New quasar survey with WIRO:
The light curves of quasars over ~15 year timescales

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Abstract

Quasars, a type of active galactic nuclei (AGN), are known to vary in brightness on timescales of days to many year. While it has been proposed that this variability is caused by instability in the accretion disk, disturbances propagating in the relativistic jets, Poisson processes, or microlensing, the exact cause remains mysterious. Understanding the physical mechanisms that drive quasar variability will require multiwavlength measurements of quasars over a wide range of timescales. In particular, the observations required to constrain longer timescales can be difficult to conduct. This summer ~1000 quasars in Stripe 82 were observed in ugriz wavelength bands using WIRO, the University of Wyoming's 2.3-meter telescope. Using these images, earlier data from the Sloan Digital Sky Survey's observations of Stripe 82, as well as various data reduction methods, the quasars' magnitude can be studied on an extended 3 day to 15 year timescale. Here, we present a subset of the light curves of ~1000 quasars observed in the ugri bands over the last 15 years.

Methods

For our study, we observed quasars located in a subset of SDSS's Stripe 82—between RA of 315 and 330 degrees and Declinations of 0 to 1 degree. Each 39' field was observed twice at WIRO in the ugriz filters with a 5 minute exposure. Subsequent observations took place 2 to 4 days after the first. Data was processed by removing telescope biases, flat-fielding images, and fringe correcting where necessary. Using the SDSS database and catalogs of known standard stars, Sloan stars were matched with those in WIRO fields. A linear curve was fit to the data, modeling the magnitude variation in standard stars. This function was used to finish calibrating our quasar data, ensuring that variability was intrinsic to the source and not bias from the telescopes or sky conditions.

Finally, we combined our data-set with that on the SDSS server, extending the 8 year SDSS survey to longer timescales; using the magnitudes from SDSS as well as those collected at WIRO, we constructed light curves of quasars over a 15 year period.

Results

We present a few representative light curves of the ~1000 quasars observed for this study. Figures 1-4 depict those of four objects observed this summer in ugri bands. Data points between MJD 52000 and 55000 are those taken from SDSS while those around 57500 represent follow-up observations taken at WIRO.

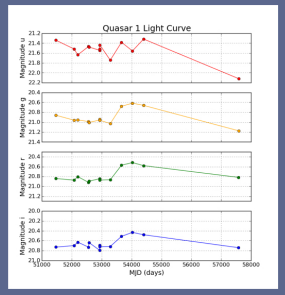

Figure 1: Light curves of quasar located at (318.10, 1.3085) with z=2.240

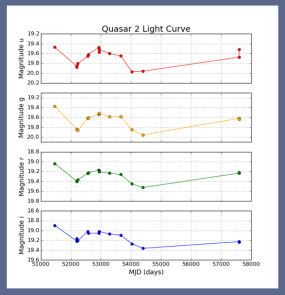

Figure 2: Light curves of quasar located at (318.32, 1.1358) with z=1.476

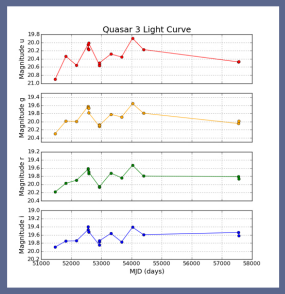

Figure 3: Light curves of quasar located at (323.86, 0.7267) with z=1.462

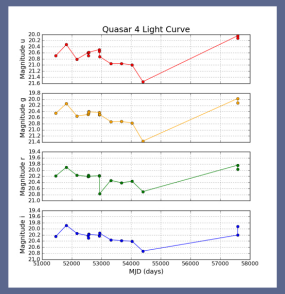

Figure 4: Light curves of quasar located at (320.28, 0.1083) with z=1.241

Conclusion

Over the summer of 2016 we successfully observed ~1000 known quasars in Stripe 82, calculating their magnitude in multiple bands on two subsequent nights. Using data from SDSS, we created light curves for these quasars over the 15 years of observation. From these curves, we can see evidence for variability on multi-year timescales. This variability seems to be dependent upon the timelag between observations—smaller magnitude differences are seen between neighboring data points while larger differences appear between more temporally distant observations. There also appears to be a dependence on wavelength. As evident in Figures 1-4, for a given quasar light curves in the u and g bands show larger variation than those in r and i. These correlations are in accordance with previous research, such as that done by Berk et al [1].

To better model the variability of these quasars, further work would include the creating a structure function, such as that of MacLeod et al [2]. Once the nature of the quasar structure function is constrained and well understood, it could aid astrophysicists in identifying or confirming QSO candidates. Further research could expose more information about quasar evolution and the forces responsible for their observed variability, providing us with a better understanding of our universe.

Acknowledgements

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References

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[2] MacLeod C. et all. 2012, AJ, astroph[1112]

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