Title:

On the origin of color anomaly between multiple images of lensed quasars

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Abstract

Utilizing achromatic properties of gravitational lensing, roughly 100 lensed quasars have been discovered until now. Although such lensed quasars are confirmed by spectroscopic studies, recent photometric observations reveal that there exists chromatic feature, i.e., color anomaly (or difference) between multiple images.

In this study, we try to reproduce observed color anomaly by numerical simulations that based on reliable physical models. To reduce uncertainties, we pick up 15 lensed quasars that the lens and the source redshifts have already been known and the photometric data with more than 3 HST bands is available.

Qualitatively, there are three possibility to explain observed color anomaly; (1) time delay plus intrinsic color change of quasars, (2) differential reddening due to lens galaxies, and (3) quasar microlensing. Thanks to the recent extensive studies done by SDSS, it becomes clear that the anomaly cannot reproduced by the first scenario. However, both of latter two scenarios successively reproduces the anomaly except a few special object.

To evaluate the second scenario, we have used an inhomogeneity of gas in a galaxy which obtained from a numerical calculation and realistic differential reddening are calculated through extinction laws that are investigated from observation of local universe. This calculation indicates that differential reddening are sufficient to explain the anomaly for the most of multiple quasars, qualitatively.

In contrast, we also evaluate the third scenario by using a standard theoretical model for quasar central engine and simple magnification property due to caustic crossing of quasar microlensing. This calculation indicates that quasar microlensings are also sufficient to explain the anomaly for the most of multiple quasars.

Therefore, we conclude that continuous monitoring of multiple quasars is necessary to separate these two effects and extract absorption nature of the lens, a galaxy and emission nature of the source, a quasar.