The Magellanic Quasars Survey

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The Magellanic Quasars Survey (MQS) has now increased the number of quasars known behind the Magellanic Clouds to **~800**! All survey fields in the Large Magellanic Cloud (LMC) and 70% of those in the Small Magellanic Cloud (SMC) have been observed. The targets were selected from the third phase of **the Optical Gravitational Lensing Experiment (OGLE-III)** based on their optical variability, mid-IR (from **the Spitzer Space Telescope**) and/or X-ray (from **ROSAT**) properties. We spectroscopically confirmed **758 (565 LMC and 193 SMC)** quasars behind the Magellanic Clouds, of which **713 (527 LMC and 186 SMC) are new**. The MQS quasars have long-term (12 years and growing for OGLE), high-cadence light curves, enabling unprecedented variability studies of quasars. The MQS quasars also provide a dense reference grid for measuring both the internal and bulk proper motions of the Clouds, and 50 quasars are bright enough (I<18 mag) for absorption studies of the interstellar/galactic medium of the Magellanic Clouds.

Quasar selection methods

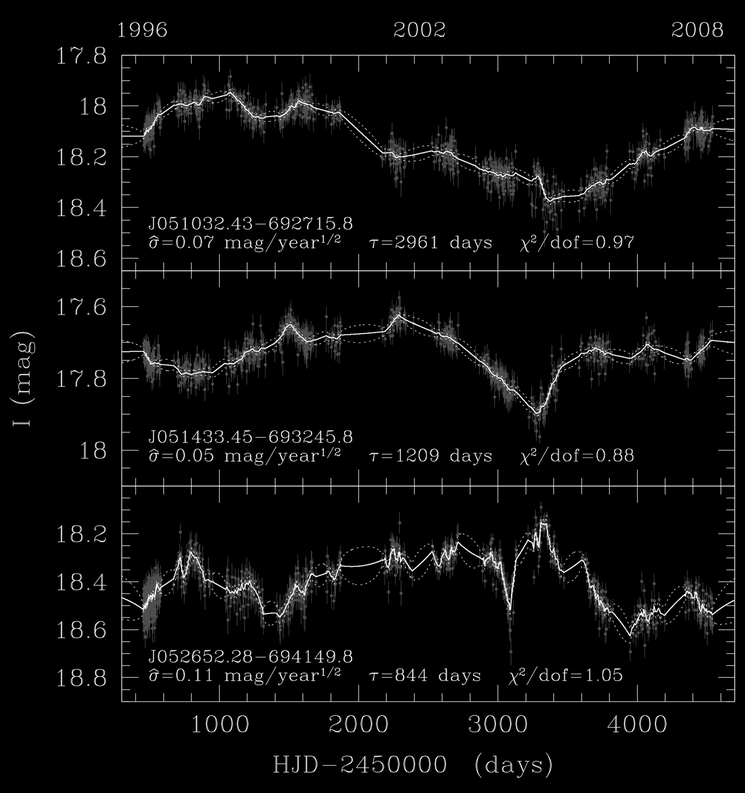
Standard optical color selection methods do not work for the Magellanic Clouds, but there are two alternative methods. First, objects with red mid-infrared colors (3.6 versus 4.5 microns) are either AGNs or the relatively rarer stars with warm dust – normal stars and galaxies are blue sources in these bands. The primary contaminants are AGB stars, young stellar objects (YSOs) and planetary nebulae (PNe), but these can be controlled with a few ancillary cuts, as we explored in Kozłowski & Kochanek (2009). Second, we can use the variability parameters (see the next box below) to identify sources varying like quasars. Here the contamination comes from irregularly varying massive stars, but most of the quasar parameter range differs from that of the stars, as we showed in Kozłowski et al. (2010). Individual methods typically have yields of order 30%, combinations of two methods have yields of order 55%, and combining them with the requirement of X-ray emission returns yield of 70%.

Quasar variability

How do you turn an apparently random wandering in quasar brightness into numbers that you can analyze and use as astrophysical tools? A solution was proposed by Kelly et al. (2009) who showed that individual light curves could be well modeled as a particular stochastic process, the damped random walk (DRW). This reduces the random wanderings of the light curve into two numbers, an amplitude (σ) and a time scale (τ), and Kelly et al. (2009) showed using a sample of about 100 AGN that these parameters appeared to be correlated with the physical properties of the AGNs.

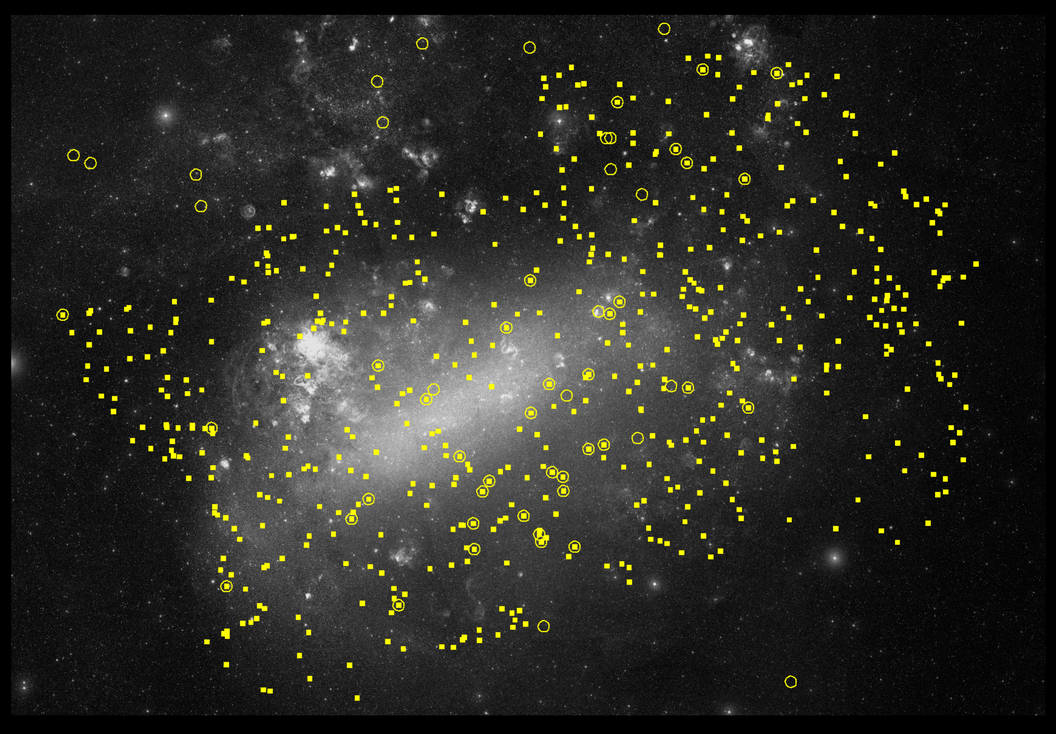
While the SDSS Stripe 82 quasar sample (9000 AGNs) is the largest and best available, the light curves are not very good – too few epochs and an effective duration too short to well-constrain the variability parameters of individual quasars.

There are, however, quasars with extremely well-sampled light curves – any quasars lying in the fields monitored by the microlensing surveys of the Magellanic Clouds. The OGLE survey currently contains 12-year-long continuously growing light curves with ~1000 epochs for millions of sources in the Magellanic Clouds.



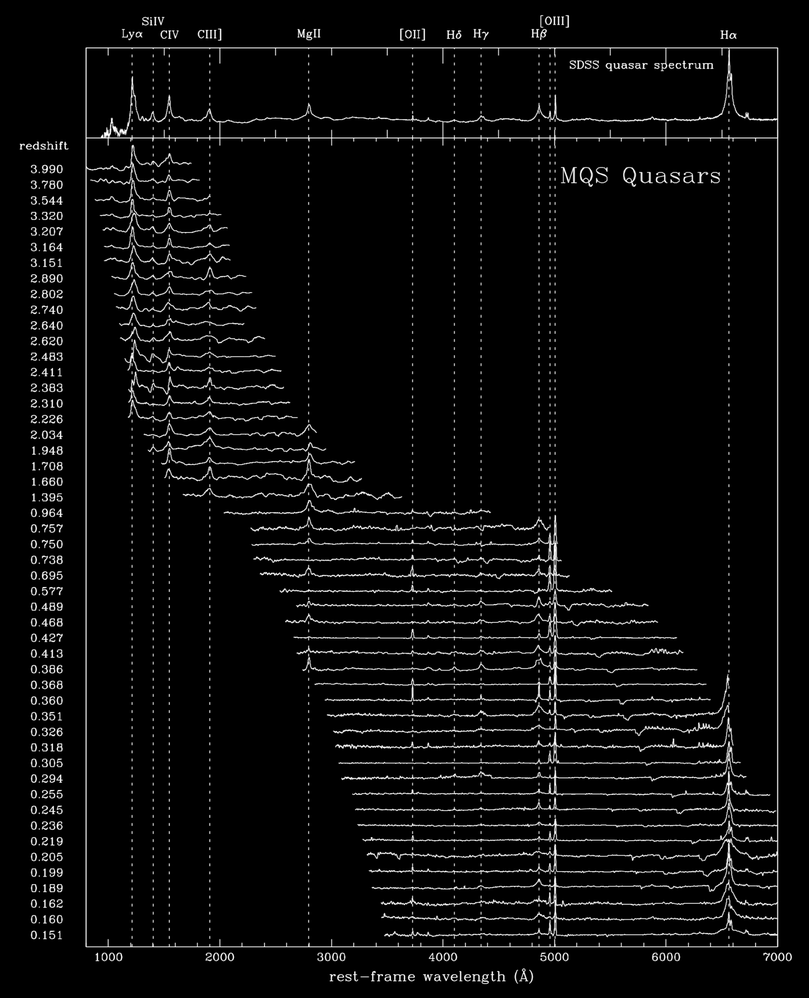
Examples of DRW models for three quasars from Kozlowski et al. (2010). The 12-year-long light curves are from the OGLE survey (years 1996-2008, separated with the seasonal gaps).

New quasars behind the LMC



The 565 MQS quasars (squares) and previously known quasars (open circles) behind the LMC are marked.

Spectra of new quasars



Rest frame spectra of 50 out of the 713 new LMC/SMC AGNs discovered by MQS. They have been spectroscopically confirmed with the 3.9 meter Anglo-Australian Telescope.

References: Kelly et al. 2009, ApJ, 698, 895 Kozłowski & Kochanek 2009, ApJ, 701, 508 Kozłowski et al. 2010, ApJ, 708, 927 Kozłowski, Kochanek & Udalski 2011, ApJS, 194, 22 Kozłowski et al. 2012, ApJ, 746, 27 Kozłowski et al. 2013, arXiv:1305.6927

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