

Studying the “Changing Look” Quasar SDSS-RM RMID 017

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Outline

- An Introduction to Quasars and Hypervariability
- Why the Standard Thin Disk Does Not Work
- The Case of SDSS-RM RMID 017
- My Project: Can a Reprocessing Hemisphere Work?
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 - Some Preliminary Tests



An Introduction to Quasars and Hypervariability

- **Quasar** - an extremely luminous **Active Galactic Nucleus (AGN)**
- We have long seen coordinated variations in the optical/UV that look like reprocessing (Clavel+ 1991, Peterson+ 1991, Krolik+ 1991, etc.)
- A small fraction of quasars exhibit large optical luminosity variations of factor greater than 2 → **hypervariable quasar**
- Rarely, they show appearance/disappearance of one or more broad emission lines; associated with factor of around 10 variations → **“changing look” AGN/quasar**



Why the Standard Thin Disk Does Not Work

- The optical/UV emission of quasars has long been known to vary, but typical variations are about 10-20% on month to year timescales
- Standard thin accretion disk theory (Shakura & Sunyaev 1973) predicts $10^4 - 10^6$ year inflow time, but we see hypervariability on much shorter timescales
- The picture of small amplitude variability on top of slow intrinsic accretion power variability doesn't work anymore!



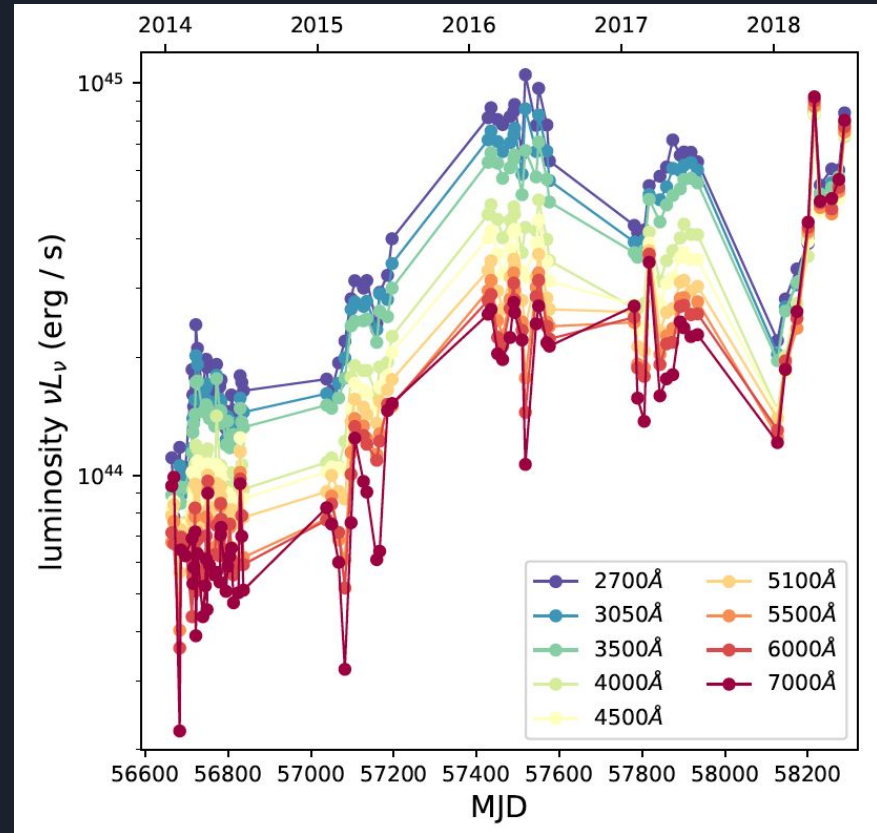
The Case of SDSS-RM RMID 017

- SDSS J141324 +530527 or SDSS-RM RMID 017 was recently identified as a changing look quasar
- Broad H-alpha and H-beta lines increased in strength with a large change in continuum luminosity in 2017 (Wang+ 2018)
- Included in the SDSS Reverberation Mapping campaign; has been monitoring 849 quasars with optical imaging and spectroscopy since 2014
- As part of this campaign, we have optical and spectral data for this object for 2009 - 2018 (Dexter+ 2019)

The Case of SDSS-RM RMID 017

- Optical photometric data for RMID 017 between 2014 and 2018
- Large variability of factor ~ 10 in this short time period
- Coordinated variations throughout the entire optical spectrum that looks like reprocessing

Figure taken from Dexter+ 2019





My Project: Can a Reprocessing Hemisphere Work?

- Various physical pictures:
 - Massive outflows (Proga+ 2000, Laor & Davis 2014)
 - An elevated accretion disk (Begelman & Pringle 2007, Begelman+ 2015, Jiang+)
 - A tilted disk that warps and/or tears into rings (Pringle 1996, Nixon+ 2012, Liska+)
- An extremely simple model: a spherical shell reprocessing central UV or X-ray emission
 - Geometric reprocessing model in a thin disk (Shappee+ 2014)
 - We need reprocessing in a high covering shell of material around the quasar (Dexter+ 2019)



Assumptions and Set-up

- Geometry: hemisphere at a given, constant radius
- Newtonian gravity
- Zero albedo
- Everything is reprocessed!
- Planck function for a blackbody
- Geometric time delay:

$$\tau(R, \mu = \cos \theta) = \frac{R}{c}(1 - \mu)$$

- Effective temperature:

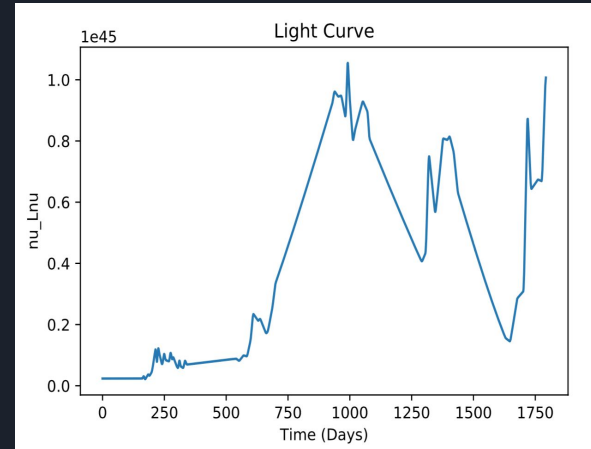
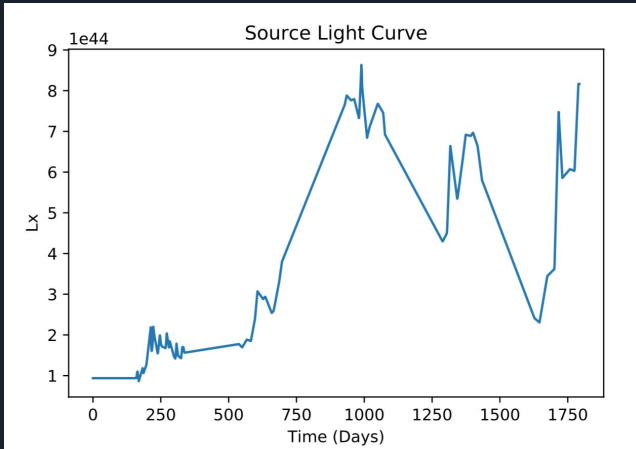
$$\sigma T_{\text{eff}}^4 = \frac{L_C(t - \tau(R, \mu))}{4\pi R^2}$$

- Specific luminosity:

$$\nu L_\nu(\nu, R, t) = \frac{(4\pi)^2 h \nu^4}{c^2} \int_0^1 \frac{R^2 d\mu}{\exp(h\nu/kT_{\text{eff}}(R, \mu, t)) - 1}$$

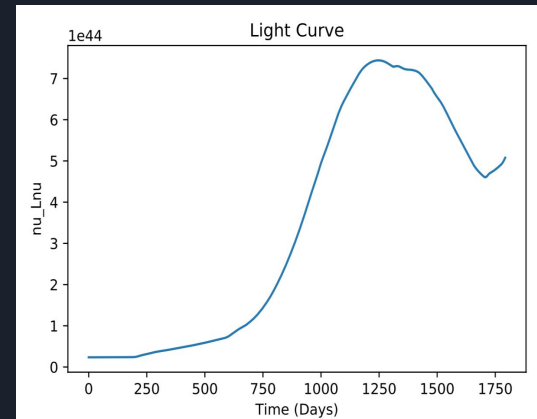
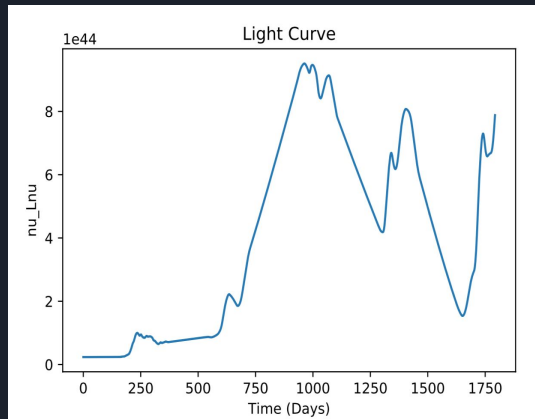
Preliminary Tests 1 - the "smearing"

Source



10^{15} Hz

$4 \cdot 10^{14}$ Hz

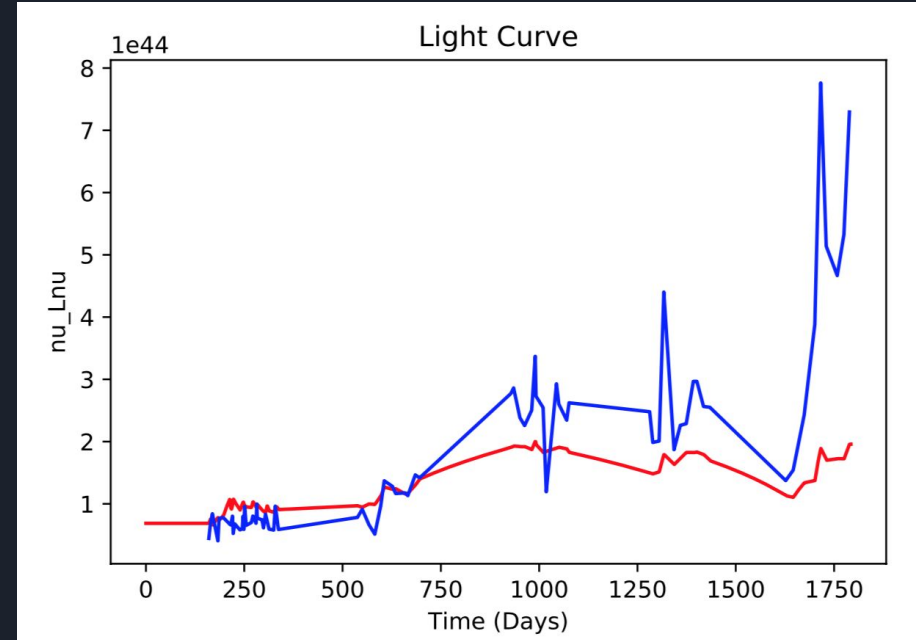
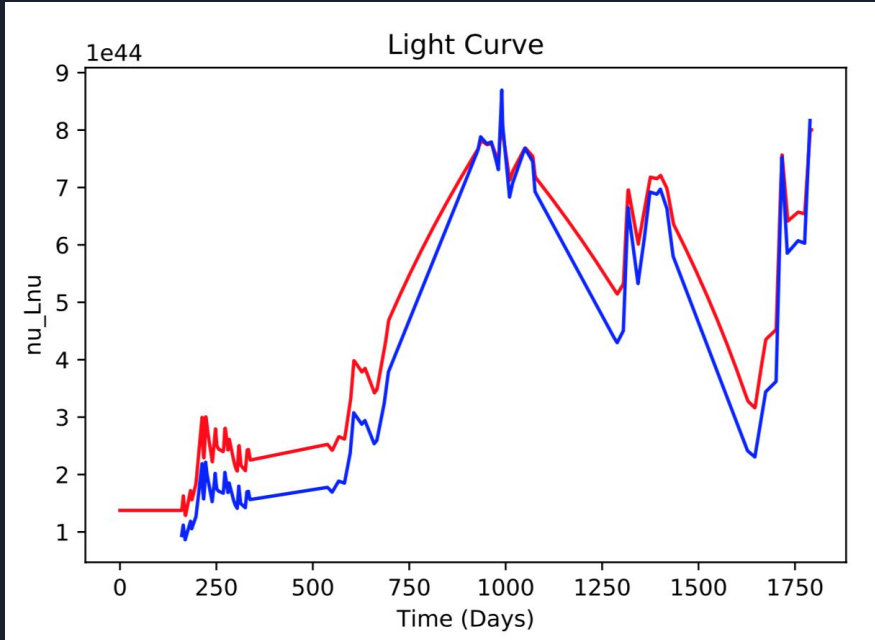


10^{14} Hz

Preliminary Tests 2 - amplitude matching

2700 Angstroms

5500 Angstroms



Red: predicted by model

Blue: observed data