA10
Investigators: M. KURSTER, A.P. HATZES, W.D. COCHRAN, K. DENNERL, S. DOBEREINER, M. ENDL, M. VANNIER
Title: THE ESO RADIAL VELOCITY PLANET SEARCH PROGRAM

Summary

We give an overview of current search programs for extra-solar planets using high precision radial velocities. Gemini's possibilities in this new field are identified. Pending instrumental developments at ESO are discussed in terms of their promise for RV measurement precision as well as important stellar line profile studies. Preliminary results are shown from the planet search program carried out at the ESO CAT+CES with data on the candidate extra-solar planets around iota Hor and phi 2Pav.

Instrumentation: Future fibre-fed spectrograph with R>120,000; required wavelength range 5100-5900~A ; R>200,000; if fibre-fed: image quality not crucial, AO not required; special calibrations: iodine gas absorption cell.

Program reference: SA11
Investigators: N. MORRELL, V. NIEMELA
Title: EMPIRICAL INITIAL MASS DETERMINATIONS FOR O-TYPE STARS IN THE GALAXY

Summary

Empirical mass determinations for zero age main sequence early O-type stars are either uncertain or definitely lacking. Most orbital studies deal with stars that have already evolved, and consequently lost a probably considerable fraction of their initial masses. In order to determine masses for the most luminous O-type stars, which have just arrived to the main sequence, we propose to exploit the IR spectroscopic capabilities of Gemini to study binary systems in star forming regions, still embedded in their parental clouds.

Instrumentation: GNIRS using a wavelength region centered at 2um and working at R ~ 18000. Observations during several nights are needed to properly cover orbital phases of the binaries. Signal to noise ratio of 100 or better is required. Image quality should be sufficient to exclude close visual neighbours.

Program reference: SA12
Investigators: J. GREGORIO-HETEM, T. MONTMERLE
Title: STAR FORMATION IN GIANT MOLECULAR CLOUDS

Summary

ROSAT observations of two molecular clouds are used to examine the possibility that X-rays can serve as tracers of star formation at distances 1 Kpc. The targets are the molecular clouds associated with the Monoceros R2 reflection nebula and the Rosette giant HII region. Comparison with recent near-infrared surveys supports the correspondence, previously found in nearby clouds, between X-ray and near-infrared sources associated with young stellar objects. The X-ray properties are comparable to those found for low- and intermediate-mass pre-main sequence stars in nearby star forming clouds.

Instrumentation: NIRI, (AO). The program is based in deep near-infrared imaging of young stellar clusters embedded in distant molecular clouds. In order to detect faint stars, resolving individual members of the clusters, it is required long exposure times (S/N > 100) and high resolution images (psf ~ 0.1 arcsec). The fields are typically < 5 arcmin, and the wavelength range includes the J, H, and K bands.

Program reference: SA13
Investigators: C. C. BATALHA
Title: HIGH RESOLUTION OPTICAL SPECTROSCOPY OF PRE MAIN SEQUENCE STARS

Summary

We propose to determine with unprecedented precision the fundamental parameters of pre Main Sequence Stars that are still surrounded by active circumstellar disks. In addition, we intend to explore the short-term variability of narrow and broad emission lines typical of these objects.

Instrumentation: HROS. The spectral format we intend to explore covers the whole optical range. In the extreme blue, we want to study the whole Balmer series and follow their intrinsic variability, comparing with that of the CaII H & K lines. In those stars of very large disk accretion rates there will be plenty of FeII lines to study variability as well. At the other end of the spectral format, we will target the CaII infrared triplet lines (8500 A) and the 2-0 band of the Phillips system of C2. The desirable resolution is larger than R ~ 50000. In order to achieve proper time—resolution, a large aperture telescope such as Gemini is required.

Program reference: SA14
Investigators: R.H. BARBA, N.R. WALBORN, M. RUBIO, V. NIEMELA, N. MORRELL, R.G. PROBST
Title: MASSIVE STARS: RESOLUTION AND MORPHOLOGY OF COMPACT STELLAR GROUPS IN THE MILKY WAY, THE MAGELLANIC CLOUDS, AND BEYOND...AN INFRARED POINT OF VIEW

Summary

Massive-star-forming regions are objects whose observation presents major challenges to current ground-based telescopes. High-performance telescopes like Gemini allow us to study these objects in very reddened regions of the Milky Way and the Magellanic Clouds, and to extend such studies to other extragalactic neighbors. A special case study, the 30 Doradus region in the LMC, is proposed as an example.

Instrumentation: NIRI, GNIRS, (AO). The observing plan proposed for this project includes two phases: a) NIR Imager observations (with resolution <0.2 arcsec at 2um, AO required) to establish the morphology of crowded star-forming regions of massive stars; b) NIR Spectrograph (NIRS) observations between 1 and 5 micron of each stellar component in those star-forming regions, down to a reasonable limiting magnitude and with moderate S/N to establish their spectral morphologies. Multiobject spectroscopy is highly applicable to such regions and will greatly enhance the efficiency of the program.

Program reference: SA15
Investigators: A. M. MAGALHAES
Title: POLARIMETRY WITH GEMINI

Summary

Imaging polarimetry and spectropolarimetry with the Gemini telescopes will be able to help us elucidate a number of important astrophysical problems. We describe the basic techniques involved in polarimetry in the optical and near infrared. We also describe a sample of those problems that includes: star forming regions and young stars, stellar disks and envelopes, interstellar dust and magnetic field structure in dark clouds and galaxies and the structure of active galactic nuclei.

Instrumentation: The programs described here could use the following instruments, with varying resolution: GMOS, HROS, NIRS, MIRI, NIRI and Michelle, all mounted at the straight-through port. If instrumental polarization can be corrected for or is not important for the particular program, AO can be profitably used.

Program reference: SA16
Investigators: V.S. NIEMELA, N.I. MORRELL
Title: EARLY TYPE BINARIES IN THE MAGELLANIC CLOUDS: STEPS TOWARD AN EMPIRICAL MASS-LUMINOSITY RELATION FOR THE HOTTEST O STARS

Summary

The empirical mass-luminosity relation is relatively well known only for stars less massive than about 20 Msun. The estimates of masses via comparison with numerical evolutionary tracks or mass-luminosity relation, lack the necessary empirical checks for the most luminous stars. We are performing a search for spectroscopic binaries among the hottest O stars in the Magellanic Clouds, which would provide empirical estimates of the masses of the components. The stars in the Magellanic Clouds, particularly those in the Small Magellanic Cloud, will also provide suitable empirical tests on how the mass-luminosity relation behaves in environs of different metallicity.

Instrumentation: GMOS. Repeated spectra, typically two per night, of O type stars with GMOS, R ~ 10000 or higher, image quality sufficient to exclude close neighbours, accurate wavelength calibrations

Program reference: SA17
Investigators: J. A. DE FREITAS PACHECO
Title: CHEMICAL EVOLUTION OF THE LARGE MAGELLANIC CLOUD

Summary

A chemical evolutionary model for the LMC is presented, taking into account constraints in the star formation history imposed by recent data on color-magnitude diagrams of field stars. A steeper IMF seems to be necessary to produce negative [O/Fe] ratios, and new data on the luminosity function of field stars are necessary to settle this question. Moreover, the signature of the past enhanced star formation period 2-3 Gyr ago is clearly seen in the evolution of oxygen (and other primary elements), representing an important observational test for the proposed model.

Instrumentation: HROS, wavelength range 0.45 - 0.70 nm, R ~ 30 000 for targets with V ~ 18

Program reference: SA18
Investigators: S. A. CELLONE
Title: LOW SURFACE BRIGHTNESS DWARF GALAXIES

Summary

Recent work on low surface brightness (LSB) dwarf galaxies is reviewed, particularly, the use of the surface brightness profiles of dwarf elliptical (dE) galaxies in nearby clusters of galaxies as a distance indicator. The use of the Gemini telescopes to study the existence of a fundamental plane for dEs is proposed. The stellar populations in dEs' nuclei, and the possible relationship between nucleated dE galaxies and the population of "blue" globular clusters associated with central galaxies in clusters (eg. NGC1399, in Fornax) are also discussed.

Instrumentation: HROS, GMOS. HROS for measuring stellar velocity dispersions in dE galaxies, and low dispersion spectra (with GMOS) to obtain information about metallicity and kinematics of extragalactic globular cluster systems. Optical and infrared direct imaging of dE nuclei are also tentatively planned. The expected spatial resolution at optical wavelengths (~ 0.3") will be appropriate for nearby clusters of galaxies, like Virgo and Fornax.

Program reference: SA19
Investigators: B. X. SANTIAGO
Title: GLOBULAR CLUSTER SYSTEMS IN GIANT ELLIPTICAL GALAXIES: HST RESULTS AND FUTURE GROUND-BASED FOLLOW-UP

Summary

We discuss recent results concerning the properties of the globular cluster systems in luminous elliptical galaxies, in particular the existence of bimodal colour distributions. We also assess the

importance of spectroscopic studies of globular cluster samples in order to investigate the presence of kinematically distinct populations of globulars.

Instrumentation: GMOS. The aim would be to obtain optical spectra (4000 - 7000 A) for samples of globular clusters in nearby luminous ellipticals identified in HST-WFPC2 fields. Within the 5.5 arcmin field of view covered by GMOS several dozens of such objects could be succesfully targeted at once under normal seeing conditions, there being no need for AO or for special calibrations.

Program reference: SA20
Investigators: R. R. DE CARVALHO, H. V. CAPELATO
Title: FUNDAMENTAL PLANE OF E GALAXIES - THE ROLE OF NON-HOMOLOGY

Summary

We report the status of our continuing program aimed to study the physical properties of the “Fundamental Plane” (FP) of elliptical galaxies. Previously we have shown that the characteristic parameters of the remnants of dissipationless mergers is able to closely reproduce the observed FP and have traced back this effect as due to the non-homology of the central mass-velocity distributions of these remnants. Here we discuss the results of a set of “hierarchical” simulations which merged the past remnants among themselves. We show that the hierarchical scheme is able to produce remnants which span the range of the observed FP, although wit a possible small bending at higher hierarchical levels. This effect may be related to some recent obervations that suggest a small evolution of the FP with redshift.

Instrumentation: GMOS + IFU. Based on our previous experience using the Keck telescope we plan to take spectra of Es at redshifts ranging from 0.1 to 0.8. Intermediate resolution is required to reliably measure central velocity dispersion. The central wavelength will be such to include the redshifted lines of Hbeta, Mg2, Fe5270 and Fe5335. The two-dimensional spectroscopy done with the IFU will be an essential tool to measure the degree of non-homology in Es, especially at redshifts of ~ 0.4 - 0.4, where these galaxies have a typical re of 3-4 arcsecs. These characteristics match with what is provided by the IFU, spectroscopy over 50 arcsec^2 are with 0.2 arcsec sampling.

Program reference: SA21
Investigators: R. A. SCHOMMER
Title: COSMOLOGICAL MEASUREMENTS WITH DISTANT TYPE Ia SUPERNOVAE

Summary

The High-Z SN Search is an international collaboration to discover and follow SNe Ia at z > 0.2 with the aim of tracing out cosmic deceleration and global curvature. This project has discovered 72 supernovae (0.09 < z < 0.97) using the Blanco 4-meter telescope at CTIO and the CFHT over the past 2.5 years. We have obtained spectra and two color photometry for most of these supernovae and find that 35 of the objects are SNe Ia useful for measuring distances.

Instrumentation: GMOS, GNIRS, NIRI. Searches will be done with wide-field 4m telescopes. Gemini observations would include spectroscopy at 5-10 A resolution from 5000-10000 A, photometry in redshifted bandpasses from 7000-9000 A with AO, and possible near-IR photometry and spectroscopy.

Program reference: SA22
Investigators: J. R.D. LEPINE
Title: EVOLUTION OF GALACTIC DISKS IN THE REDSHIFT RANGE z = 0 - 1

Summary

We discuss the expected changes in the aspect of isolated spiral galaxies that should be observable over the range of redshift z = 0 to 1, corresponding to a lookback time of about 7 billion years. We use the structure and the evolution of the Galaxy as a guide for the study of other galaxies. At the epoch corresponding to z = 1, the bulge and the thick disk of the Galaxy already reached their present aspect, although the stars were younger. But the thin disk and the spiral arms of z = 1 galaxies should show differences with respect to present day galaxies.

Instrumentation: NIRI, mid-IR + AO. The program requires images of disks of galaxies in the near-infrared (J,H,K,L), with angular resolution of about 0.2”, in order to observe colors as a function of radius for disks with total size 1-2”. So, adaptative optics would be required.

Program reference: SA23
Investigators: R. E. DE SOUZA, S. DOS ANJOS
Title: THE BULGES OF SO GALAXIES

Summary

The identification of true S0 galaxies is achieved by a numerical code that adjust a Bulge+Disk model to the observed images. It is concluded that bulges are triaxial structures with mean axial ratio 1:0.75:0.60. In almost all cases the brightness profile is slightly shallow than the one found in Ellipticals. A distinct characteristic is the presence of dust lanes along the major axis in 30-40 of our sample. The presence of these dust lanes argues in favor of recent star forming events that may be responsible for the a continuous formation of the bulge itself.

Instrumentation: GMOS + IFU to map the star forming regions. An spectral resolution of 5000 will be adequate to obtain the prominent optical absorption lines and detect the gradients of metallicity indicators inside the Bulge.

Program reference: SA24
Investigators: R. C. KENNICUTT, B. T. SOIFER, J. H. ELIAS, P. PUXLEY, J. C. SHIELDS, S. VEILLEUX, D. ZARITSKY
Title: THE NATURE AND EVOLUTION OF STARBURST GALAXIES

Summary

Gemini promises major advances in observations of star forming galaxies, and towards understanding the physical processes that drive the star formation. This paper focuses on the

physical nature and evolution of starburst galaxies, and describes an example of a program to study the cosmological evolution of starbursts, as a followup to two upcoming space infrared missions. The importance of coordinated supporting observations on 4m-class telescopes is emphasized.

Instrumentation. This program would use GMOS to obtain deep multi-slit spectroscopy of faint galaxies (R = 24--25). The program requires moderate resolution (R = 1000--2500), over the wavelength range 0.4--1.0 micron. This program would benefit from the proposed near-IR extension of GMOS to 1.5 micron.

Program reference: SA25
Investigators: H. DOTTORI, W. BRANDNER, E. K. GREBEL, M. KUNKEL, J. MELNICK, A. MONETI, H. ZINNECKER
Title: EMITTING CONDENSATIONS EMBEDDED IN NGC~3603 HII REGION

Summary

Narrow band Halpha and broad band R imaging has been used to find high surface brightness, Halpha emitting condensations within the giant HII region NGC 3603. Two of them, C13 and C16 are analysed. They present high Halpha/Hbeta ~ 20. The size of the condensations is ~ 0.1 pc. They are cocoons partially and externally ionized by the NGC3603 that present hidden IR sources, most probably PMS, intermediate mass stars.

Instrumentation: GNIRS, NIRI to study the hidden sources. AO to look for substructures

Program reference: SA26
Investigators: E. TELLES
Title: HII GALAXIES - PROBING GALAXY EVOLUTION

Summary

I briefly summarize a line of work in tackling the problem of galaxy evolution which I believe will gain more impetus with the new instrumentation and image quality delivered by the GEMINI telescope. High spectral and spatial resolution observations of nearby starbursts and intermediate z galaxies will provide a more physical understanding of the star formation history of galaxies on galactic scales and their evolutionary links related to galactic structure and dynamics.

Instrumentation: GMOS + IFU, GMOS in imager mode, NIRI The general characteristics of this possible observing programme for Gemini consists of intermediate spectral resolution and high image quality observations both in the visible and in the near-infrared. This programme also envisages an extensive use of the Integral Field Unit (IFU) and longs for future developments towards large field IFUs.

Program reference: SA27
Investigators: L. E. CAMPUSANO, R. G. CLOWES
Title: LARGE QUASAR GROUPS IN THE EARLY UNIVERSE: OBSERVATIONS WITH GEMINI

Summary

We briefly review the observational status of the search for large scale structures (LSS) at high redshift ($z > 0.1$), from the galaxy distribution and quasar absorption lines but with special emphasis on the input from quasar samples and particularly from quasar groups. We propose pencil beam imaging and spectroscopy in the direction of the ~ 200 h-1 Mpc quasar group at z ~ 1.3 discovered by Clowes & Campusano (1991) (RA = 10h40m00s (1950.) DEC= 5^o 00' 00").

Instrumentation: GMOS in imaging mode, filters V and I, image quality= 20% or better. GMOS, wavelength range:3700-10,500 A, resolution=670, image quality=50% or better.

Program reference: SA28
Investigators: C. MENDES DE OLIVEIRA, U. HOPP, R. BENDER, N. DRORY, R. P. SAGLIA
Title: A NIR SEARCH FOR HIGH-REDSHIFT CLUSTERS

Summary

We describe our preliminary results on a search for high-redshift ($z > 0.5$) galaxy clusters using near-infrared photometry obtained with the Omega camera at the 3.5m telescope at Calar Alto.

Instrumentation: NIRI, GMOS. We could use Gemini for spectroscopy of the best candidate clusters selected from the NIR/optical photometry. Possibly GMOS would be used, with a minimum resolution of 15 A FWHM.

Program reference: SA29
Investigators: M. G. PASTORIZA, C. BONATTO, D. ALLOIN, E. BICA
Title: NUCLEAR STARBURST ACTIVITY IN NEARBY Sb GALAXIES

Summary

As part of a systematic study of the UV properties of galaxies in the IUE library, we present an analysis of nuclear stellar populations in Sb galaxies with radial velocity < 5000 Km sec-1. In the central kpc of the galaxies with strong UV flux, we find that the mass stored in the young components ($t < 500$ Myr) is typically 10^7 solar. We confirm that such star-formation enhancements occur preferentially in barred spirals.

Instrumentation: GMOS, NIRI, NIRS. Will need also AO and flux calibrations. High spatial resolution and optical and infrared imaging of the central region of the SBb galaxies with circumnuclear ring will give unique view of the Super Star Clusters and surrounding interestellar medium. The optical and near infrared spectroscopy with IFU will permit the identification of pre-Wolf-Rayet, Wolf-Rayet, OB associations, as well as, Red Supergiants.

Program reference: SA30
Investigators: T. STORCHI-BERGMANN, C. WINGE
Title: IR EXTENDED EMISSION IN NEARBY AGN

Summary

In the Unified Model scenario for Seyferts, the nuclear radiation is collimated by an optically thick molecular torus which surrounds the ionizing source. We propose to look for signatures of this torus, and its collimating effect in the IR taking advantage of the reduced relative attenuation at these wavelengths. We discuss results of long-slit spectroscopic observations in the near-IR for 5 nearby Seyferts with ionization cones, using the CTIO 4m telescope. Extended IR line emission has been detected in the 5 galaxies, consistent with previous optical imaging studies, but a better spatial coverage and resolution is necessary in order to resolve the torus.

Instrumentation: NIRI, GNIRS + AO. NIRI narrow-band imaging of the closest AGN using filters centered on the emission-lines [FeII]lambda 1.257micron, Pabeta, H2 lambda1.122micron and Brgamma, and adjacent continua to subtract its contribution; NIRS long-slit spectroscopy at J and K at R=5400, along the collimation axis and perpendicular to it; NIRS at J and K bands with AO and IFU at R=5400 to obtain complete spatial coverage of structure and kinematics.

Program reference: SA31
Investigators: R. CID FERNANDES, H. R. SCHMITT, T. STORCHI BERGMANN
Title: SPATIALLY RESOLVED STUDIES OF THE STELLAR POPULATIONS IN ACTIVE GALAXIES

Summary

2-D high-resolution maps of the spectral characteristics of galaxies would provide invaluable tools to probe the history of their stellar and gaseous components. In this contribution we illustrate how much information is available through 1-D spectral maps of active galaxies obtained through long-slit spectroscopy in a 4m telescope. Radial variations of stellar absorption features and continuum colors are used both to map stellar populations and to study the active nuclear component.

Instrumentation: GMOS with AO and IFU to obtain 2-D spectra of the inner 7x7 arcsec of active galaxies, with 0.2 arcsec sampling, in the wavelength range 3500-7000A at R=1250. As the goal is to map - at the highest possible spatial resolution - the spectral features of the stellar population, good image quality is needed.

POSTER PAPERS:

Investigators: R. DE LA REZA, F. REQUEIJO, L. DA SILVA, C.A.O. TORRES, G.R. QUAST
Title: STUDIES OF PROTOPLANETARY DISKS

Instrumentation: Mid-IR imager

Investigators: N. V. LEISTER, S. JANKOV, E. JANOT-PACHECO
Title: ASTEROSEISMOLOGY: THE STUDY OF NON-RADIAL STELLAR PULSATIONS

Instrumentation: GMOS, wavelength range 0.36 - 1.10 micron, resolution:10,000; HROS, wavelength range 0.30 - 1.0 micron, resolution: 50,000.

Investigators: C. D. GNEIDING and J. E. STEINER
Title: THE SPIN-DOWN IN 4U1626-07: OPTICAL PULSATIONS

Instrumentation: GMOS with resolution of R=5000 and integration time of 1 second.

Investigators: J. BRAGA
Title: OBSERVATIONS OF ACCRETION DISKS AROUND COMPACT OBJECTS IN LOW-MASS X-RAY BINARIES

Instrumentation: HROS with spectral resolution of ~ 30000, especially using the mirror UV capability.

Investigators: M. J. SARTORI, J. R. D. LEPINE
Title: A SEARCH FOR CIRCUMSTELLAR DISKS AROUND HERBIG Ae/Be STARS

Instrumentation: Near-Infrared Imager; bands: J (1.25 micron), H (1.65 micron), K (2.2 micron), L (3.4 micron), M (5.0 micron); plate scale: 0.02 arcsec/pixel

Investigators: M. P. ALLEN, J. E. HORVATH, E. G. M. DAL PINO, G. A. MEDINA TANCO, T. P. DOMINICI, M. MENDEZ
Title: PHOTOMETRY OF ISOLATED PULSARS

Instrumentation: Optical and near infrared imagers. We expect to obtain seeing 0.1”-0.3”, with need for AO.

Investigators: B. V. CASTILHO
Title: ABUNDANCES OF LIGHT ELEMENTS

For the 7Li (lambda 670,7nm) abundance determinations we need HROS with R = 50000, for the 6Li/7Li ratio R > 50000. For the Be abundance determinations we will need HROS with R = 50000 at lambda 313,0nm and lambda 332,1nm.

Investigators: S. ROSSI, C. CHIAPPINI, T. C. BEERS, F. MATTEUCCI
Title: CHEMICAL EVOLUTION IN THE EARLY GALAXY

Instrumentation: HROS in wavelength range 3100 - 10,000 A. AO is needed once we want to narrow the slit down to < 1” in order to get the best possible resolution. It will speed observations up by about a factor of 2.

Investigators: J. MELENDEZ, B. BARBUY
Title: SPECTROSCOPY IN THE INFRARED

Instrumentation: For medium resolution spectroscopy: NIR spectrometer, 1-2 micron, R ~ 6000. For high resolution spectroscopy: PHOENIX, 1-2 micron, R ~ 70000.

Investigators: S. CASTRO, G. F. PORTO DE MELLO
Title: ABUNDANCES OF HEAVY ELEMENTS IN BULGE STARS

Instrumentation: HROS. Cu and Y lines will be very weak (10 - 20mA) and thus will require S/N>120, R > 50,000 to be detected.

Investigators: A. RINGUELET, L. CIDALE, R. VENERO
Title: CENTRAL STARS OF PLANETARY NEBULA

Instrumentation:HROS. According to Perek's Catalogue of Planetary Nebula, there are 38 stars, appearing as central stars of planetary nebula, brighter than photographic magnitude 12. That means that we may integrate up to one hour on the basis of a resolution Delta lambda/lambda > 10(-6); wavelength interval: 3500 - 7000 A.

Investigators: A. RINGUELET, A. CRUZADO
Title: HIGH RESOLUTION OBSERVATIONS OF IR EXCESSES IN Be STARS

Instrumentation: GNIRS, in the range 1 - 5.5 micron

Investigators: F. CUISINIER, W.J. MACIEL, A. ACKER, J. KOPPEN
Title: THE GALACTIC BULGE: THE PROBLEM OF PLANETARY NEBULAE ABUNDANCES

Instrumentation: GMOS for spectrophotometric observations of emission lines in the optical range, including the [OII] 372.7, [OIII] 495.9, 500.7 nm, and Halpha lines. Observations of lines in the near infrared, such as [SIII] 953.1 nm would be very helpful as well. R ~ 2 - 5 A.

Investigators: C.B. PEREIRA, V.V. SMITH, K. CUNHA
Title: HIGH RESOLUTION OBSERVATIONS OF YELLOW SYMBIOTIC STARS

Instrumentation: HROS, R ~ 30000, S/N ~ 100, spectral coverage is 5500A - 8000A. In the near infrared, the desired spectral coverage is 9900A-11000 A and 1.6 - 2.2 micron.

Investigators: A. KANAAN, S.O. KEPLER, D.E. WINGET, A. NITTA
Title: THE ORIGIN OF STRONG MAGNETIC FIELDS IN WHITE DWARFS

Instrumentation: HROS, S/N ~ 30 is needed to detect magnetic fields through the Zeeman splitting in Halpha and Hbeta lines. We estimate exposure times of roughly one hour for stars of m_V = 22.5.

Investigators: A. E. PIATTI, D. GEISLER, E. BICA, H. DOTTORI, J. J. CLARIA, J. F.C. SANTOS JR.
Title: FORMATION AND EVOLUTION OF THE LARGE MAGELLANIC CLOUD: THE OLD STAR CLUSTER CANDIDATES

Instrumentation: Optical imager We propose to obtain Washington C, T_1 CCD direct images for all the remaining LMC old cluster candidates with the Gemini telescopes in order to determine if they are intermediate-age or older, and to derive accurate reddenings and metallicities.

Investigators: R.E. CARLOS REYES, J.E. STEINER, F. ELIZALDE
Title: CHEMICAL ABUNDANCES OF HII REGIONS IN THE MAGELLANIC CLOUDS

Instrumentation: GMOS, wavelength coverage of 3700 - 9700 A, resolution of 2 - 5 A.

Investigators: R. P. SCHIAVON, B. BARBUY
Title: POPULATION SYNTHESIS IN THE NEAR INFRARED

Instrumentation: GMOS, wavelength range 600.0-1020.0 nm, R ~ 5000.

Investigators: W.J. MACIEL, R.D.D. COSTA, H.J. ROCHA-PINTO, C. QUIREZA
Title: ABUNDANCE GRADIENTS AND STAR FORMATION IN SPIRAL GALAXIES

Instrumentation: GMOS, wavelength range 3500 - 7500 A, R ~ 2000-5000.

Investigators: C. WINGE, T. STORCHI-BERGMANN
Title: INFRARED SPECTROSCOPY OF SEYFERT GALAXIES

Instrumentation: GNIRS, R ~ 5000 or greater, wavelength coverage 0.9 -- 3.0 micron. Subarcsec spatial resolution is needed, so this programme benefits from AO.

Investigators: C. BONATTO, E. BICA, M. G. PASTORIZA, D. ALLOIN
Title: UV PROPERTIES OF NEARBY STAR-FORMING GALAXIES

Instrumentation: GMOS, GNIRS. In order to detect traces of starbursts we need optical spectra in the range covered by the GMOS (3000-15000 A) with a spatial resolution of ~100pc, and infrared spectra in the range 1-5 micron. Optical and infrared images will help to detect spatial gradients in the star-formation events.

Investigators: C. C. DANTAS, H. V. CAPELATO and R. R. de CARVALHO
Title: DO DISSIPATIONLESS COLLAPSES ALSO REPRODUCE THE FUNDAMENTAL PLANE OF ELLIPTICAL GALAXIES ?

Instrumentation: GMOS + IFU: The key assumption of the non-homology of the central velocity and/or mass distribution of elliptical galaxies may be tested by detailed IR spectroscopic mappings of their central regions ($r < 0.5r_e$).

Investigators: H. CUEVAS, L. SODRE Jr., H. V. CAPELATO
Title: SPECTRAL CLASSIFICATION OF GALAXIES IN A3667

Instrumentation: GMOS. We present a procedure for spectral classification of galaxies that may be efficiently applied to data obtained with spectrographs with multi-object capability.

Investigators: I. RODRIGUES, H. DOTTORI, F. MIRABEL, E. BRINK
Title: THE INTERACTING SYSTEM NGC 6845

Instrumentation: GMOS+IFU. The study of the detailed distribution, composition and morphological details of the condensations of ejected material in interacting galaxies require high spatial resolution narrow band imagery or Fabry-Perot interferometry if available. Resolution: 0.1 arcsec (the smaller the better).

Investigators: H. R. SCHMITT
Title: THE DIFFERENCE BETWEEN THE NARROW LINE REGION OF SEYFERT 1 AND SEYFERT 2 GALAXIES

To solve the problem presented here, it is necessary to obtain mid infrared spectra of Seyferts, spectral region which shows emission lines with different degrees of ionization and is less affected by dust extinction. This can be done with the mid infrared imager/spectrometer OSCIR, now operating at the CTIO 4m telescope, in spectroscopic mode.

Investigators: R. OPHER
Title: SEARCH FOR POPULATION III OBJECTS

Instrumentation: NIRI: Sensitive IR imaging of Population III objects in: 1)Galactic halos; 2)Exploding objects at redshifts; and 3)Dwarf galaxies. For our Galactic halo, we suggest using large fields ~ 10 arcmin. For exploding objects at redshifts $z > 5$, we also suggest using large fields ~ 10 arcmin. For dwarf galaxies, such as Ursa Minor, we suggest searching in a number of dark fields of the galaxy. In order to detect the faint Population III objects in the IR, long exposure times ($S/N > 100$) are required.

Investigators: V. JATENCO-PEREIRA, R. OPHER
Title: THE FUNDAMENTAL ROLE OF ALFVEN WAVES AND MAGNETIC FIELDS IN THE FORMATION OF STARS

Instrumentation: Phoenix: we need high spectral resolution ($R > 100,000$) for detecting the weak and narrow lines of molecular hydrogen species in the near infrared.