Changing-Look QSOs in SDSS and Pan-STARRS

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Overview

- We present the serendipitous discovery of the changing-look quasar (CLQ) PS1-J081916 at *z* = 0.43 found by targeting SDSS galaxies with large-amplitude brightening in Pan-STARRS1 (PS1).
- We report results from a ***systematic search*** for CLQs based on repeat photometry from SDSS and PS1, along with repeat spectra from SDSS and SDSS-III BOSS.
- We find 11 examples of quasars that have variable and/or "changing-look" broad emission line (BEL) features in the redshift range 0.20 < z < 0.63.
- Using our selection criteria, we estimate that 10% of quasars exhibit CL behaviour over 5 to 8 years.

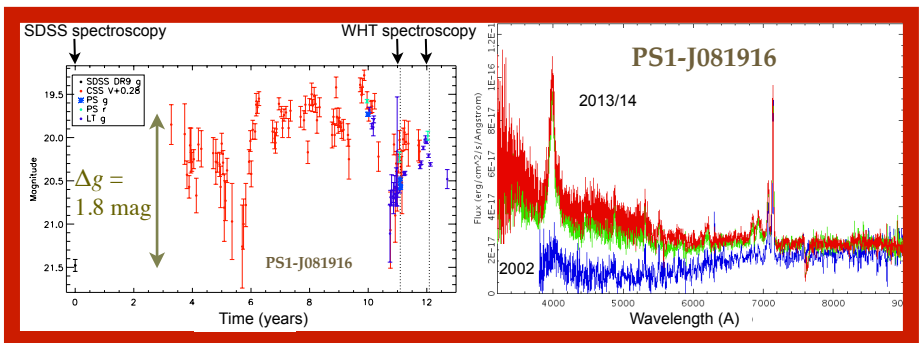

Fig 1. Light curve and spectra for PS1-J081916, which changed from an intermediate type AGN in 2002 to a Type 1 in the 2013 WHT spectrum.

Pan-STARRS "Transients"

Large-amplitude (Δm > 1.5 mag) nuclear brightening in faint extragalactic objects were discovered in Pan-STARRS-1 (PS1) 3π by comparing with the SDSS sky a decade earlier. Followup monitoring in *ugr* with the Liverpool Telescope (LT) combined with WHT spectroscopy identified a class[1] of extremely variable AGN, including J081916 at *z* = 0.43, shown above.

Base selection:
- $m_{SDSS} - m_{PS1} > 1.5$ in *g* or *r*
- On the "good" list of FGSS[2] transients
- Within 0.5" of SDSS galaxy

Systematic Search for CLQs

Motivated by PS1-J081916 and SDSS J0159+0033 (LaMassa et al. 2015), we searched for quasars with:

- |Δg| > 1 mag among any observations in SDSS and PS1
- In the SDSS DR7 quasar catalog (Schneider et al. 2010), with a later spectrum in BOSS (see Table 1).

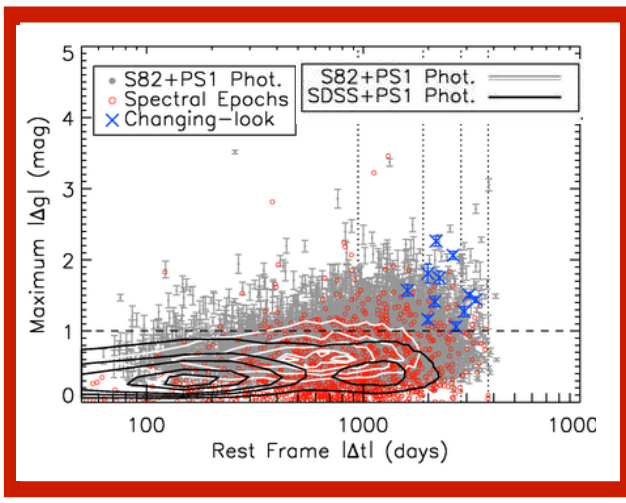

Fig 2. Distribution of max(|Δg|) vs. time lag for SDSS DR7 QSOs. The CLQs are shown as blue crosses, and are selected from objects with >1 spectra (red open points).

Selection	Total #	In S82
SDSS Quasars in DR7Q	105783	9528
with $\|\Delta g\| > 1$ mag and $\sigma_g < 0.15$ mag	6348	1692
and that have BOSS spectra	1010	287
and that show variable BELs	11	8

Table 1. Selection of spectroscopically variable quasars.

Results from Systematic Search

Out of 1010 selected, we recover SDSS J0159+0033, and we find a total of 11 CLQs:
- 5 with ***emerging*** BELs (e.g., **Fig. 3** *top panel*)
- 5 with ***disappearing*** BELs (e.g., *middle panel*)
- one with ***both*** emerging and vanishing BELs (*lower panel*)

The results will be published in MacLeod et al. (2015).

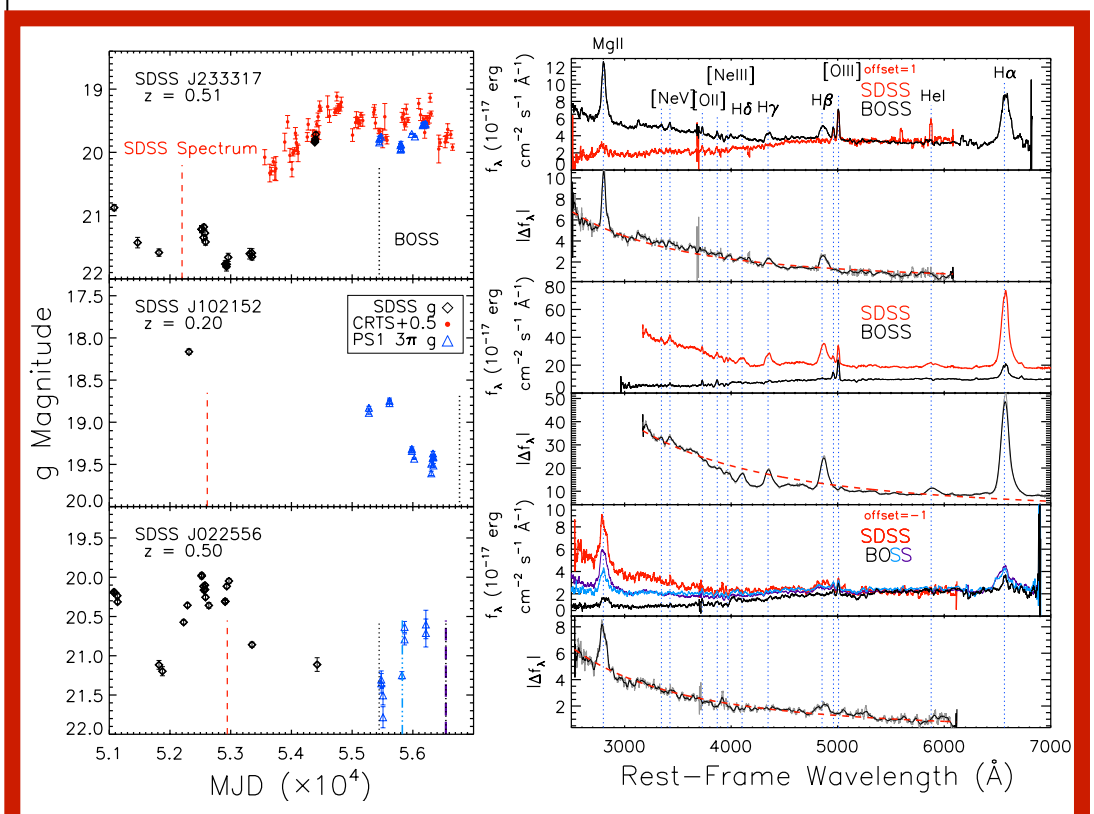

Fig 3. Three example CLQs. Light curves are shown on the left, and repeat SDSS and BOSS spectra are shown on the right, along with their flux difference in the lower panels.

Changing Mass Accretion Rate?

The two most likely possibilities for CLQ behavior are a:
- change in *obscuration* on timescale or
- change in *accretion rate* and/or *irradiating flux*.

Simple dust reddening models fail to simultaneously account for the diminishing continuum and BELs in J1021+4645 (middle panel of Fig. 3), and a more complex model for intervening material is needed. Elitzur, Ho, & Trump (2014) provide a scenario where AGN evolve naturally from Type 1 ➔ 1.2/1.5 ➔ 1.8/1.9 as the accretion rate diminishes. However, the timescale associated with an accretion rate change seems too long unless one considers a disk reprocessing scenario, where the optical-emitting region is irradiated by the central X-ray/EUV source (e.g., Cackett et al. 2007, Shappee et al. 2014).

Footnote 1: Lawrence et al. 2015, MNRAS submitted.
Footnote 2: http://star.pst.qub.ac.uk/sne/ps1fgss/psdb/

References

Elitzur, Ho & Trump 2014, MNRAS, 438, 3340
Cackett et al. 2007, MNRAS, 380, 669
LaMassa et al. 2015, ApJ, 800, 144
MacLeod et al. 2015, *under PS1SC review*
Shappee et al. 2014, ApJ 788, 48

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