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EXTRAGALACTIC GRAVITATIONAL LENSES WITH THE GTC

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We present possible programs to analyze lens systems with the GTC. Firstly, redshift and stellar velocity dispersion of galaxies involved in gravitational lensing phenomena can be provided from spectroscopy. Secondly, we could use narrow-band images of lens systems covering a wide spectral range to obtain extinction curves of lens galaxies, macrolens flux ratios, and so on. Finally, we intend to study systems with particular difficulties (very faint and/or extremely compact). In these cases, a Gravitational Lenses service program would be suitable to measure time delays, discuss on microlensing variability, and the like.

1. REDSHIFT AND STELLAR VELOCITY DISPERSION OF LENS GALAXIES

When an extragalactic gravitational deflector (main lens galaxy and secondary lens galaxies) is placed between a far quasar and an observer on the Earth, the different light trajectories followed around the main deflector produce several components (images) of the same source quasar. The redshift of the main lens galaxy, the redshift of other lens galaxies at small angular distances from the gravitational mirage and the velocity dispersions of the stars within the involved galaxies are basic data necessary to analyze the system.

In the past, the Low Resolution Imaging Spectrometer (LRIS) at the Keck II 10 m telescope was used in various GL (Gravitational Lenses) programs to measure these physical quantities related to galactic distances and masses (e.g., Falco et al. 1997; Kundic et al. 1997a,b; Tonry 1998; Tonry & Franx 1999).

In a near future, the OSIRIS instrument at the GTC telescope must be able to provide spectroscopic information with similar or better quality to the previously obtained one with LRIS (see Table 1).

2. MULTIWAVELENGTH IMAGING OF QUASAR COMPONENTS

Given a gravitational mirage with N components, we can study the magnitude differences between the components i and j at the same time of emission and several wavelengths covering a wide spectral range (see Falco et al. 1999). For this purpose we cannot collect all photometric data at a single epoch. First, we must measure the magnitudes of a component (i) at a time and, later, the magnitudes of the another one (j) at a different date. In this way, we take into account the time delay between both signals.

In general, these magnitude differences will depend on a constant macrolens flux ratio, a chromatic and time dependent microlensing perturbation and a chromatic differential extiction in the lens galaxy. In the Galaxy, typical paths have a ratio of total to selective extinction (R_V) of about 3.1 (modest value), while paths through denser, higher extinction regions can reach values of $R_V > 5$.

Physically, the extinction curve depends on the size and composition of the dust grains along the line of sight. Lower R_V values should correspond to smaller dust grains.

In a first approach, one may neglect possible gravitational microlensing effects and use R_V-dependent extinction laws (Cardelli et al. 1989) which are identical for both components. From the observations and this framework, we are able to fit three physical parameters: the macrolens flux ratio, R_V and a differencial extinction parameter. The approximation reliability can be tested from the estimate of the chi-squared value, the agreement/disagreement between the best fit for R_V and the R_V values for other galaxies, and the comparison between the obtained macrolens flux ratio and the flux ratio at radio wavelengths (if it is available).

We think that the methodology is a powerful tool to discuss on the interstellar medium of main lens galaxies and to find macrolens flux ratios. On the other hand, OSIRIS has tunable filters with FWHM from 1 to 70 Amstrongs over the whole optical wavelength range, and, therefore, tunable imaging of two QSO components at two different epochs may lead to relevant information about the dust in the main lens galaxy and the macrolens flux ratio for that system.

TABLE 1

A COMPARISON BETWEEN LRIS (KECK II) AND OSIRIS (GTC)

PARAMETER	LRIS (in GL projects)	OSIRIS
WAVELENGTH RANGE	310 nm - 1000 nm	365 nm - 1050 nm
FIELD OF VIEW	6' x 7.8'	8' x 5.2'
SLIT WIDTHS	0.7" - 1"	0.4" - 5"
PIXEL SIZE	0.211"	0.125"

3. MULTIBAND MONITORING OF FAINT AND/OR COMPACT SYSTEMS

Some gravitational lens systems have very faint QSO components and/or are extremely compact. In order to obtain multiband light curves of these systems, we need excellent telescopes, cameras and seeing conditions. Thus, taking into account that the Roque de los Muchachos is a privileged observatory with regard to atmospheric seeing, the OSIRIS instrument is able to monitorize a wide field (8.53' x 8.53' in direct imaging) at different optical bands and with very good angular resolution (0.125 arcsec/pixel), and the light collection in the 10 m telescope will be extraordinarily efficient, we conclude that the GTC could be an ideal laboratory to follow up QSO variability in special cases.

In conclusion, a Gravitational Lenses service program to study systems with particular difficulties with the GTC (several minutes per night) would be suitable to measure time delays, discuss on microlensing variability, and so on. This special program may complement the current service time programs to monitorize "normal" lens systems. Fig. 1 shows a frame of the double system QSO 0957+561 taken at the Apache Point Observatory (USA).

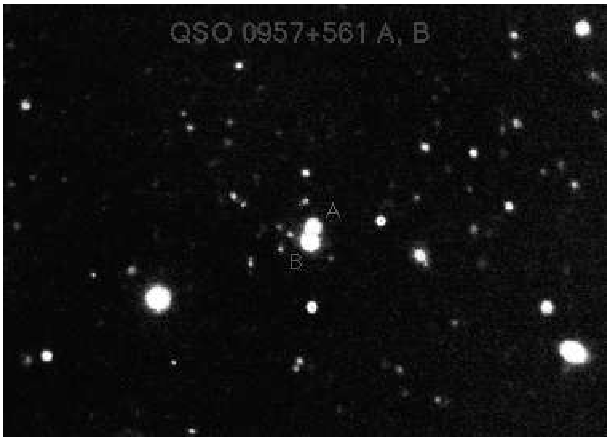

Fig. 1. GRAVITATIONAL LENS SYSTEM Q0957+561 (from the Gravitational Lens Monitoring Project, http://www.apo.nmsu.edu/Projects/Lens/lens.html)

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