Gravitational lensing of QSO spectra

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Gravitational lensing is in general achromatic (the deflection angle of a light ray does not depend on its wavelength), however, the wavelength dependent geometry of the different emission regions may result in chromatic effects. Studies aimed at determining the influence of microlensing on the spectra of lensed QSOs need to account for the complex structure of the QSO central emitting region.

According to the standard model of AGNs, a QSO consists of a black hole surrounded by a (X-ray and optical) continuum emitting region probably with an accretion disk geometry, a broad line region and a larger region that can be resolved in several nearby AGN that usually is referred to as the narrow line region. Since the sizes of the emitting regions are wavelength dependent, microlensing by stars in the lens galaxy will lead to a wavelength dependent magnification. The geometries of the line and the continuum emission regions are in general different and there may be a variety of geometries depending on the type of AGN (i.e., spherical, disk-like, cylindrical, etc.).

On the other hand, in some cases the potential of the lens galaxy may be perturbed by small satellite galaxies or globular clusters (millilensing). These perturbations will add additional complexity to the magnification function.

Here we consider the influence of (milli/micro) lensing on the spectra of lensed QSOs. We propose a method for the observational detection of microlensing and millilensing in the spectra of lensed QSOs and apply it to the spectra of the three lensed QSOs (PG 1115+080, QSO 1413+117 and QSO 0957+561) observed with Hubble Space Telescope (HST). We find that the flux ratio between images A1 and A2 of PG 1115+080 is wavelength-dependent and shows differential magnification between the emission lines and the continuum. We interpret this magnification as arising from millilensing. We also find that the temporal variations in the continuum of image C of QSO 1413+117 may be caused by microlensing, while the temporal variation observed in QSO 0957+561 was probably an intrinsic one.

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