

The Analogous Structure of Accretion Flows in Supermassive and Stellar Mass Black Holes

John Ruan

McGill University & McGill Space Institute

In collaboration with: Scott Anderson, Mike Eracleous, Paul Green,
Daryl Haggard, Chelsea MacLeod, Jessie Runnoe, Malgosia Sobolewska

Are AGN scaled-up versions of X-ray binaries?

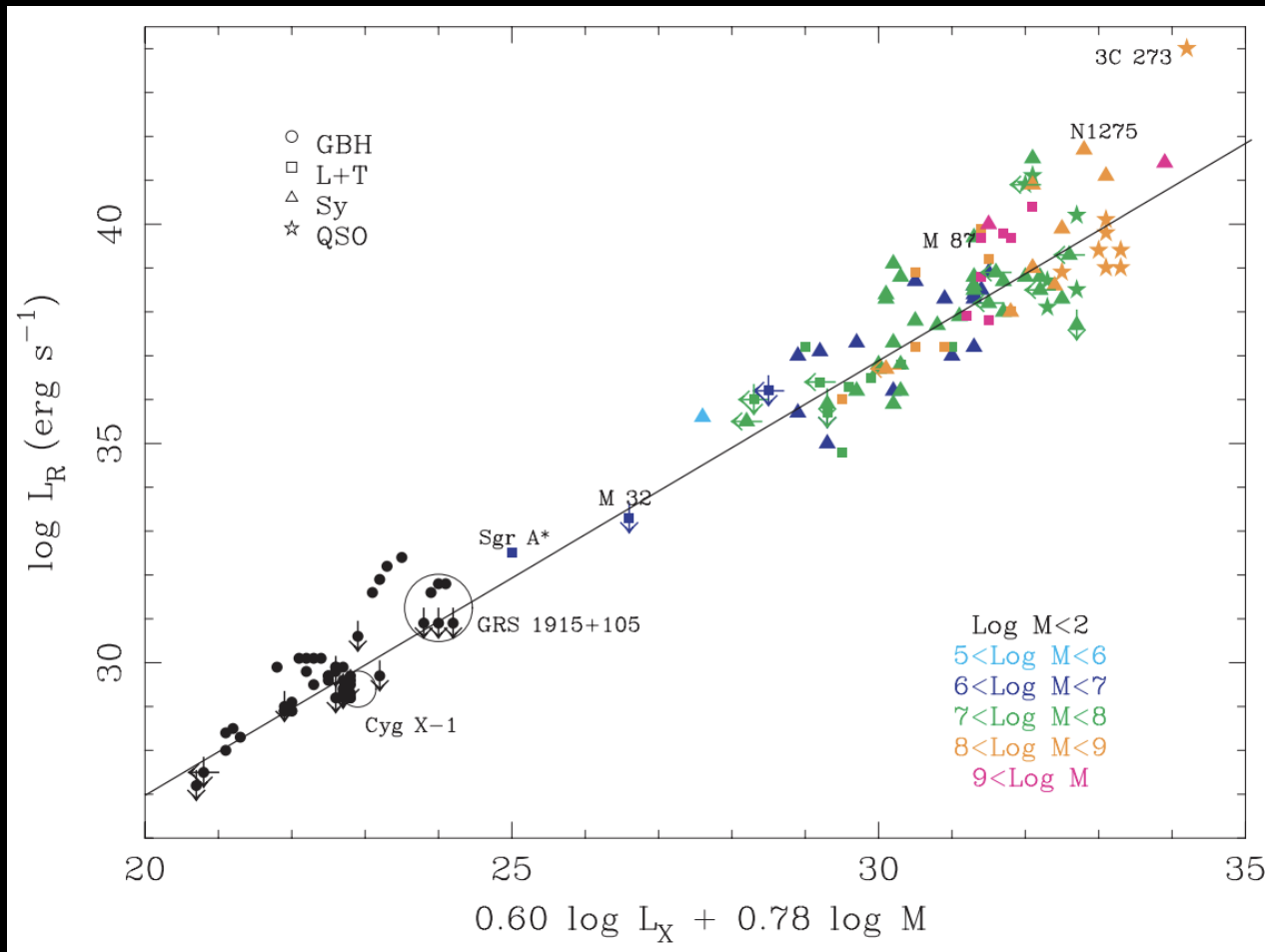
- To what extent are the structure of the accretion flows self-similar?
- Does this analogy hold in different accretion states?



Scaled up by 10^7 ?



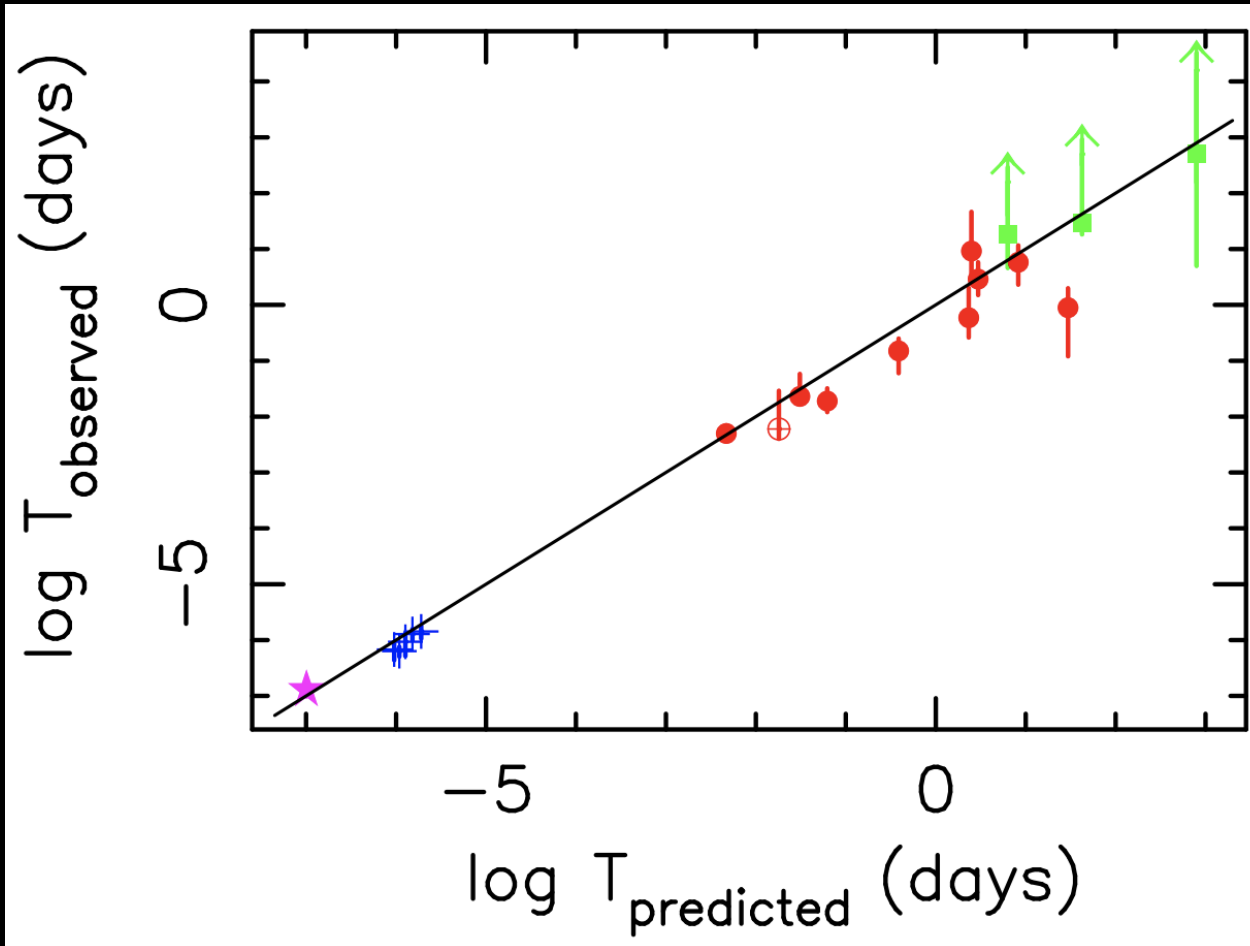
Fundamental plane of black hole activity suggests some link between low/hard state of X-ray binaries and low-luminosity AGN



- Relation between X-ray luminosity, radio luminosity, and black hole mass
- Only for low/hard state(?)
- Models suggest origin in self-similar jets or ADAF

Merloni+00,
Falcke+01

X-ray variability characteristic timescales also suggest some link between high/soft state of X-ray binaries and high-luminosity AGN



- Relation between X-ray characteristic timescale, X-ray luminosity, and black hole mass
- Only for high/soft state(?)

McHardy+06

Are AGN scaled-up versions of X-ray binaries?

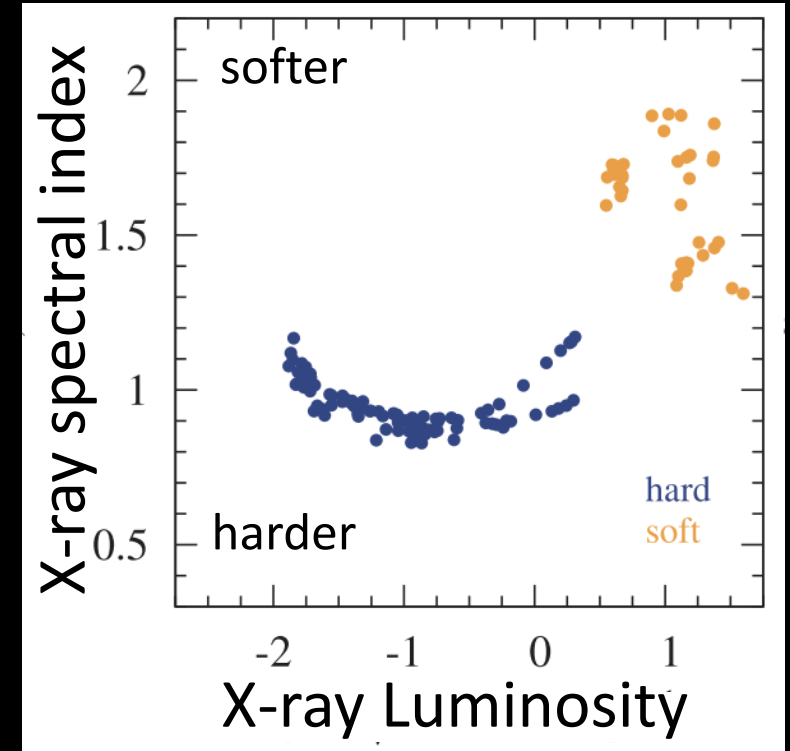
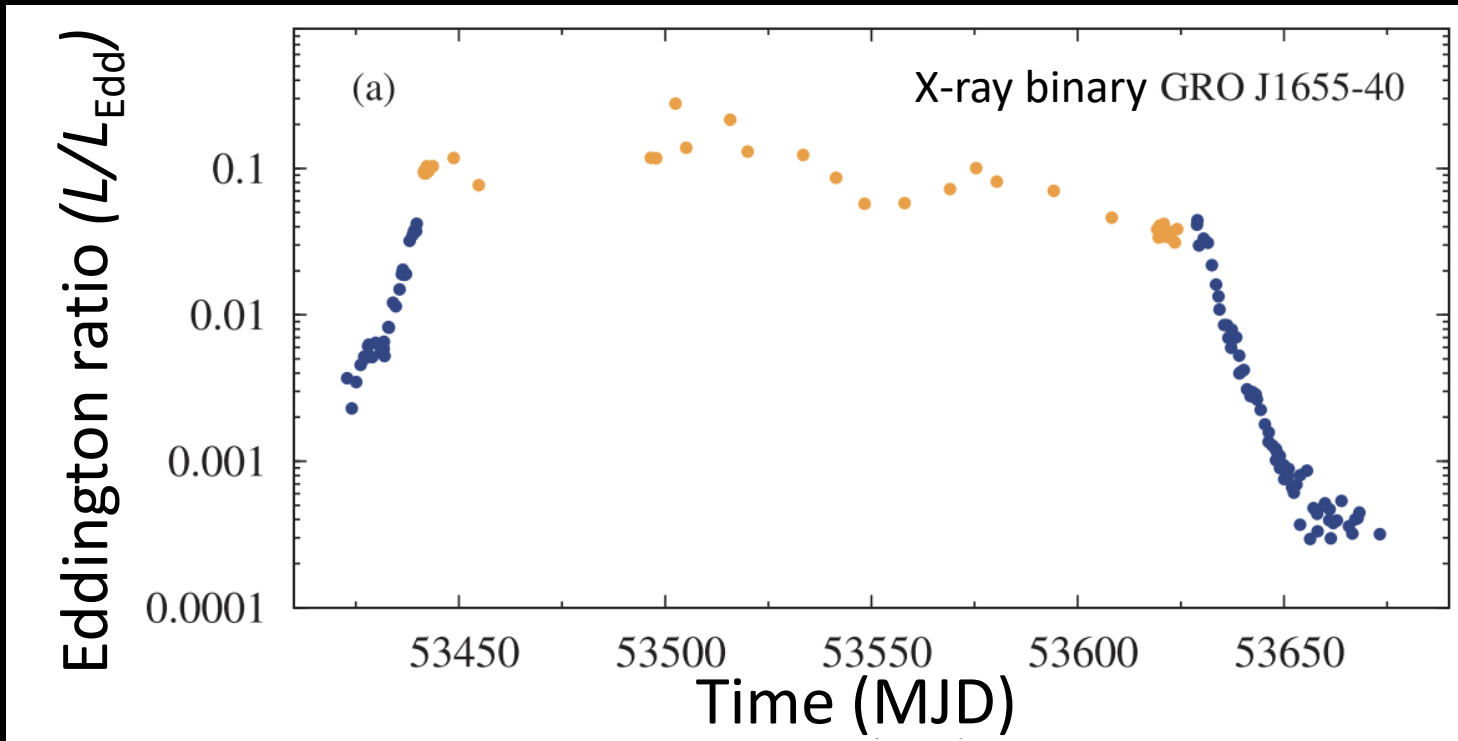
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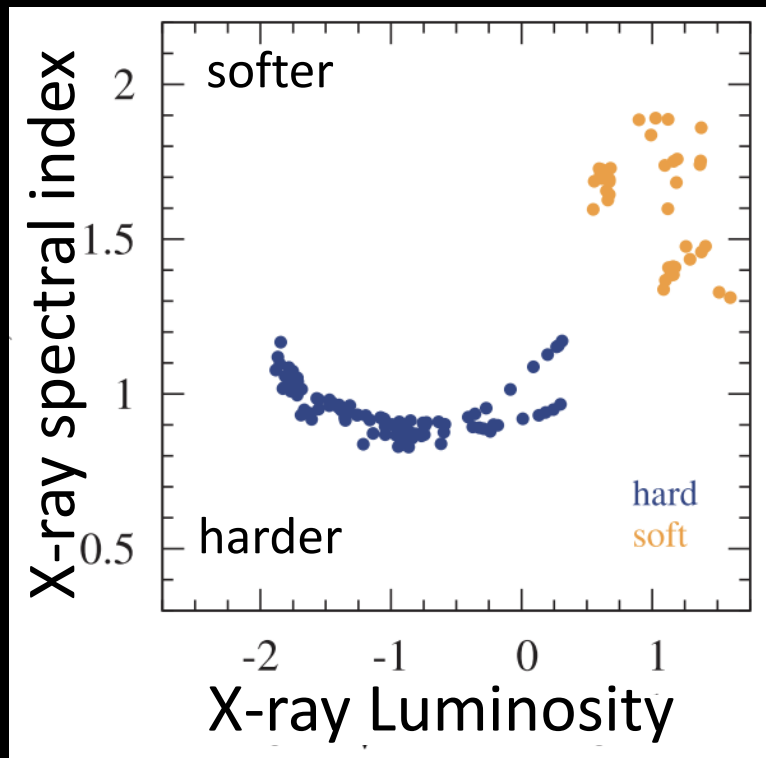


X-ray binaries in outburst display a characteristic spectral evolution

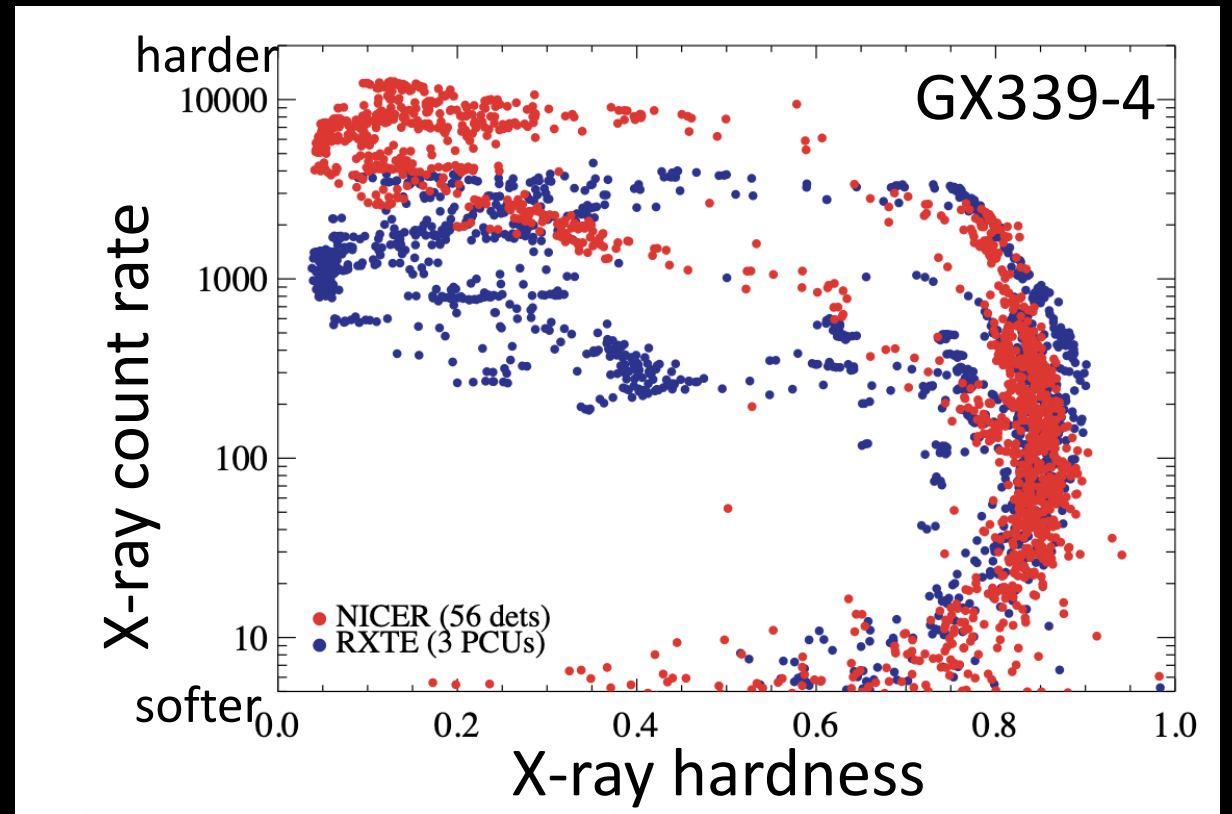


Sobolewska+11

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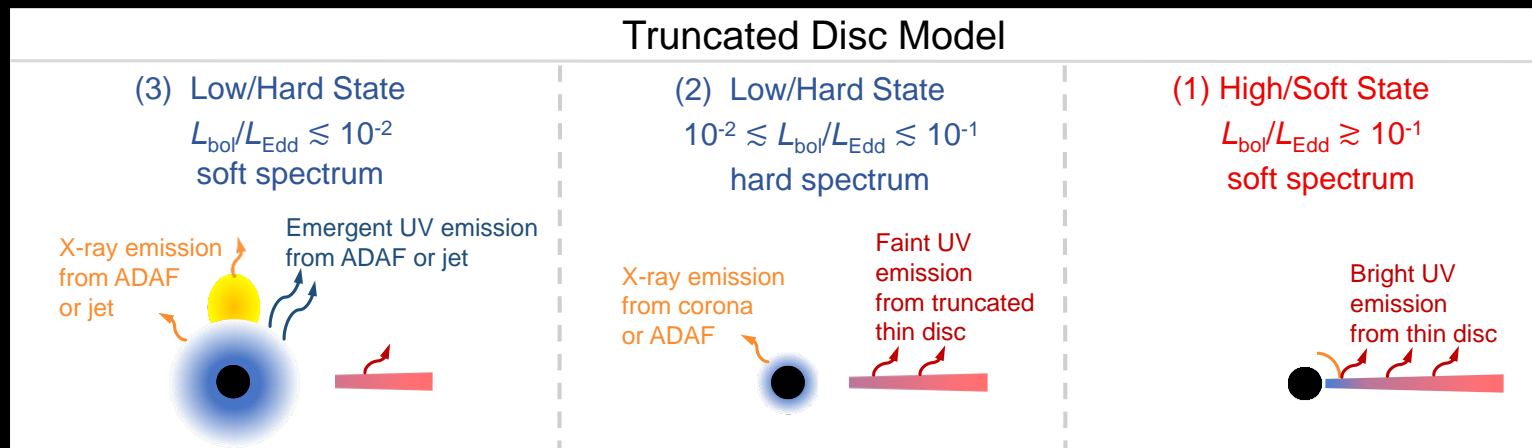
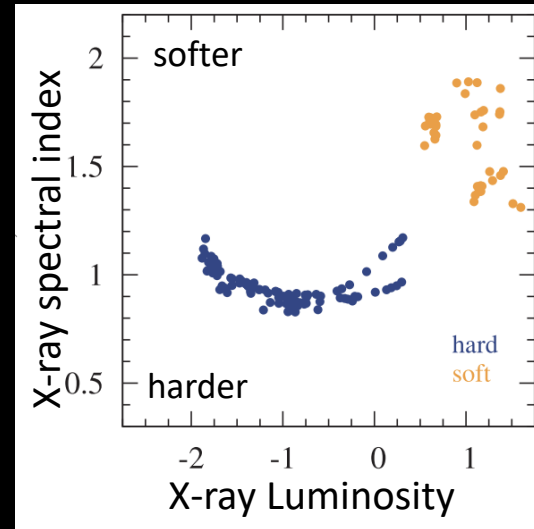


Sobolewska+11

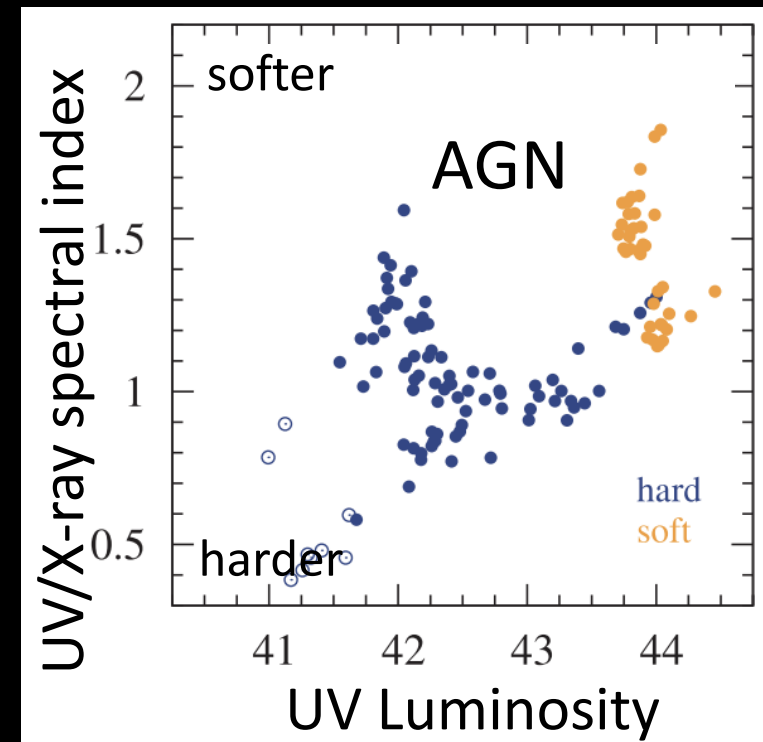
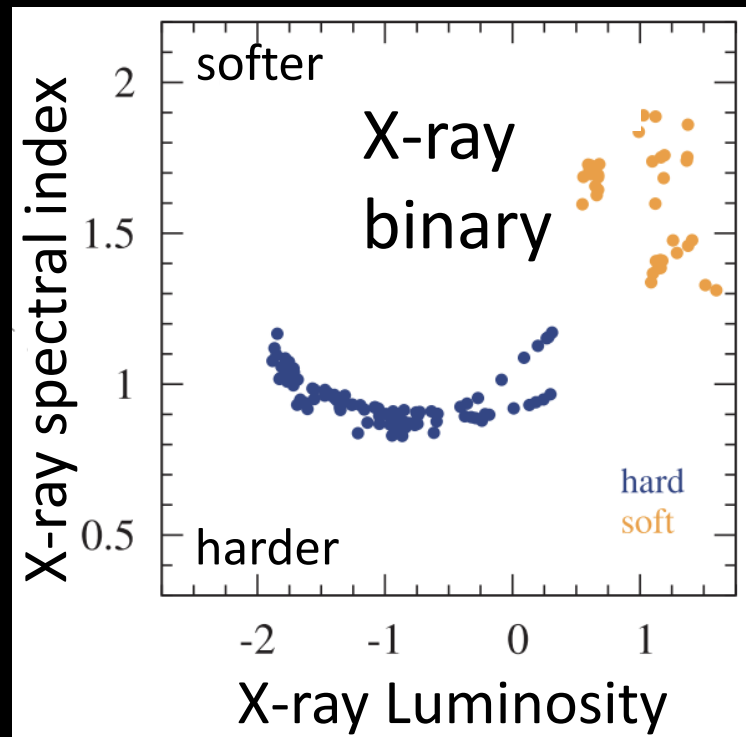


Courtesy of J. Steiner

The X-ray spectral index probes the evolution of their disk-corona system structure

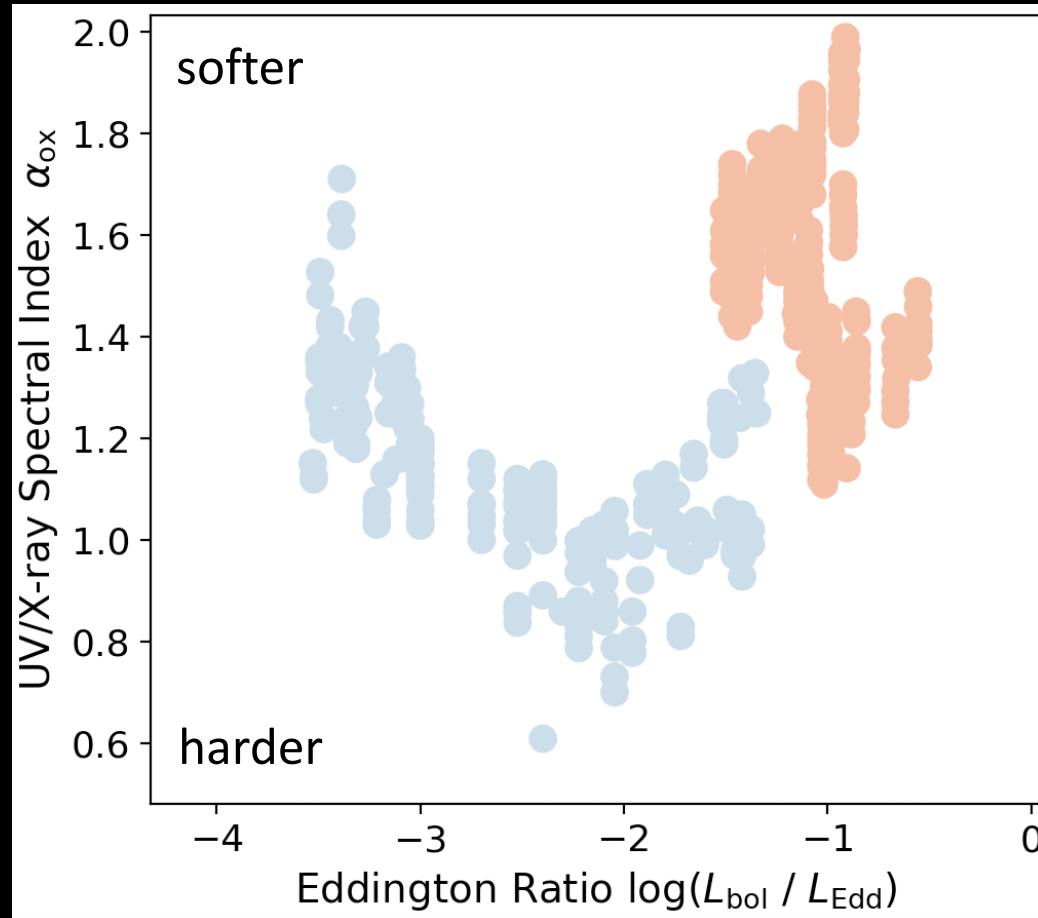


We can scale the disk and corona spectral components in X-ray binaries to predict what accretion state transitions look like in AGN



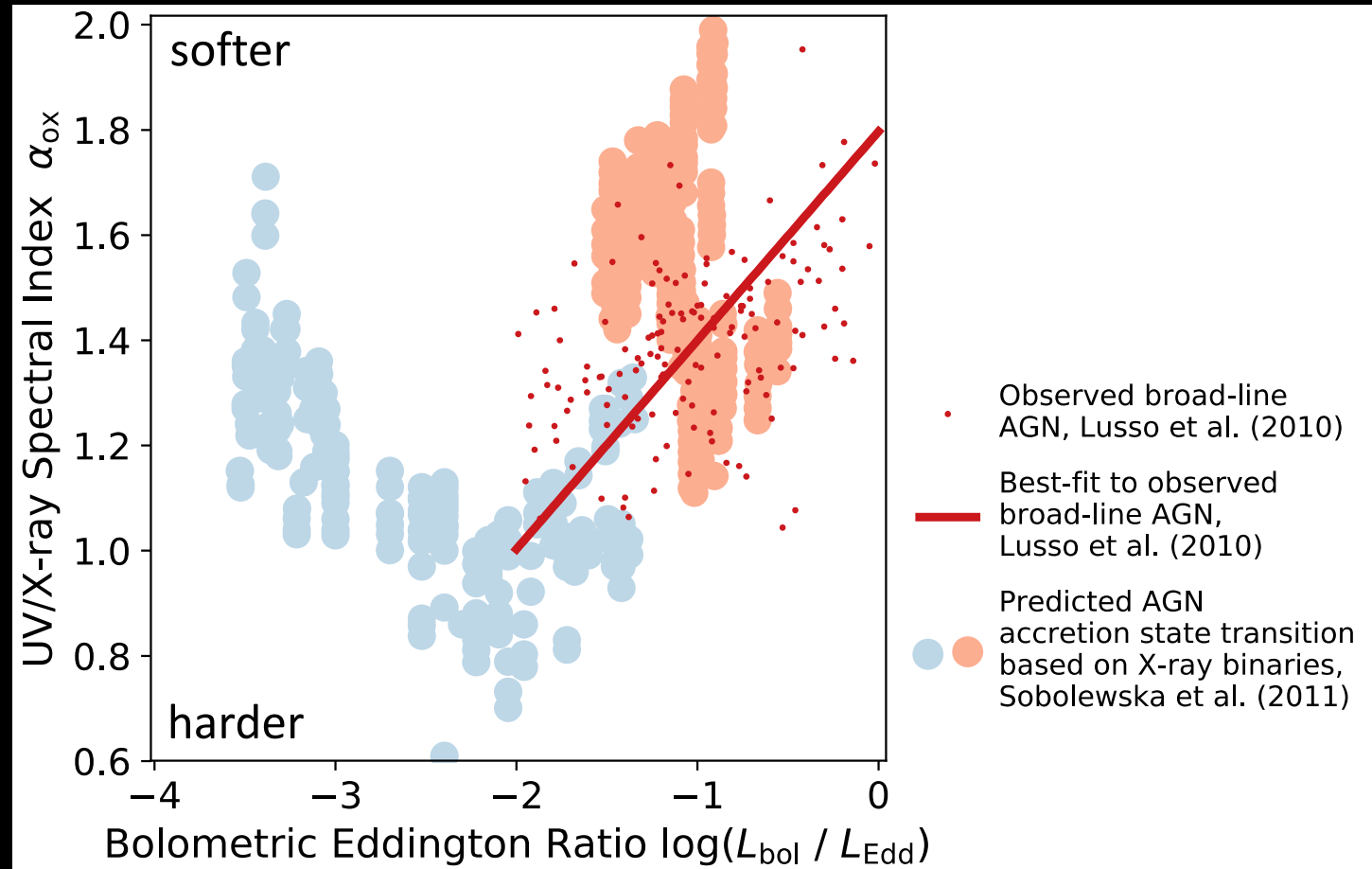
Sobolewska+11

Test AGN/X-ray binary analogy by direct comparison of their spectral evolution during state transitions

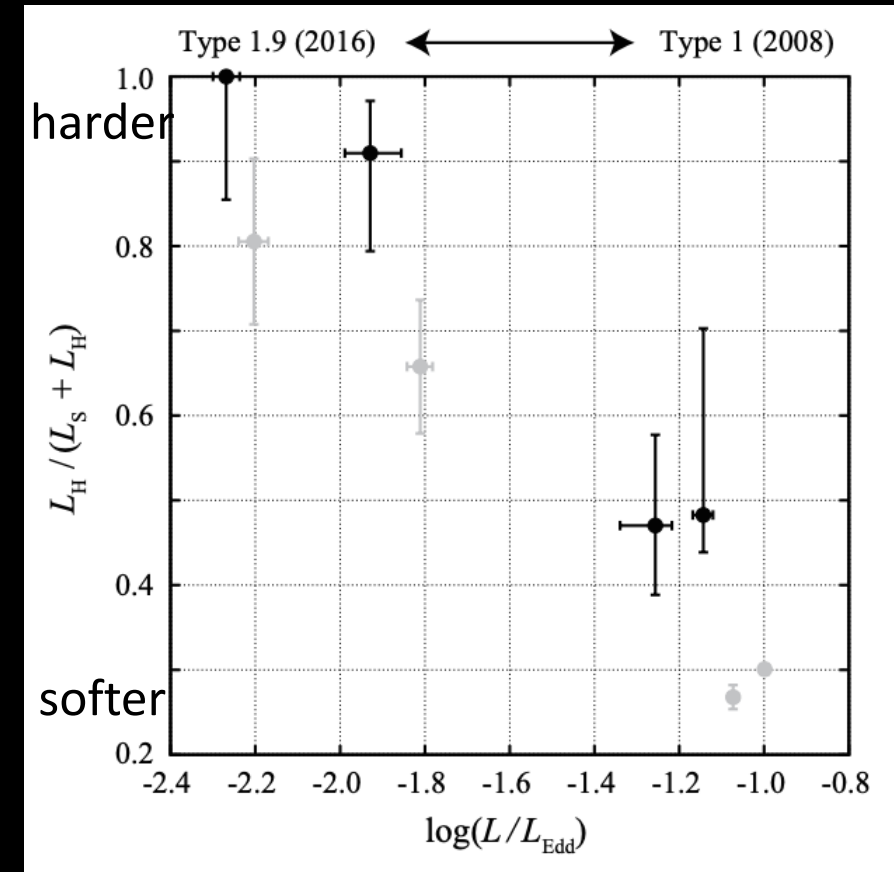
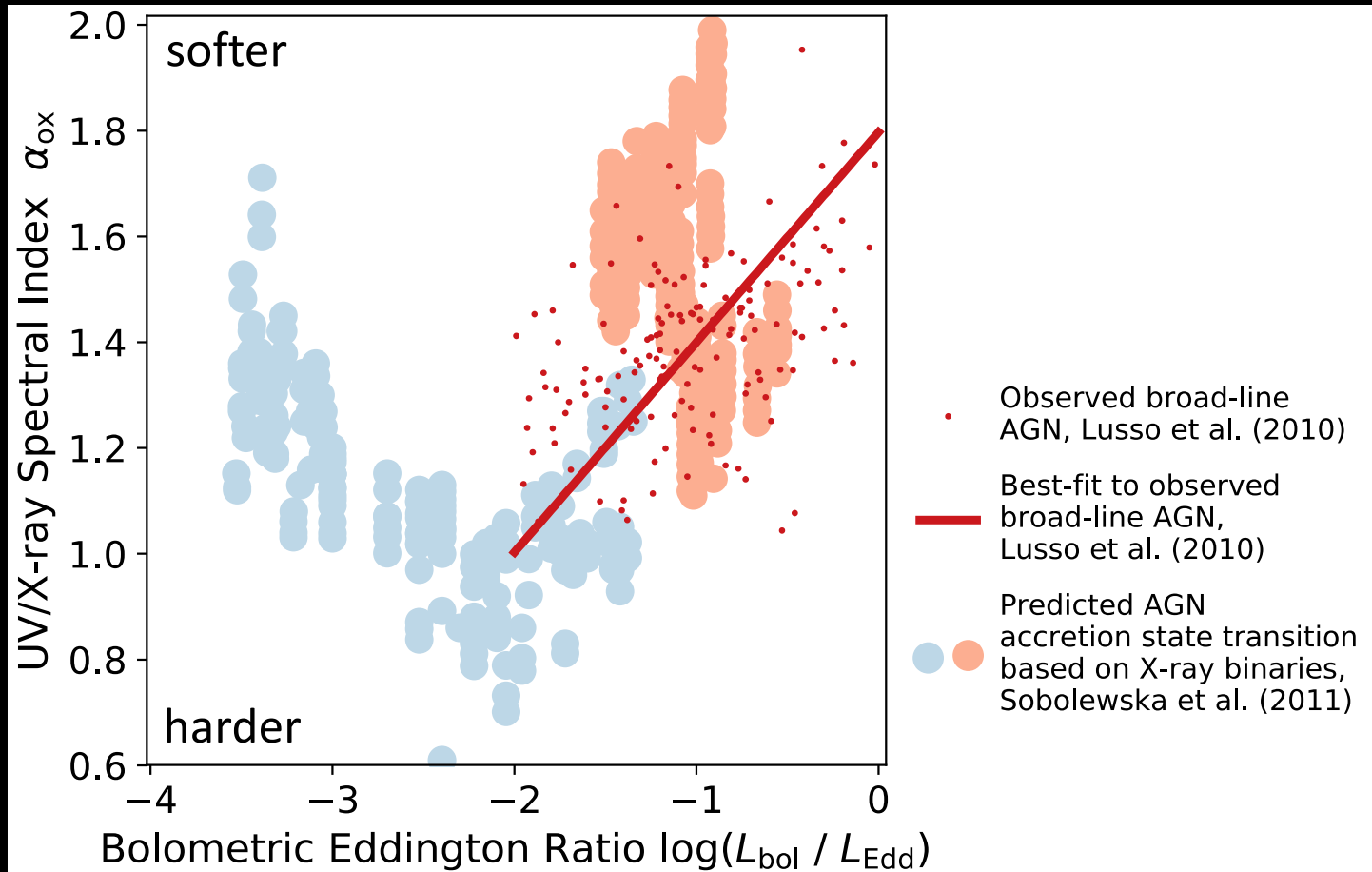


- 2 different approaches:
 - (1) Compare X-ray binaries to single-epoch observations of a *sample* of AGN that span a wide range of Eddington ratios
 - (2) Compare X-ray binaries to light curves of *individual* AGN undergoing large changes in Eddington ratio

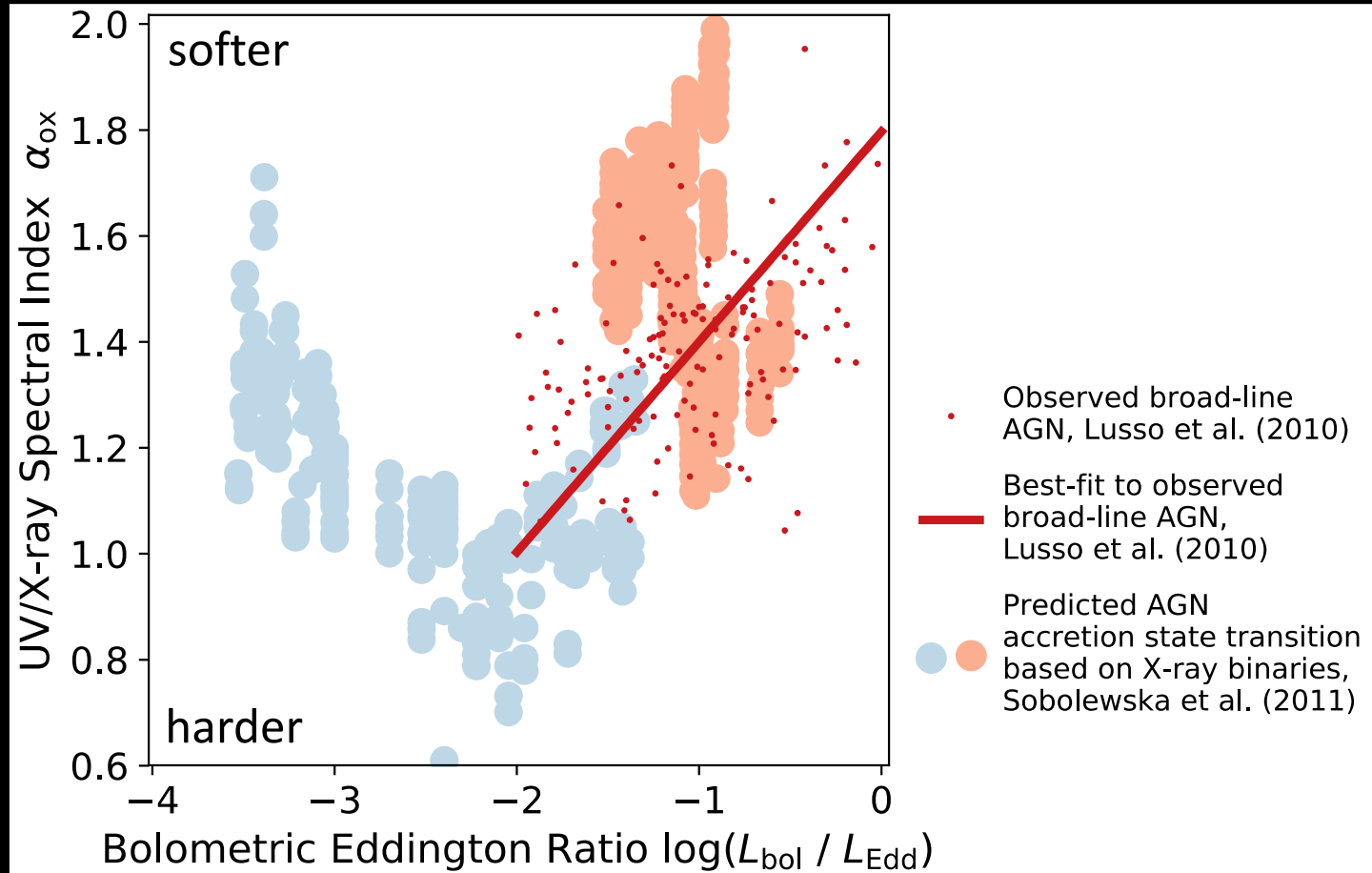
Approach 1: Compare X-ray binaries to single-epoch observations of a *sample* of AGN that span a wide range of Eddington ratios



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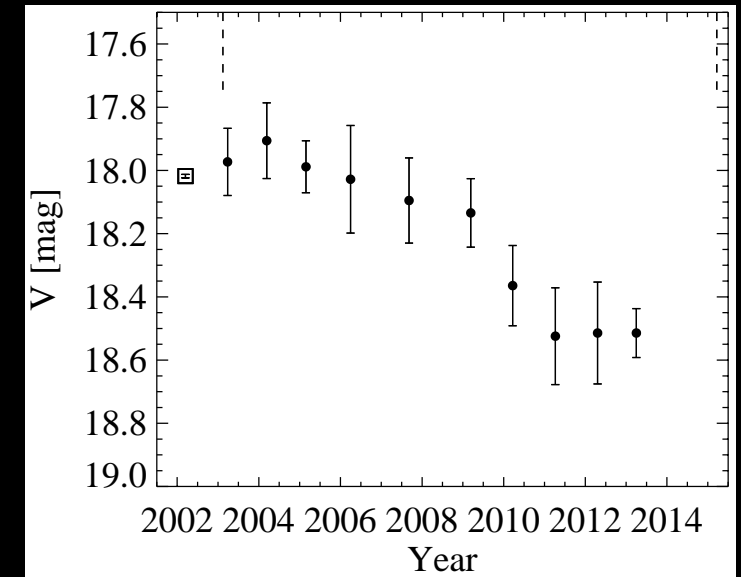
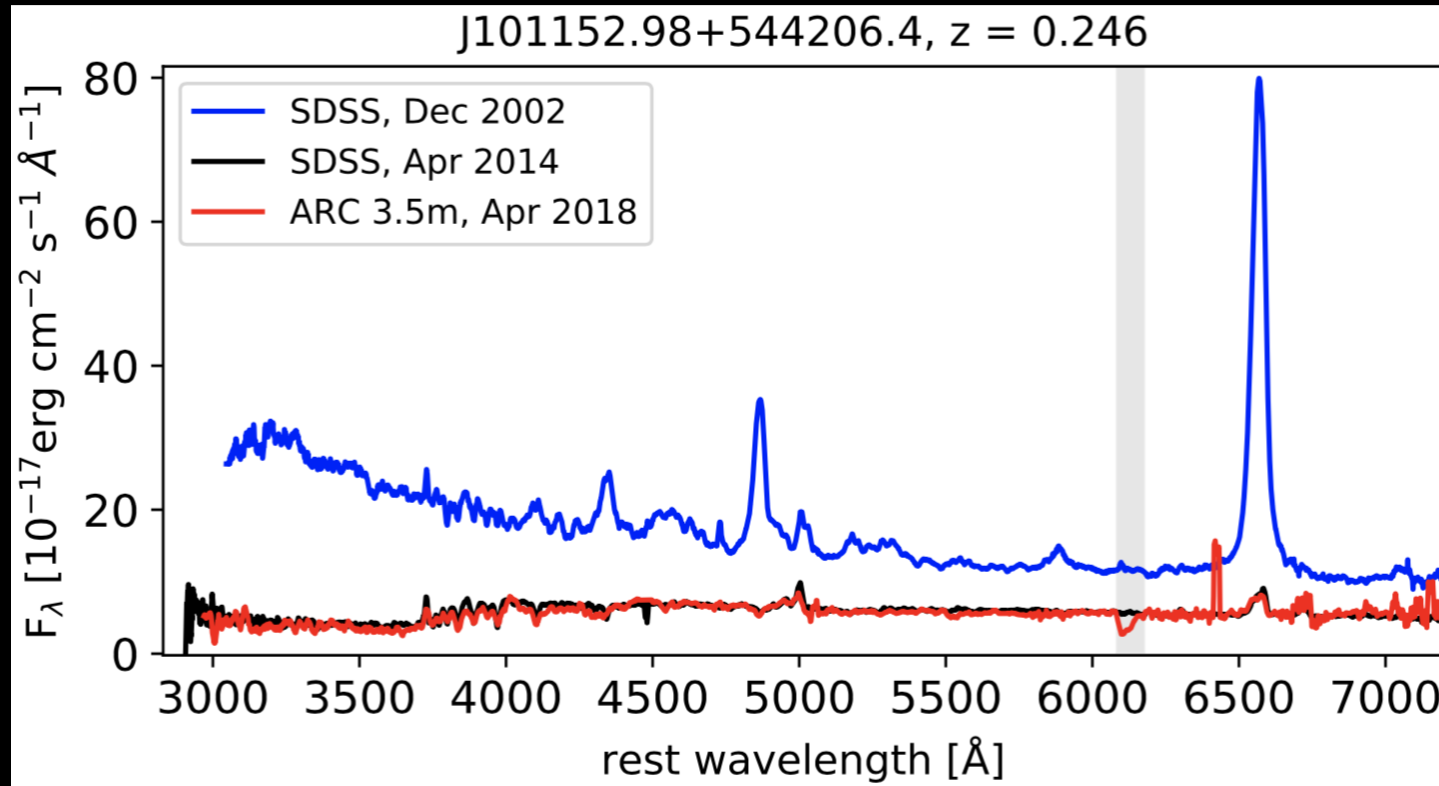
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2 problems at lower L/L_{edd} :

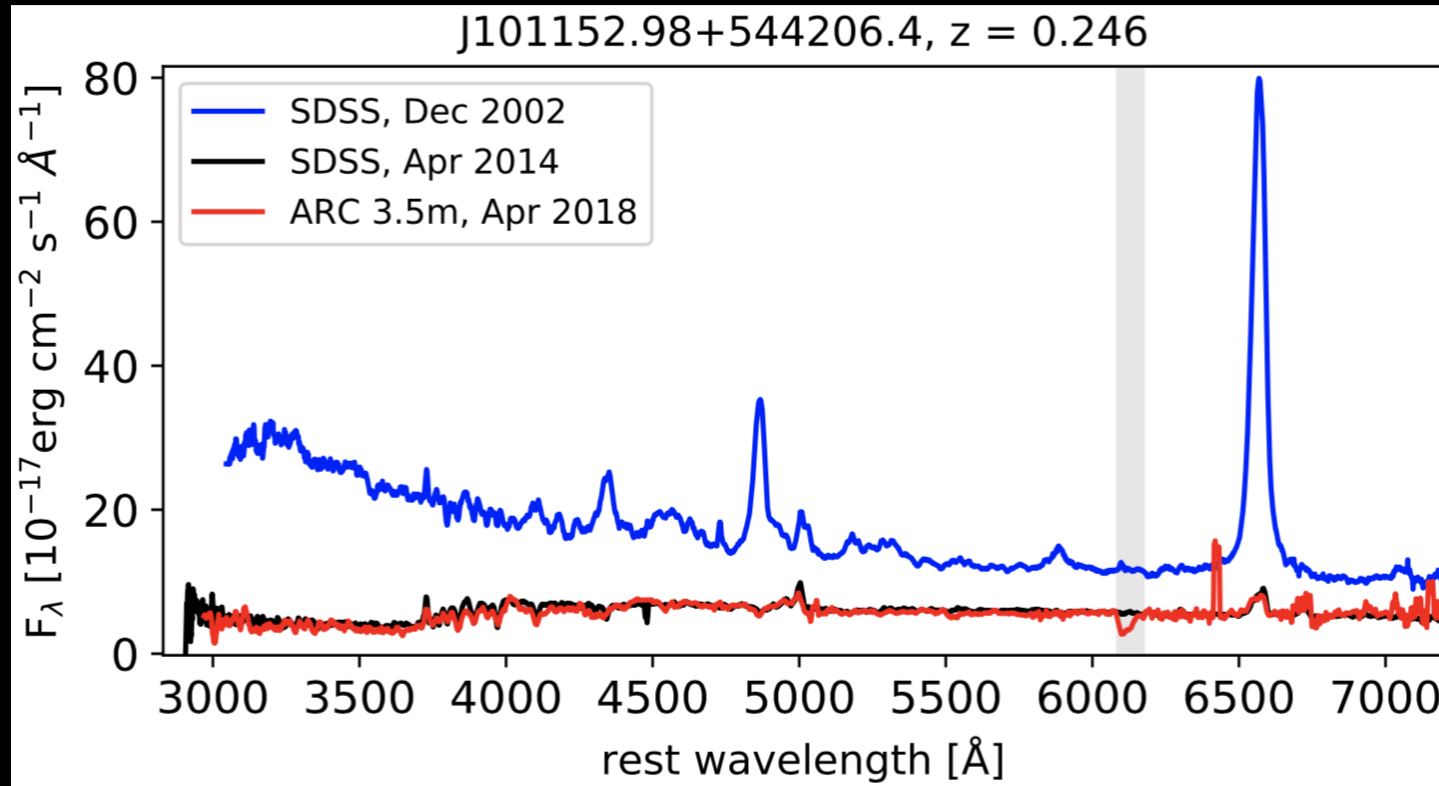
- how to get M_{BH} without broad emission lines?
- How to avoid dust extinction?

Changing-look quasars display dramatic fading of broad lines and continuum in repeat optical spectroscopy over timescales of just a few years



Runnoe+16

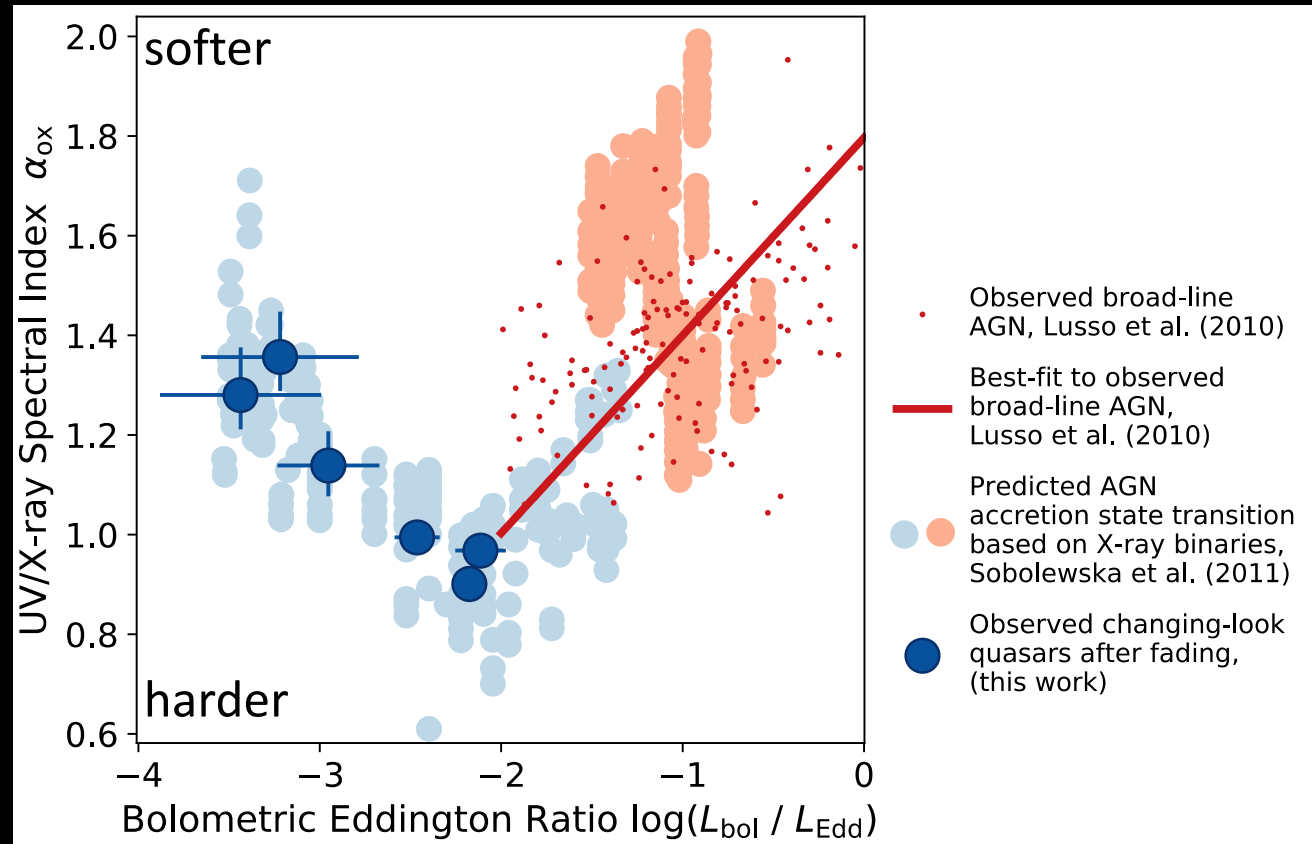
Changing-look quasars enable us to robustly probe the α_{OX} of AGN at low L/L_{Edd}



Bright state:
measure M_{BH}
from broad lines

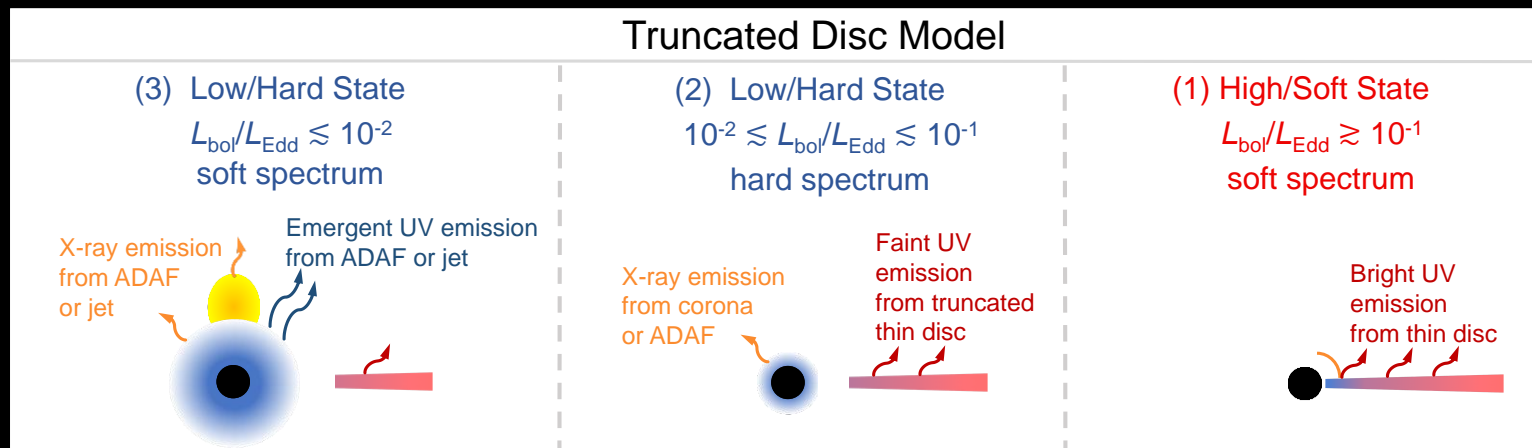
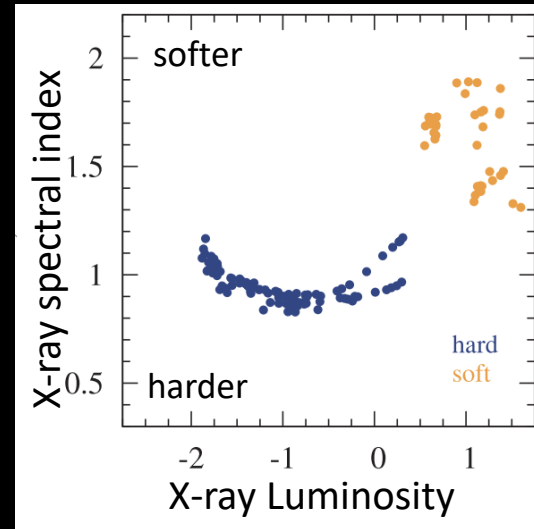
Faint state:
measure α_{OX} using
optical spectrum
and *Chandra*

Main result: Single-epoch observations of AGN *samples* reveal remarkably similar spectral evolution of AGN and X-ray binaries



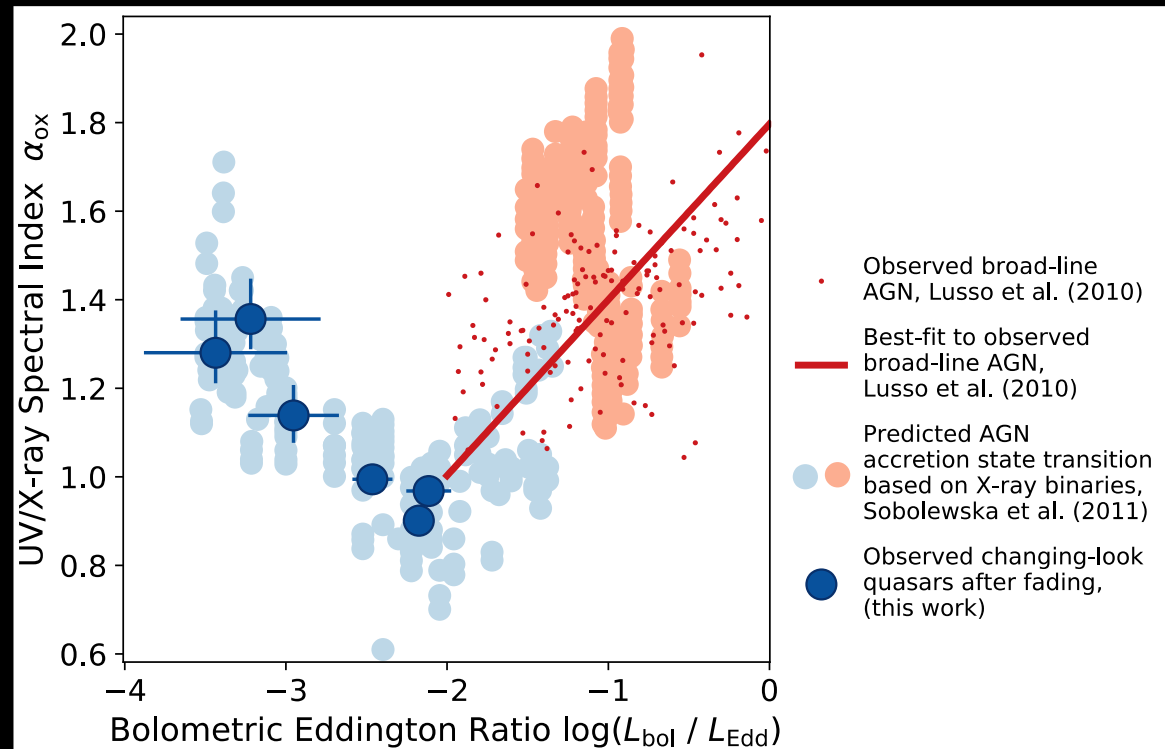
Ruan+19,
submitted

The X-ray spectral index probes the evolution of their disk-corona system structure

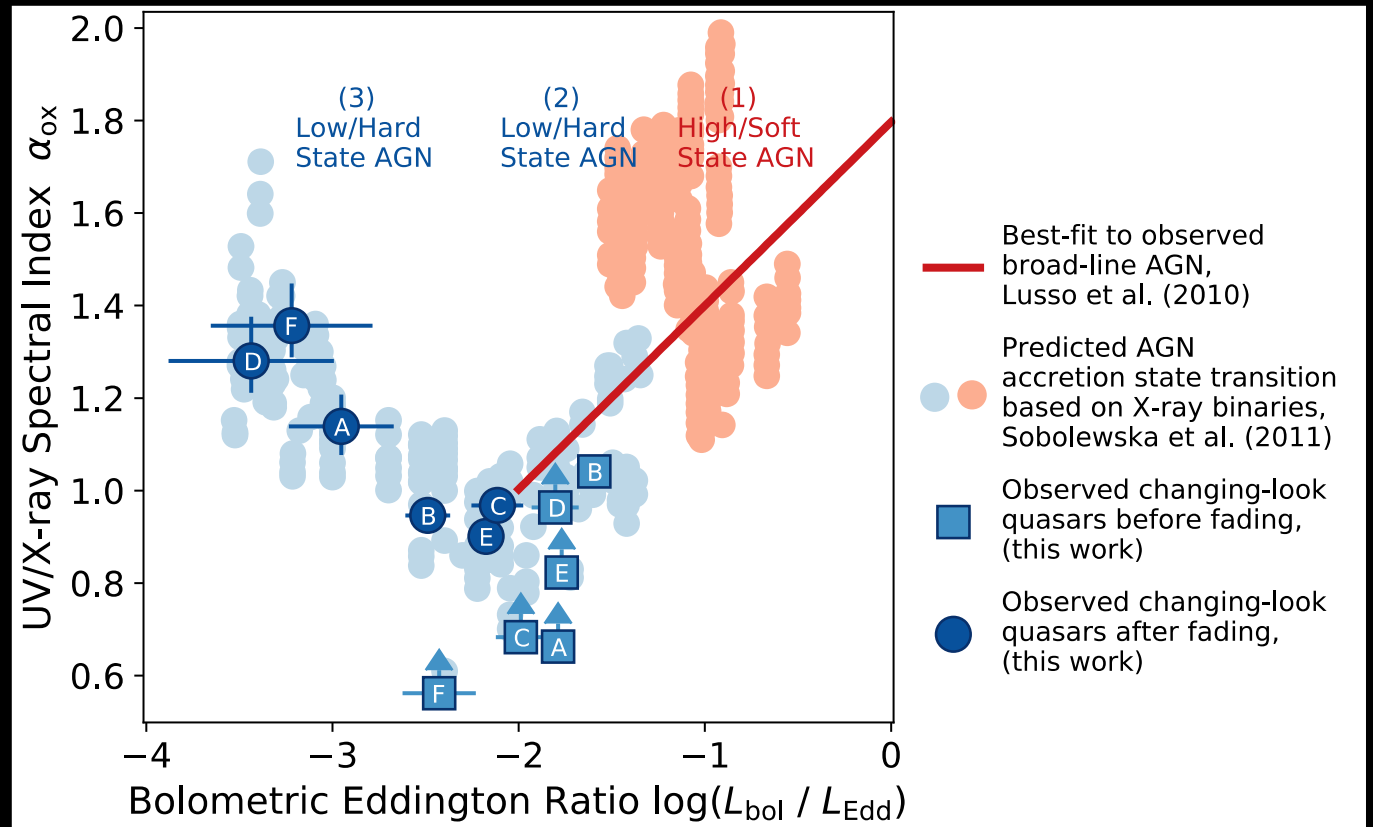
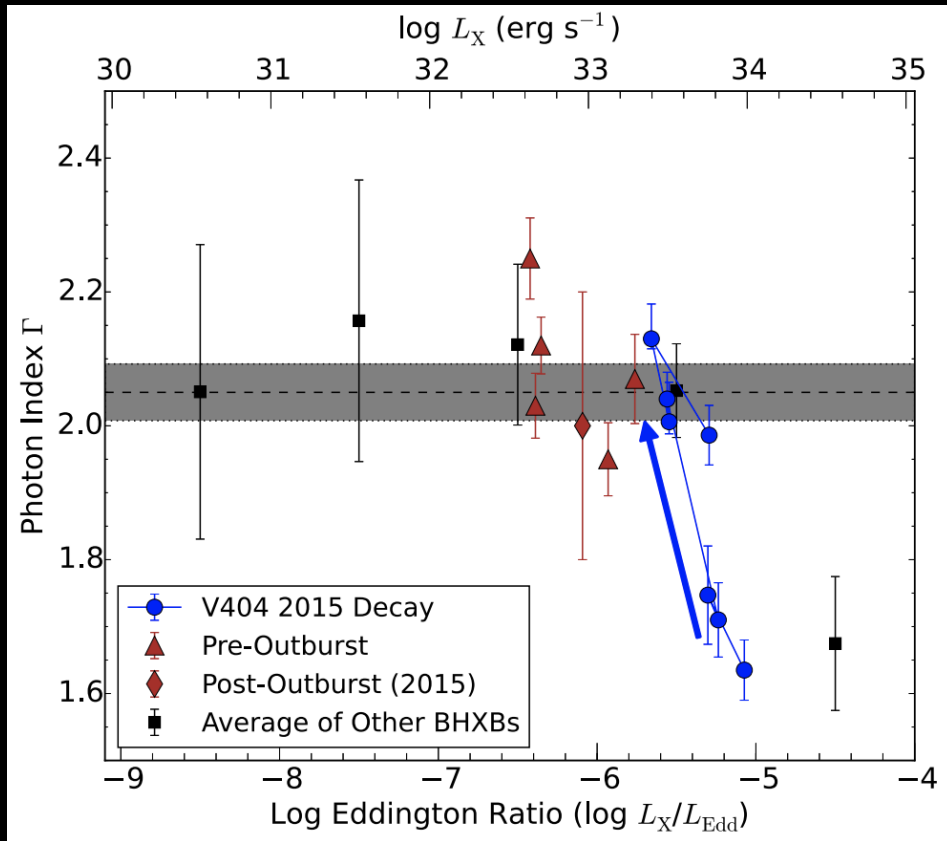


Overall conclusion: AGN and X-ray binaries display similar spectral evolution over a wide range of Eddington ratios

Broader implication: this suggests that the structure of accretion flows in X-ray binaries and AGN are analogous

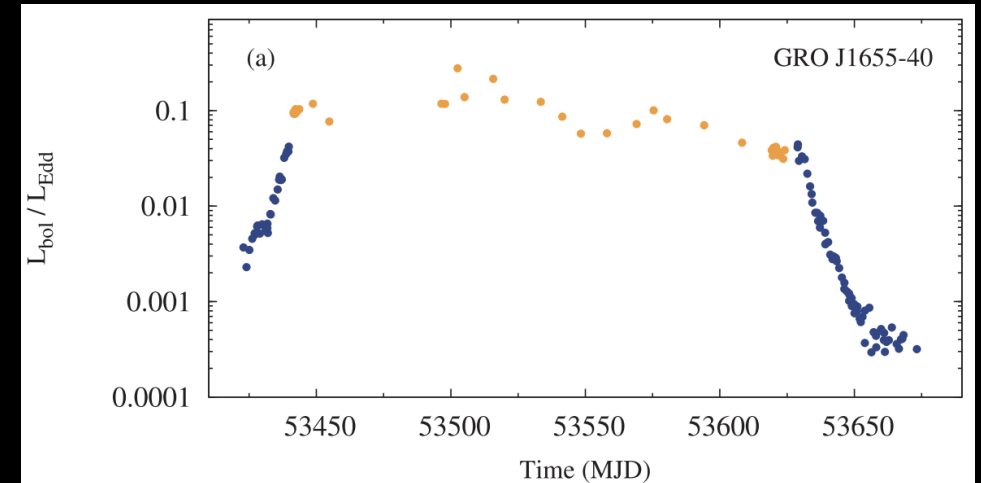
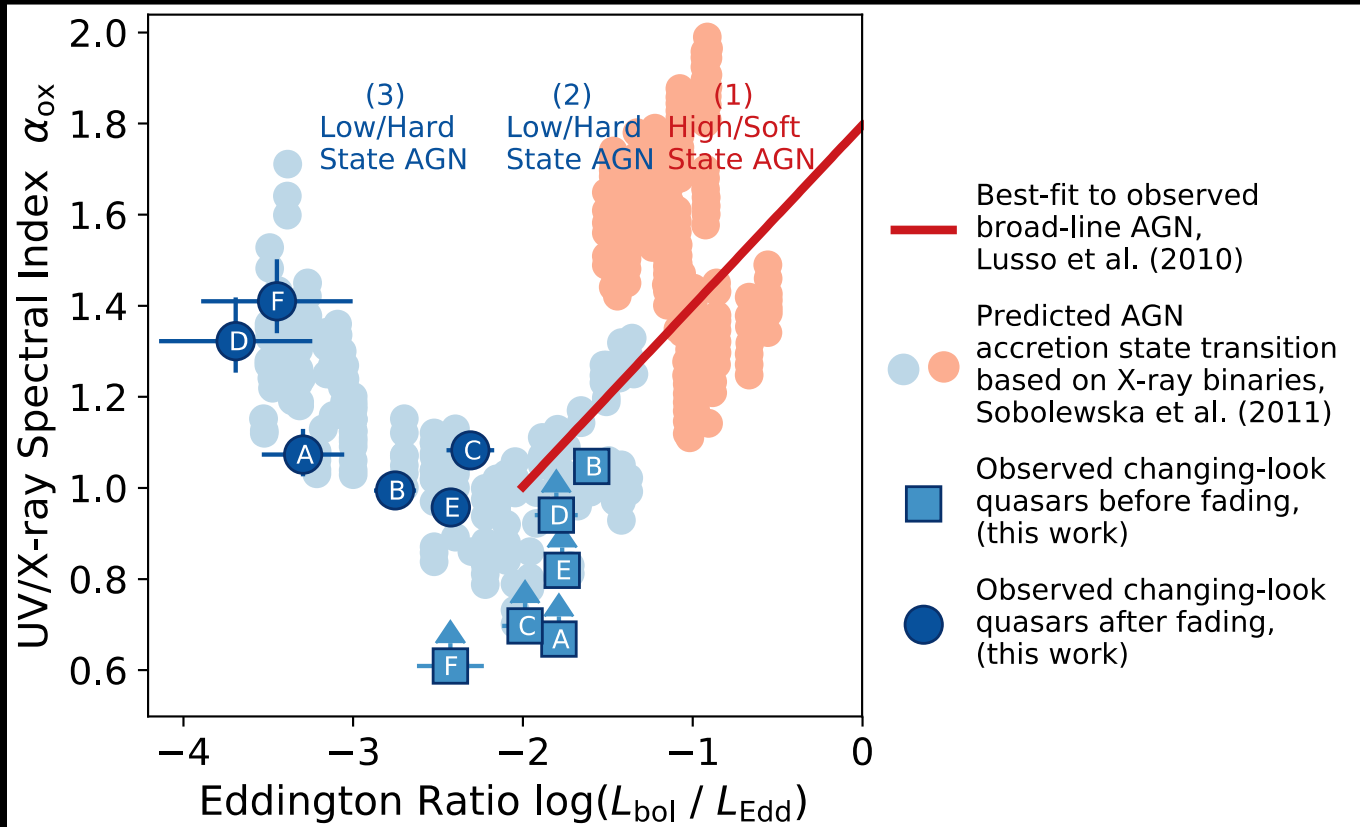


Additional test of AGN/XRB analogy: directly following changing-look quasars to quiescence



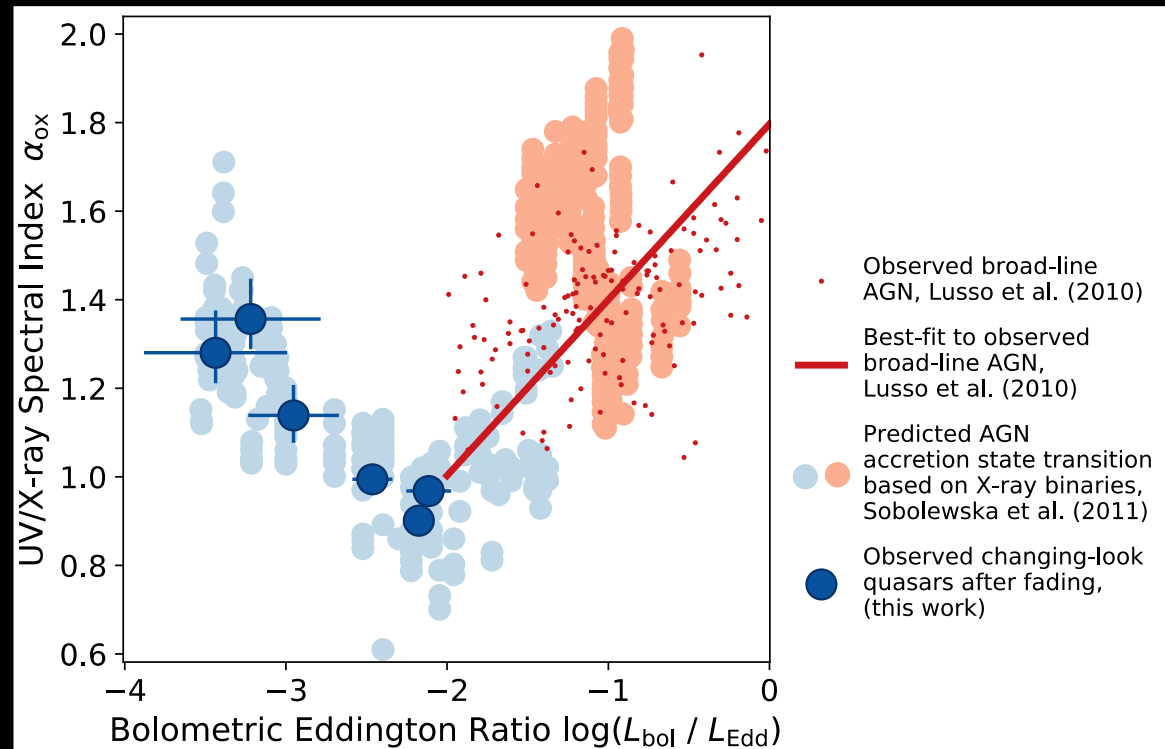
Plotkin+17

The mismatched timescale problem between AGN and X-ray binaries still persists



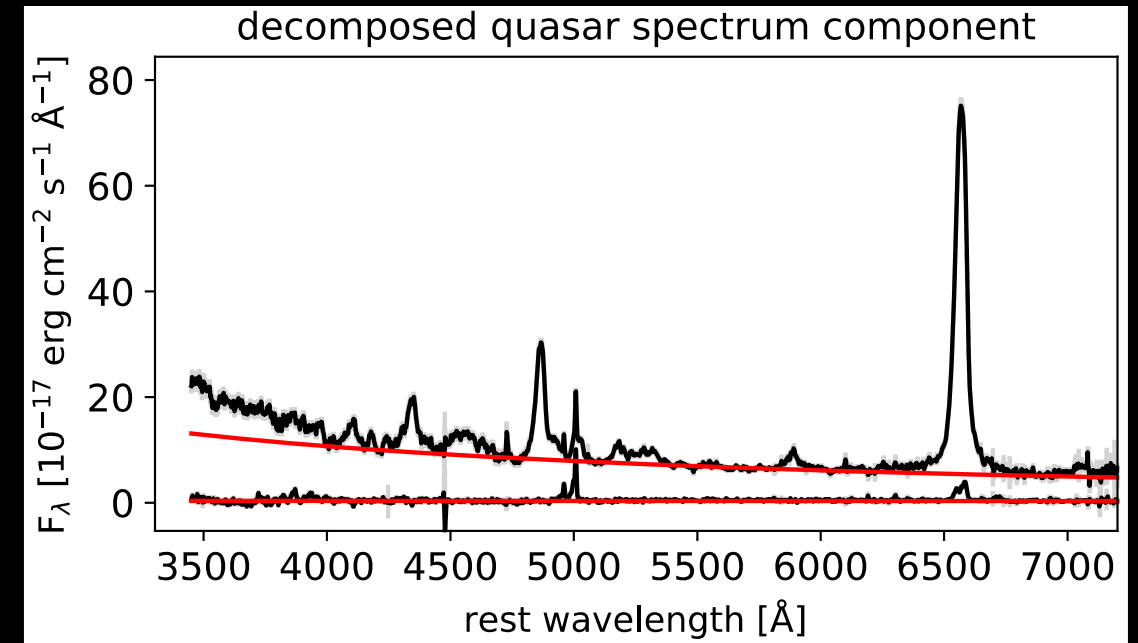
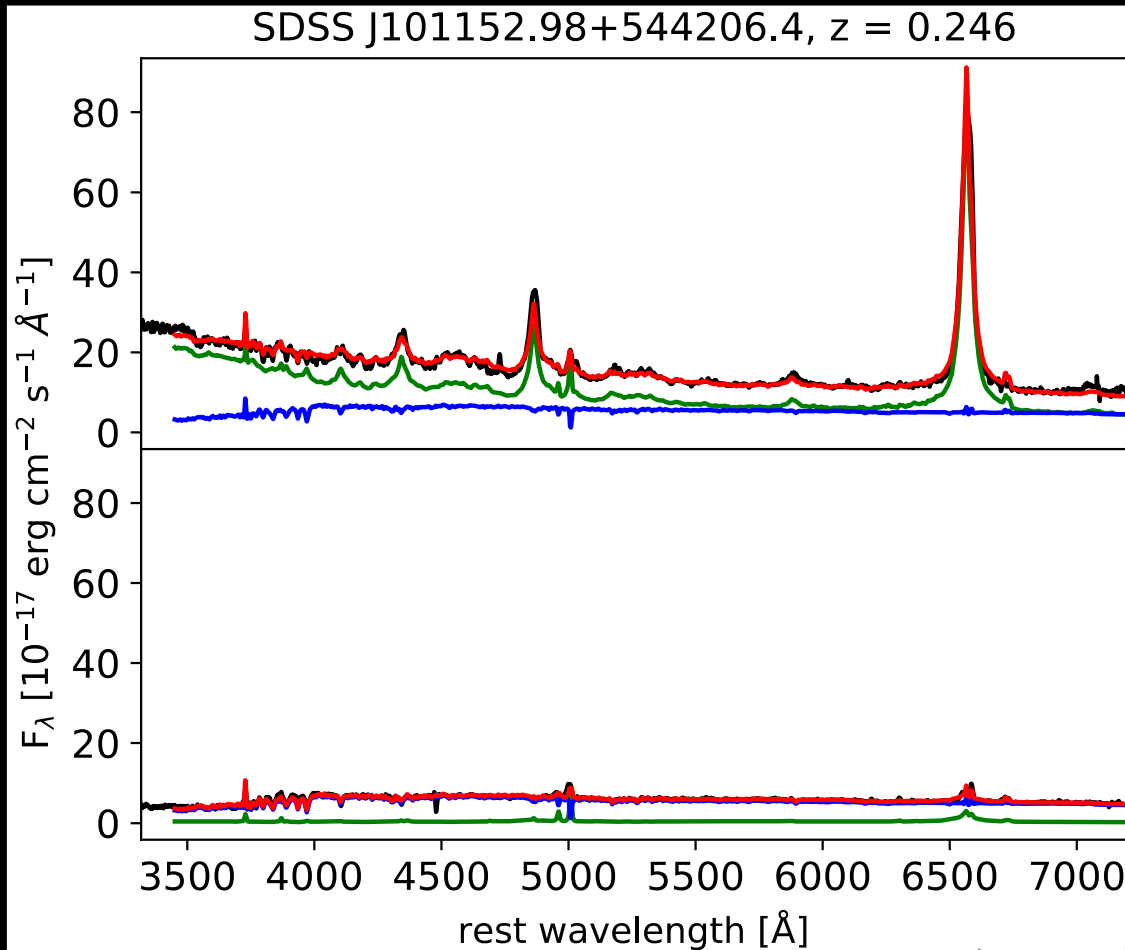
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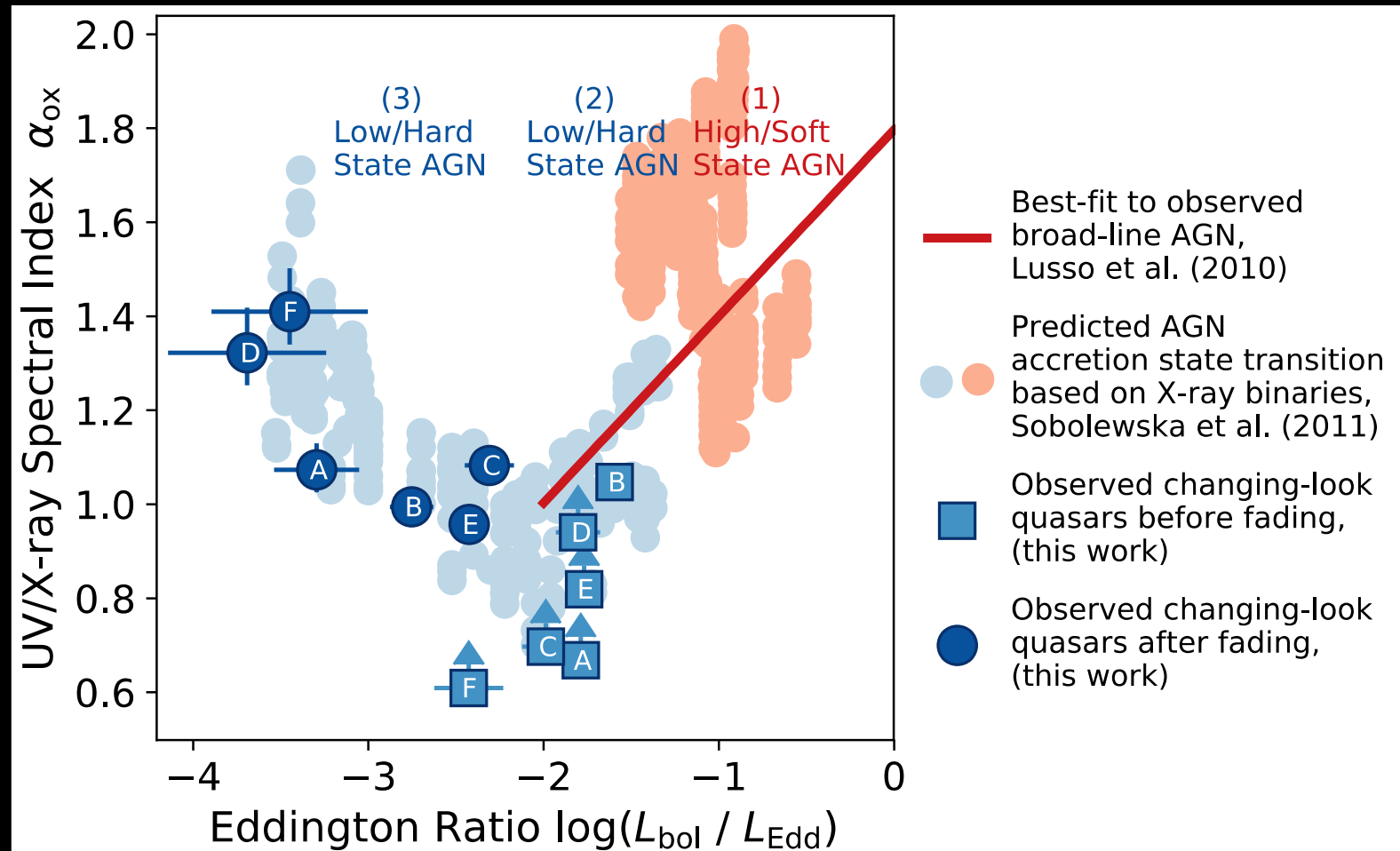
Extra Slides

Decomposition of optical spectra and fitting of the quasar component



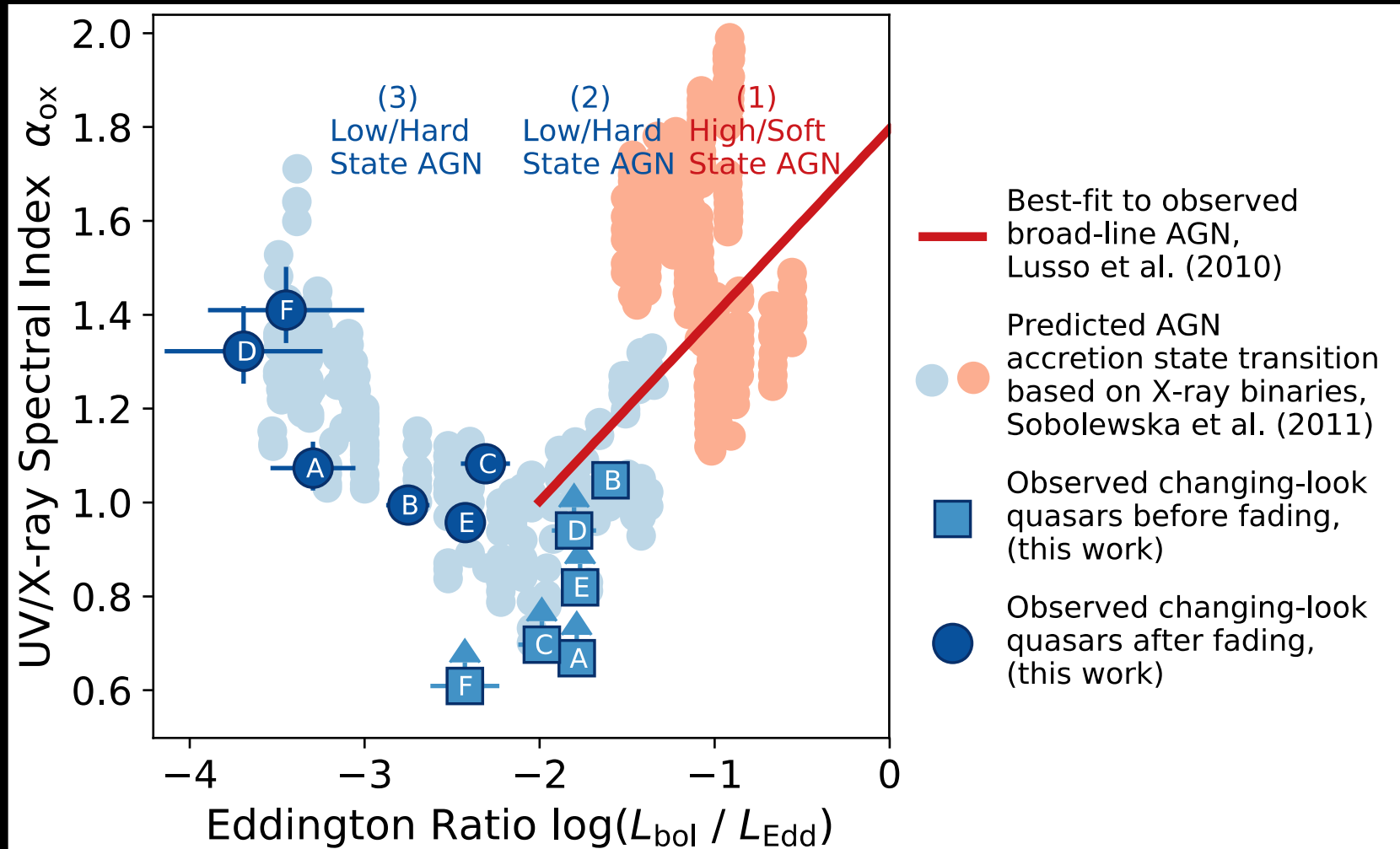
Ruan+19,
submitted

Extrapolation of the power-law from optical spectroscopy into the UV is not an issue



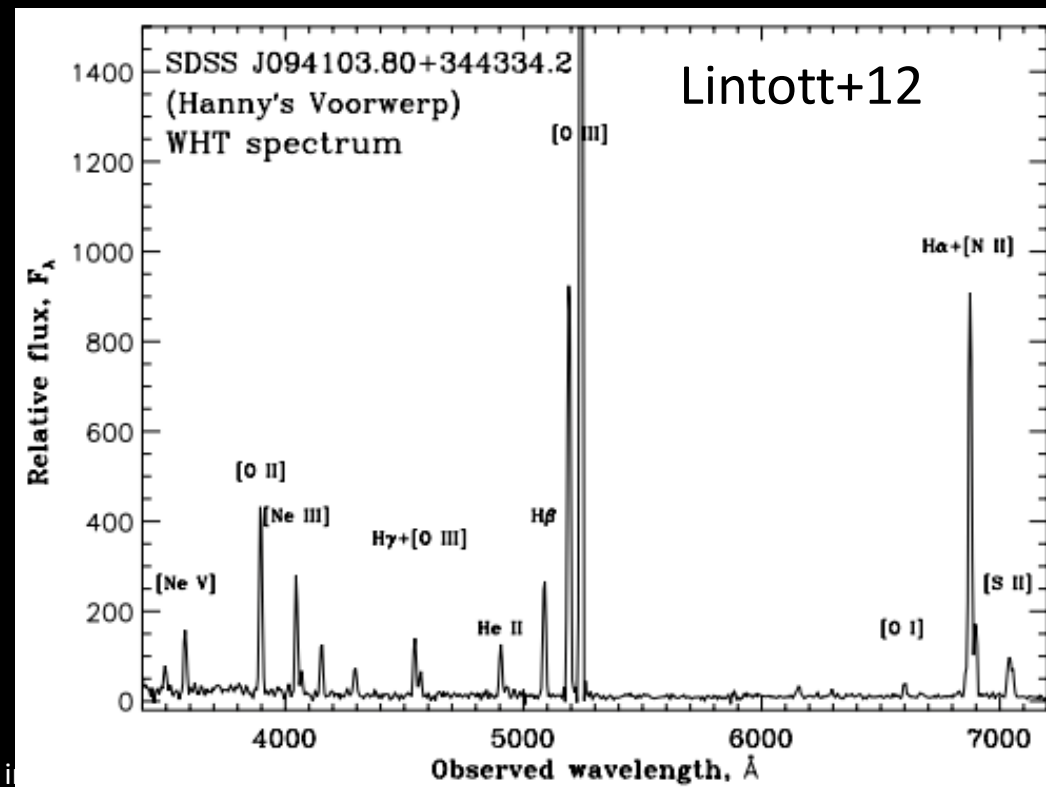
Ruan+19,
submitted

Bolometric corrections are not an issue



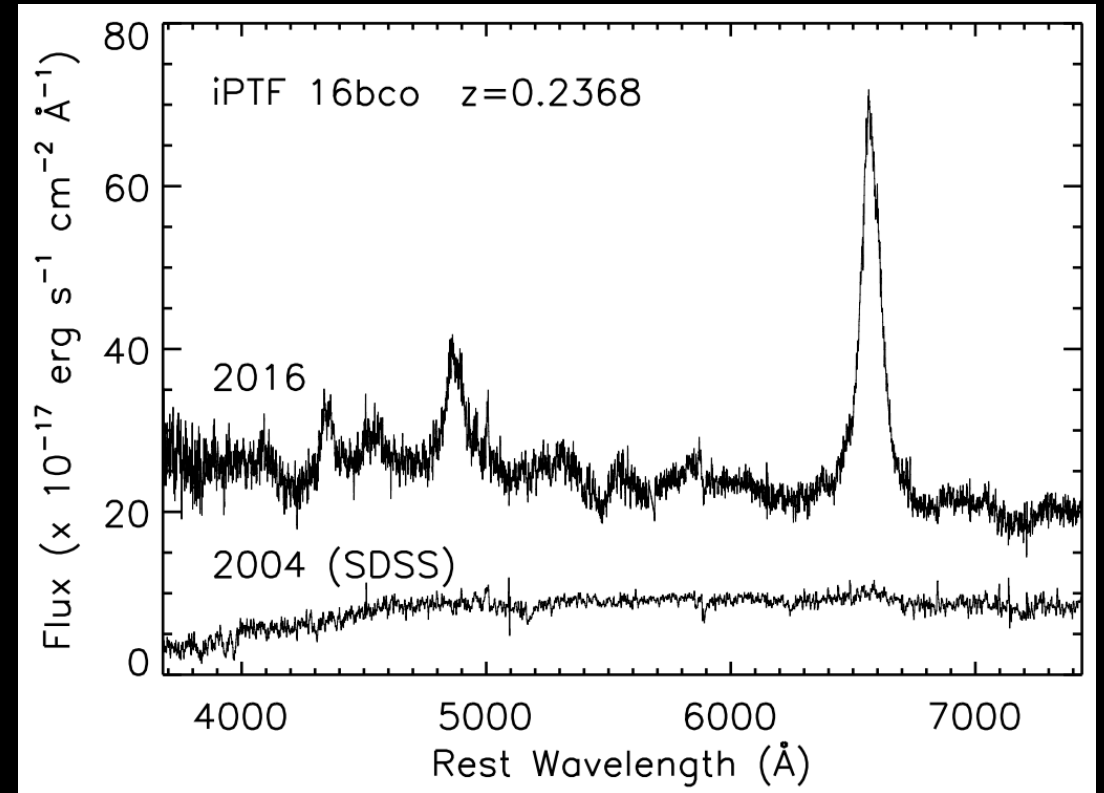
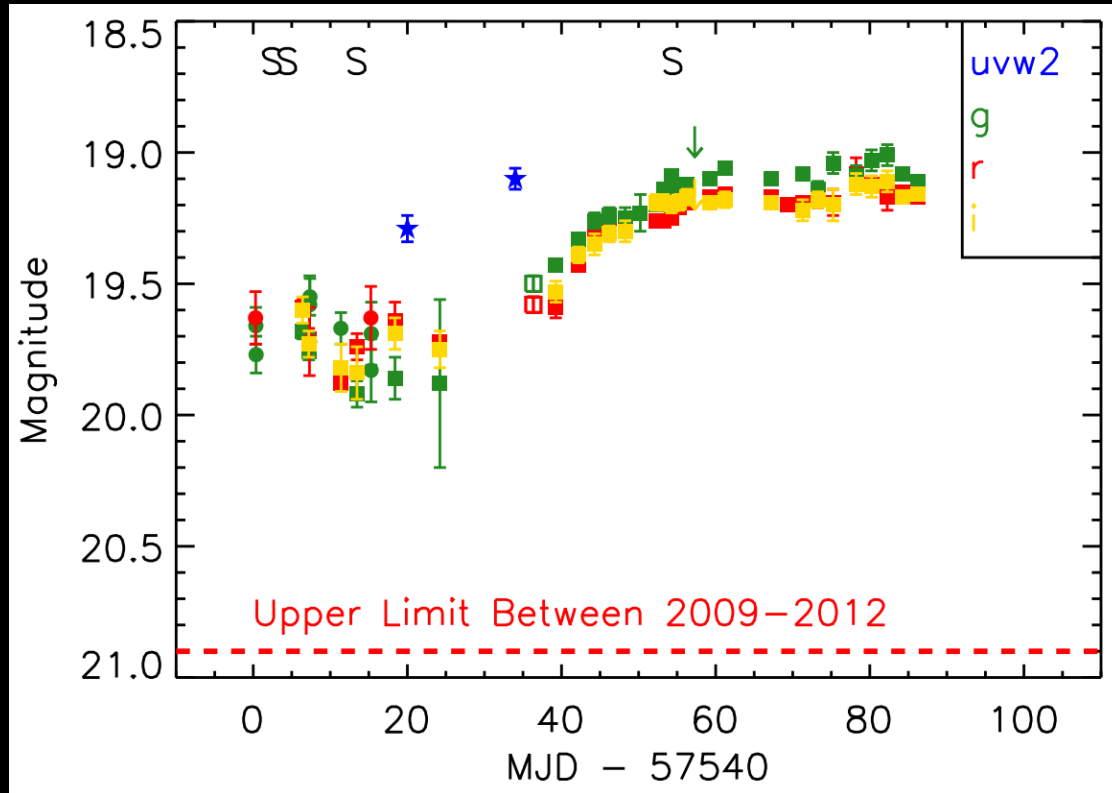
Hanny's Voorwerp

- Previous evidence for AGN accretion state transition in quasars



Keel+12

Discovery of 'turn-on' changing-look quasars



Gezari+17