Signatures of Quasar Microlensing

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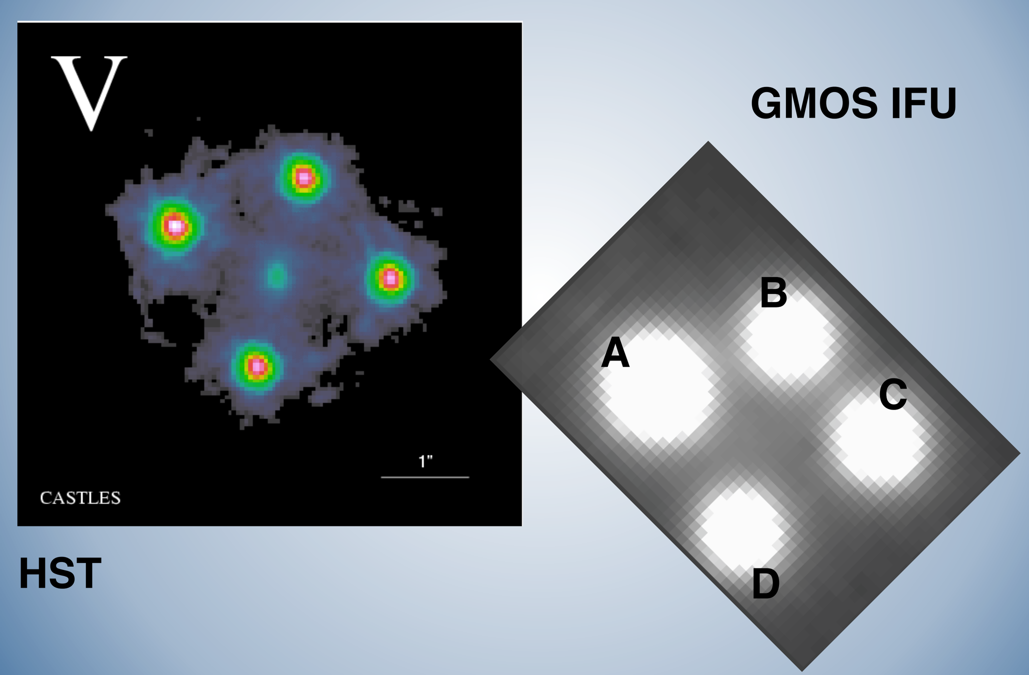
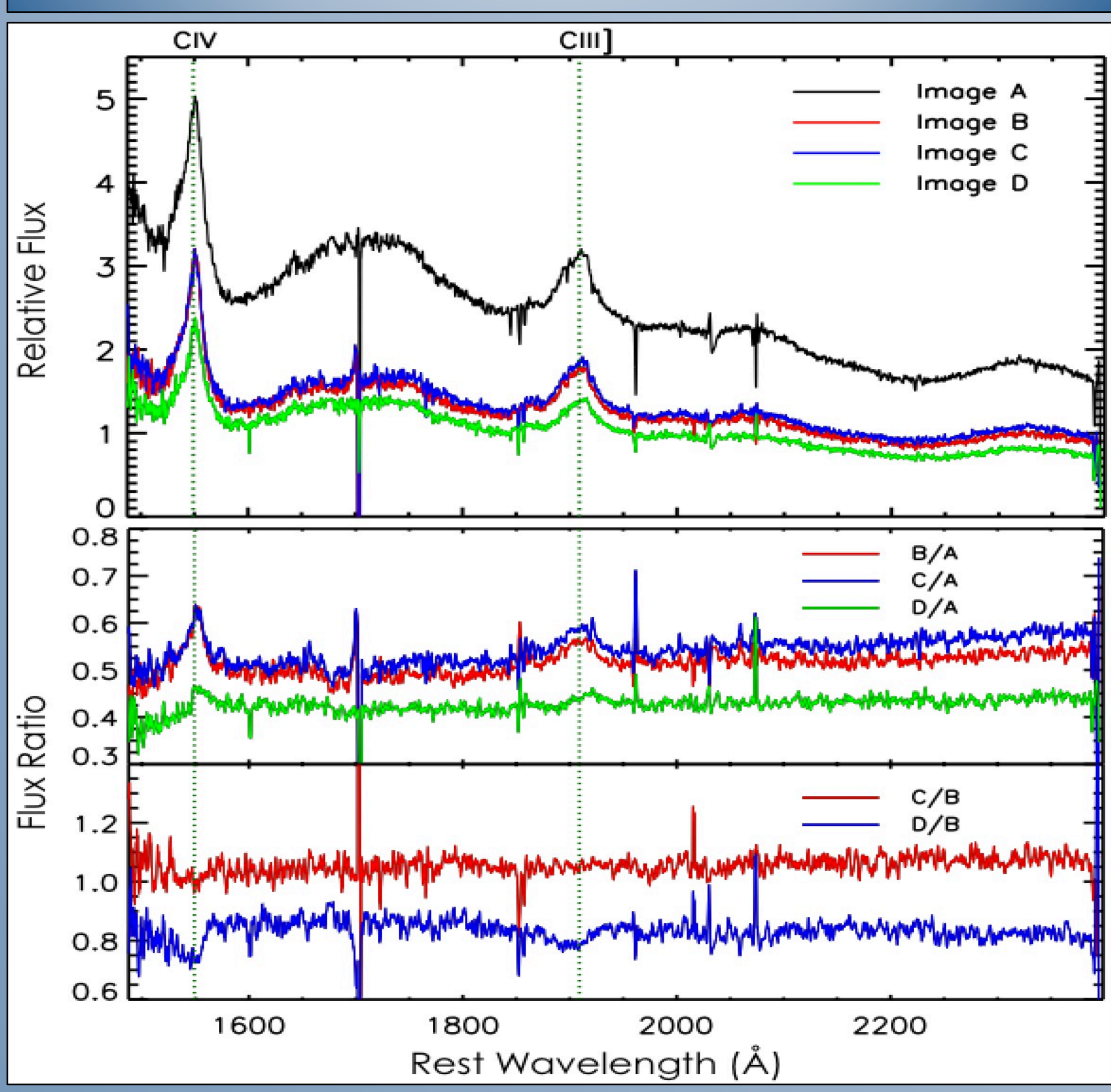
HE0435-1223



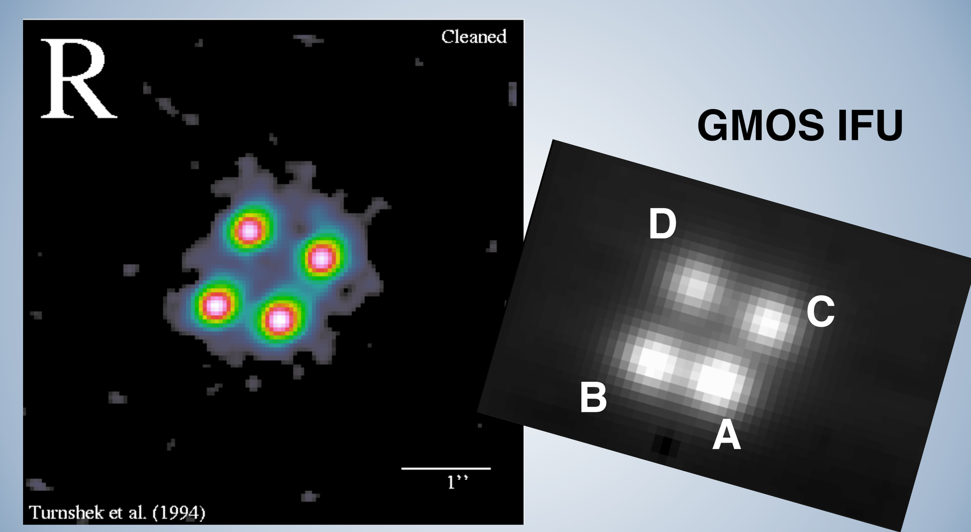


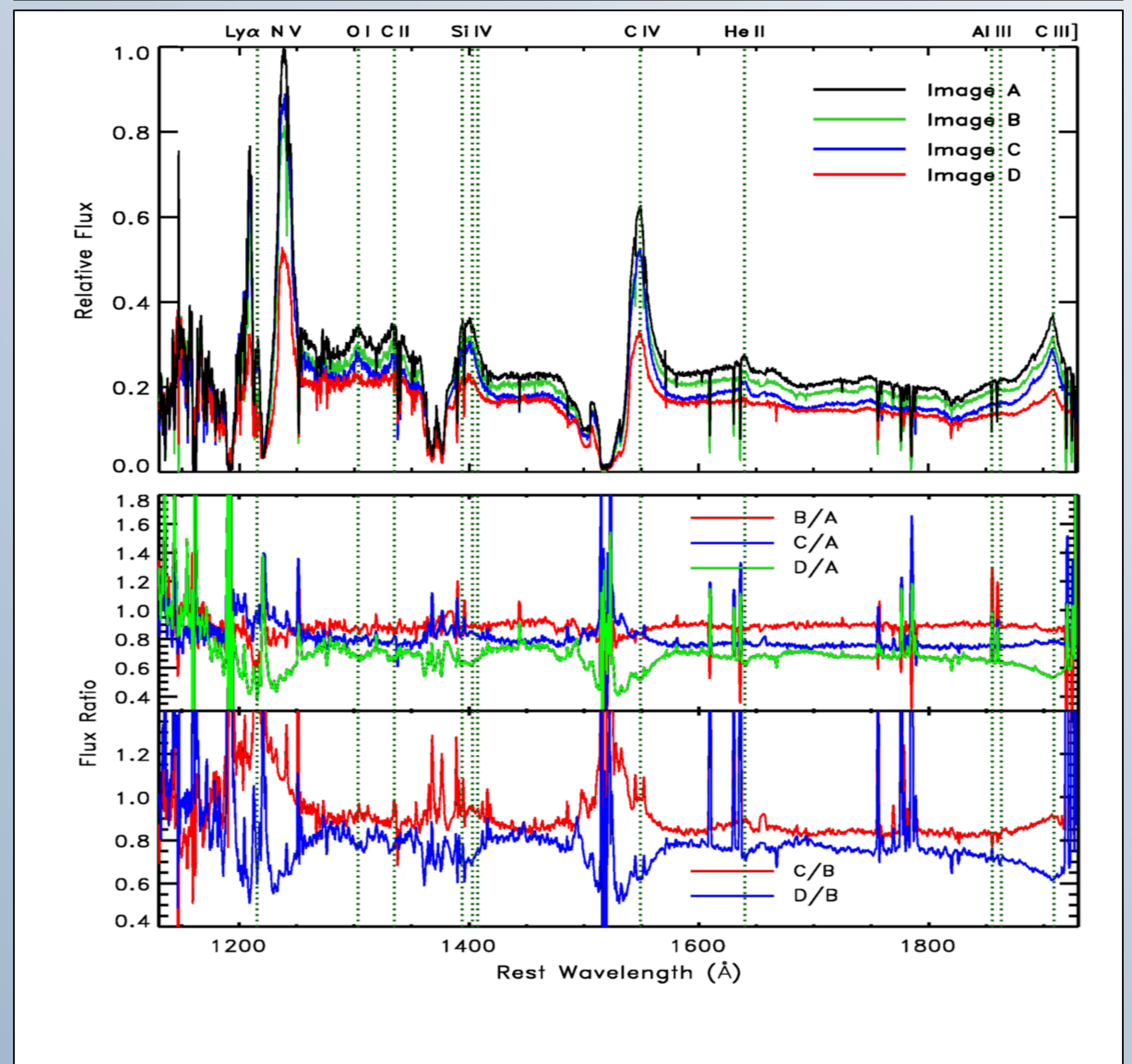
Interpretation

Image A is exhibiting strong differential microlensing between Broad Emission Line Region (BELR) and continuum region, as evidenced by the over-magnified continuum in the X/A line ratios and the slightly less-over-magnified lines in the same ratios. The flat ratio seen in C/B tells us that those lensed images are not experiencing differential microlensing (hence it must be A). We see a feature in D/B suggesting that D is also exhibiting some differential microlensing.

The fact that the very strong iron features in this spectrum do not show signatures in the ratios tells us that these iron lines are experiencing the same magnification as the continuum – hence are probably on a similar size scale, as expected if they are emitted above and close to the accretion disk.

H1413+117

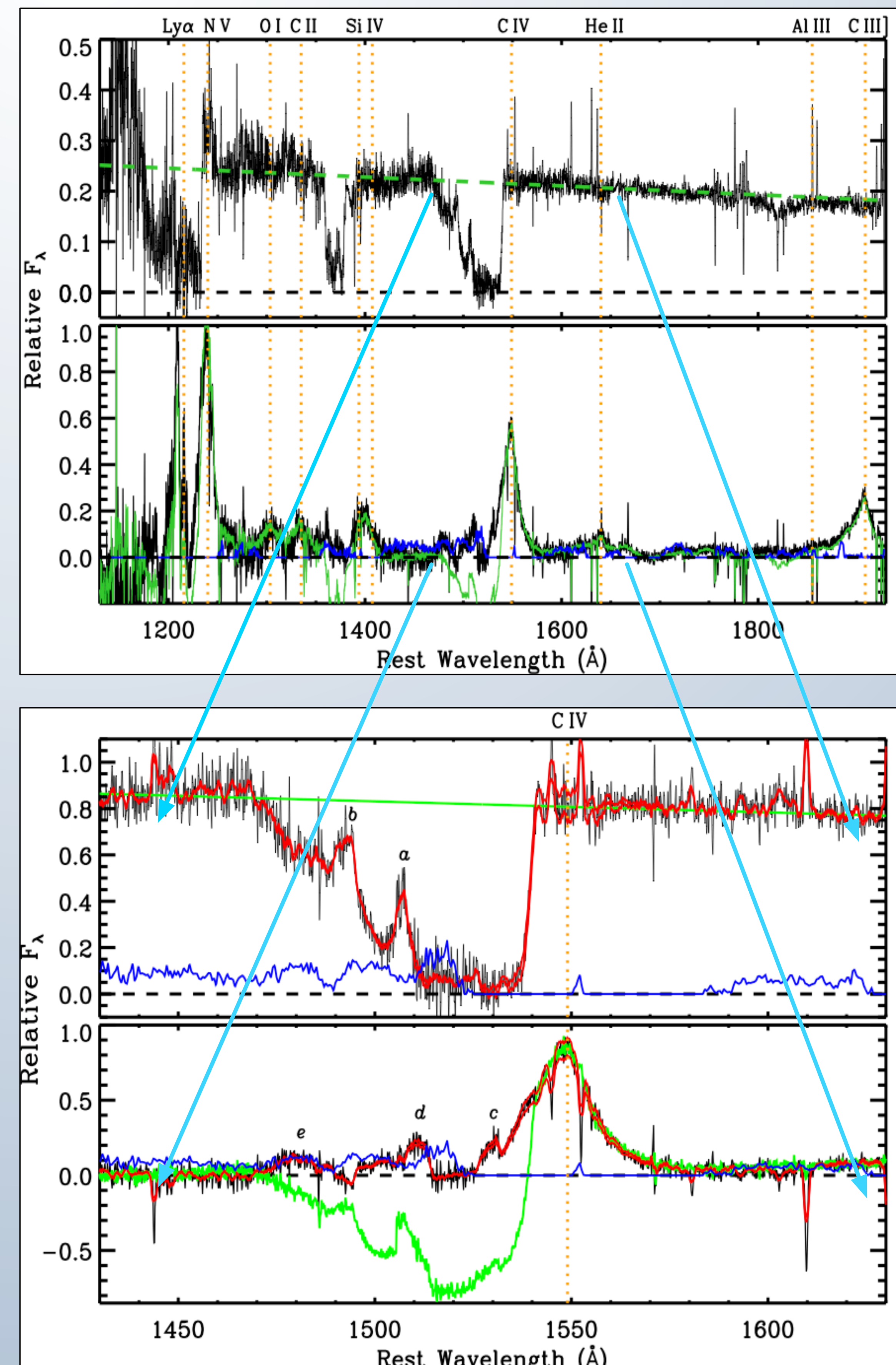




Interpretation

In this case, Broad Absorption Line (BAL) activity is evident, for example blueward of the C IV line (upper plot). There is also clear evidence of differential microlensing between the Broad Emission Line (BEL), the BAL, and the continuum in all the ratios (lower plot). The effects are particularly strong in lensed image D. The D/B and D/A flux ratio plots show that the C IV line, among others, is significantly demagnified relative to the continuum.

Not shown in these plots, our analysis of the BEL flux ratios leads to a BELR significantly larger than 10^{15}m, or more than 100 light days. This scale applies to the BAL wind also. Since the time delay between lensed images A and D is about 24 days, the intrinsic variation timescales are significantly larger than the time delay.



Interpretation

The multiple lensed images and the differential microlensing breaks degeneracy and allows us to algebraically separate the spectral components from different emission regions for image D: continuum + BAL (upper panels of both plots) and BEL + BAL (lower panels).

The sharpness and blueshift of the onset of absorption blueward of C IV, yet still within the velocity range of the BEL, tells us two things: 1) the outflow has already accelerated to some degree before either it enters our sightline or it enters the regions of efficient absorption within our sightline, and 2) the kinematics of absorbing gas in our sightline is strongly dominated by outflow, not orbital motion.

Regions of reduce absorption within the BAL outflow, like the prominent feature "a", indicate clumpiness in gas density or relative ion species density.

(The green line in the lower panels is the observed spectra. In the top plot, the continuum has been removed)

Differential microlensing, in a nutshell...

In a multiply-imaged quasar, differential microlensing is characterized by a variation in the magnification levels of different spectral components in a single lens image, compared to the unmicrolensed quasar spectrum. In the absence of microlensing, we expect emission line and continuum flux ratios to be equivalent to each other and to agree with the macro-model flux ratios, and we also expect flat, featureless spectral ratios, like in the HE0435-1223 C/B spectral flux ratio, above. In the presence of microlensing, the emission lines from the broad emission line region (BELR) and/or the continuum will cause features on the spectral ratios, like in the HE0435-1223 B/A spectral flux ratio, above. The flux ratios and the shape of the features in the spectral ratios can be used to put constraints on the size and the kinematics of the sources of emission.

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