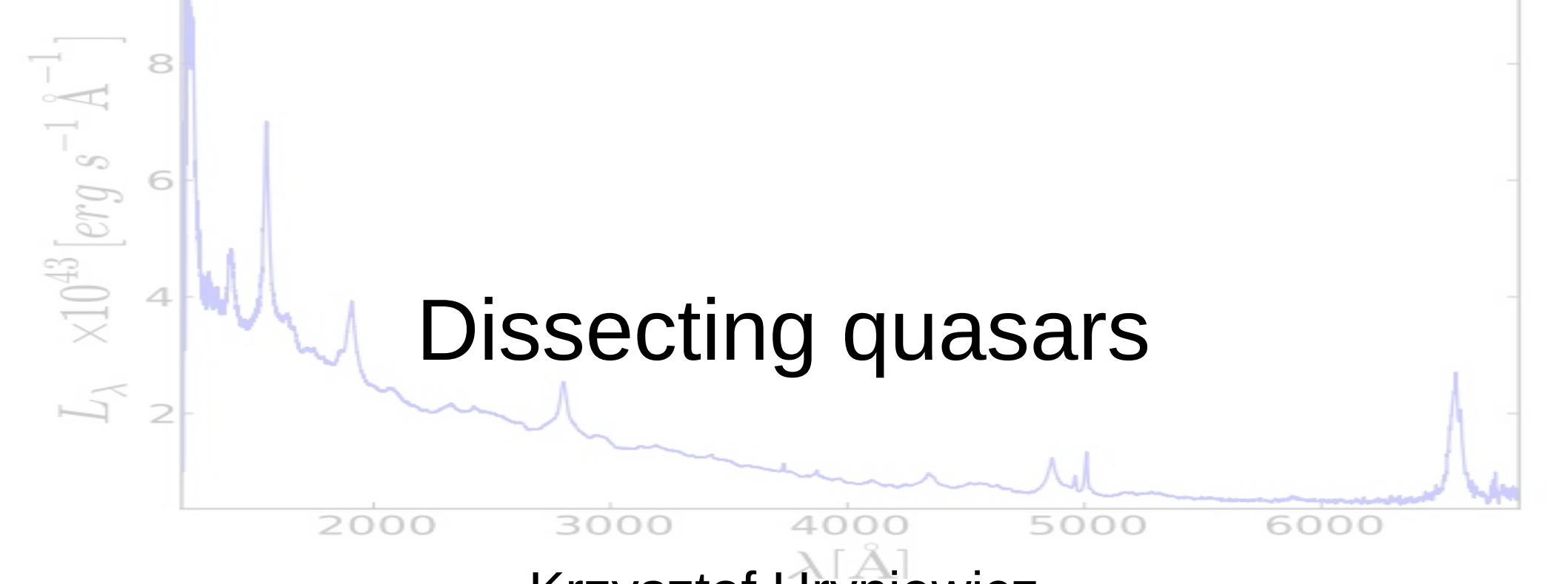


Dissecting quasars

Krzysztof Hryniewicz
NCBJ BP4

Warsaw, 16.12.2022

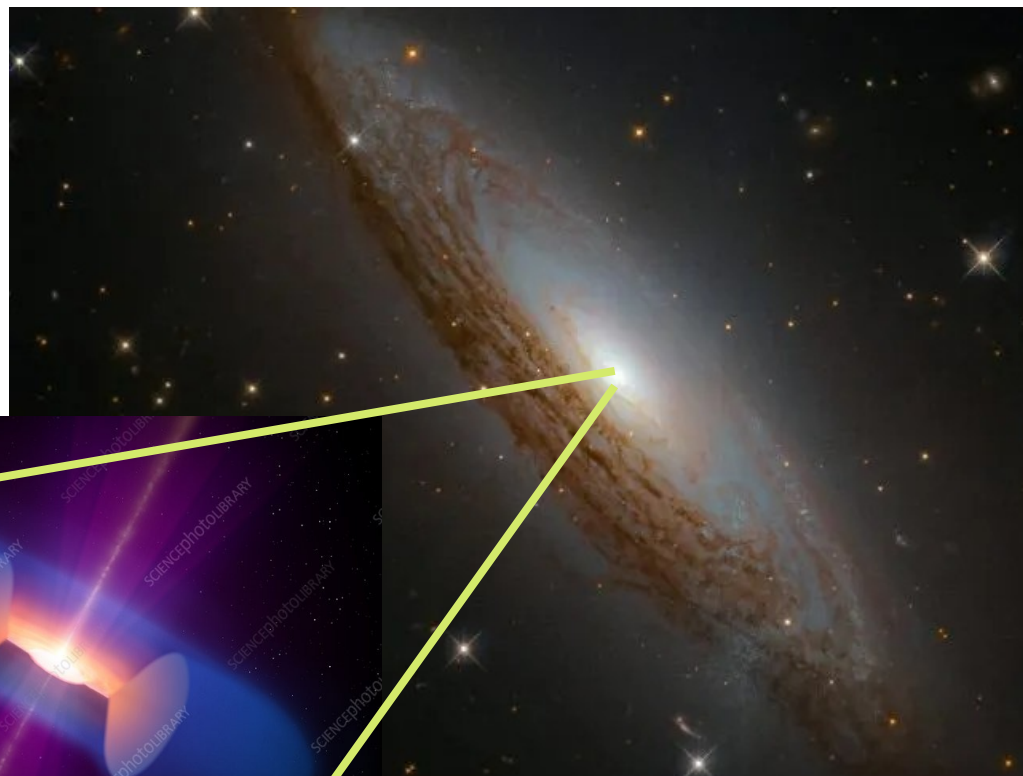
NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

Outline

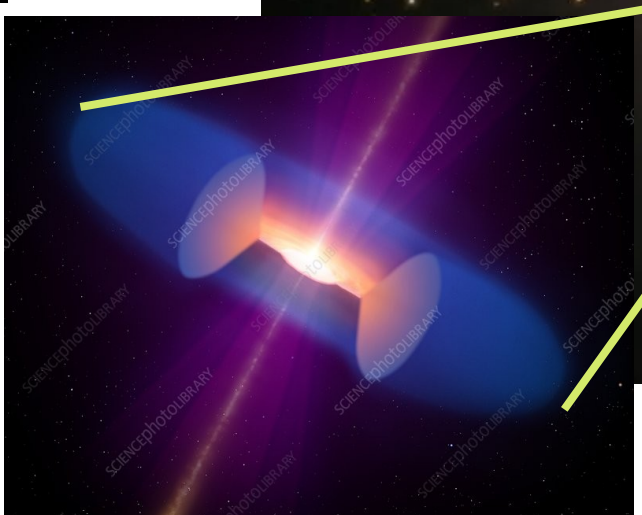
- What is quasar?
- Why quasars are interesting?
- Inner structure
- Population
- Investigating properties of extreme source
- Investigating structure stability over quasar population

Quasars

Very bright active galactic nuclei emitting powerful radiation across broad wavelength range.
Observed at radio, sub-mm, IR, optical, UV, X-ray and gamma frequencies.
Observed across broad range of redshifts.



NASA, ESA, Hubble



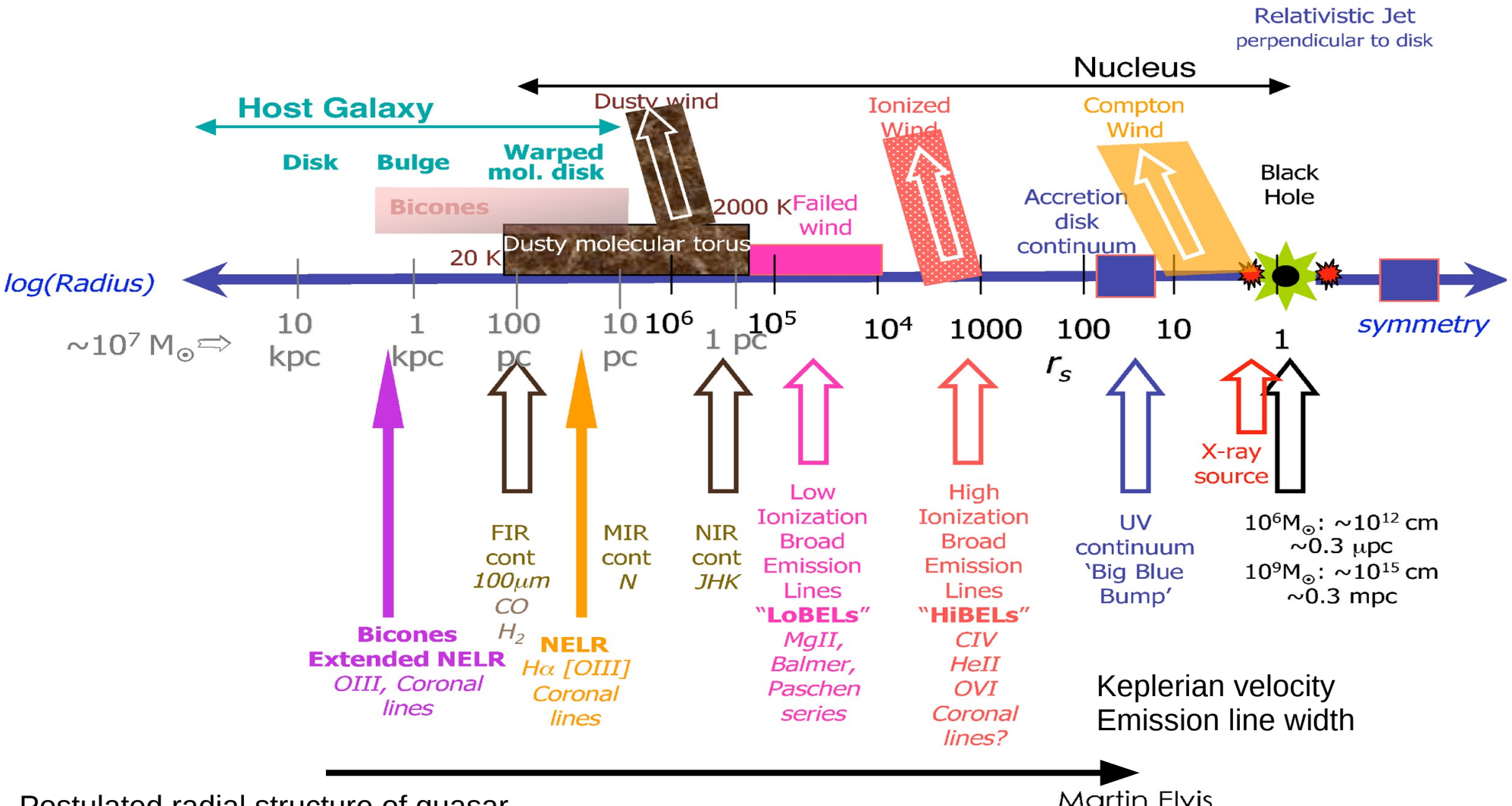
Sciencephotolibrary

Why quasars are interesting?

- Very bright and massive objects
- Sources of energetic radiation and particles
- Laboratories of strong gravity
- Covers almost whole EM radiation spectrum
- Plasma physics laboratories
- Allows for atomic physics validation
- Tools for cosmology

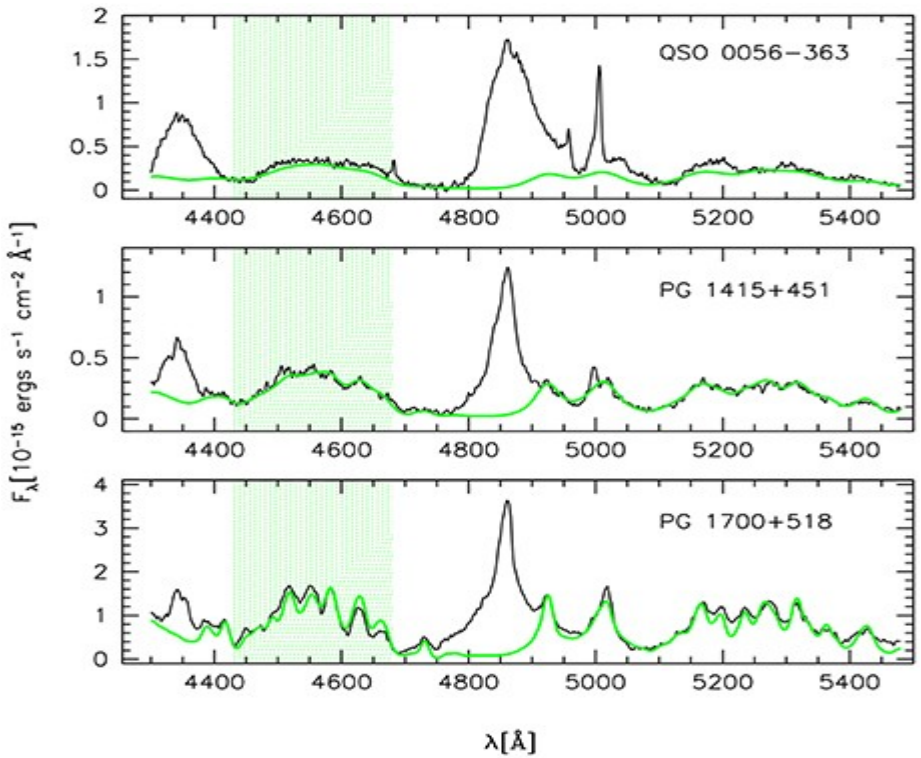
  and more...

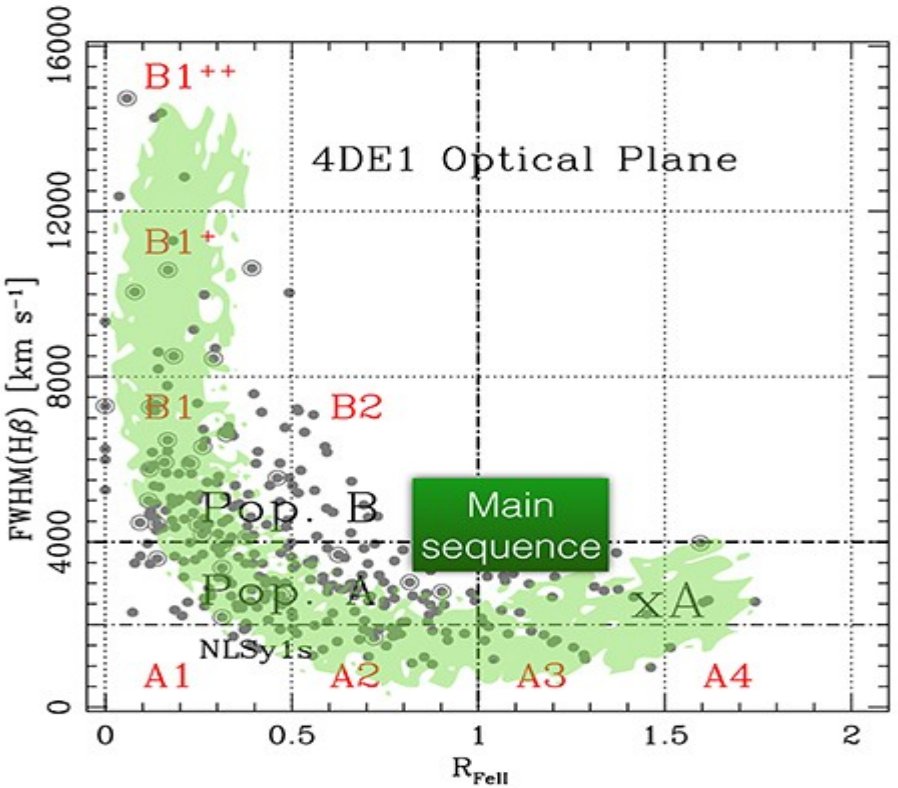
Quasar radial scale and structure



Postulated radial structure of quasar

Quasars main sequence



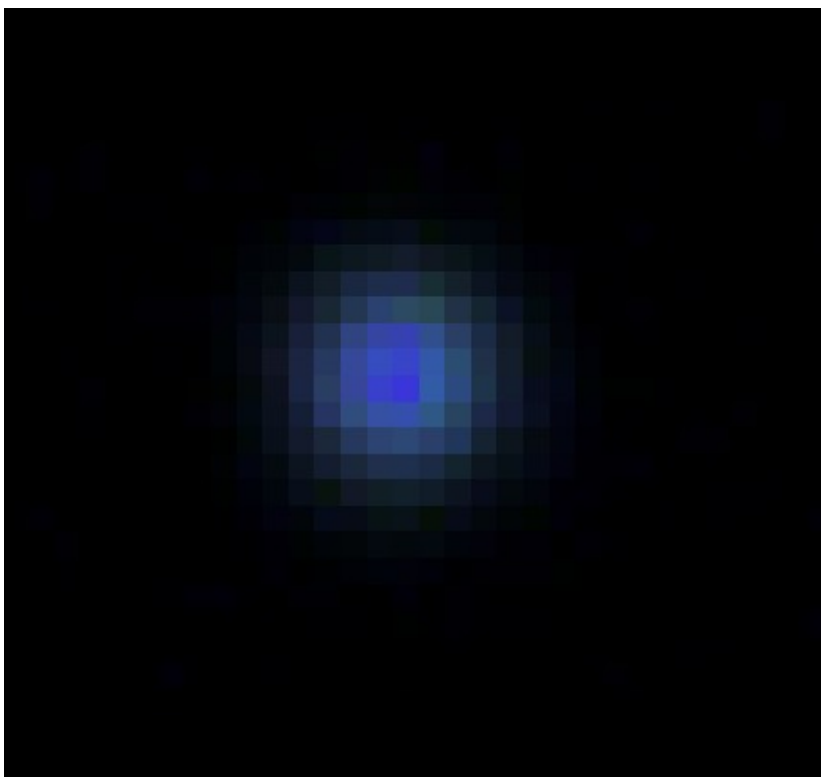


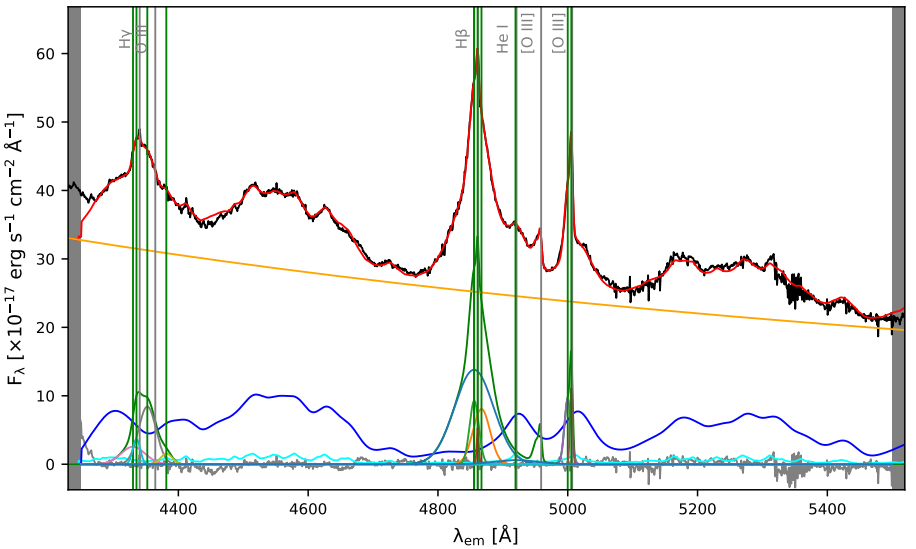
Marziani et al. 2018

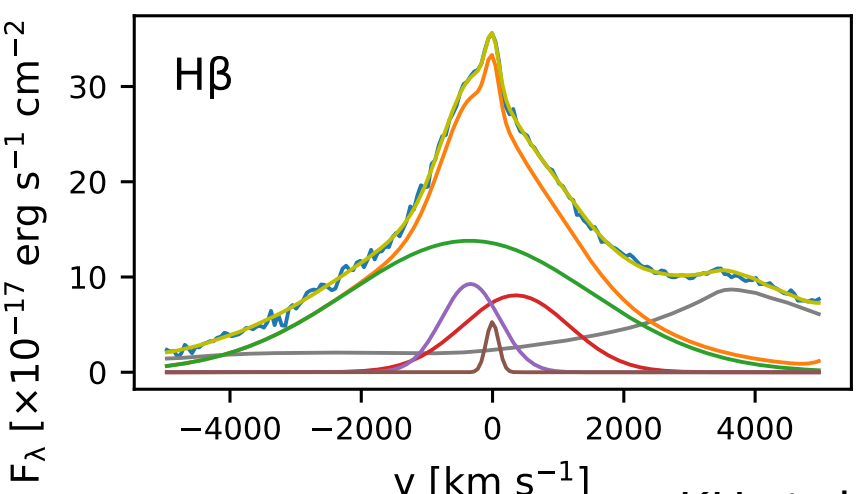
Population parametrized by emission line (Hβ and FeII) properties. Quasars move along the diagram during its lifetime.

HE 0435-5304

Quasar and ultra-luminous infra-red galaxy at the same time.





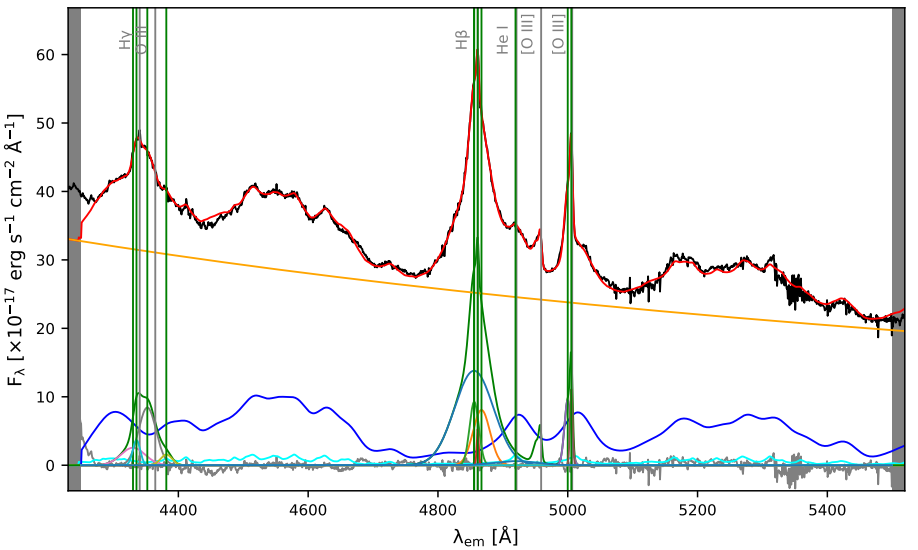


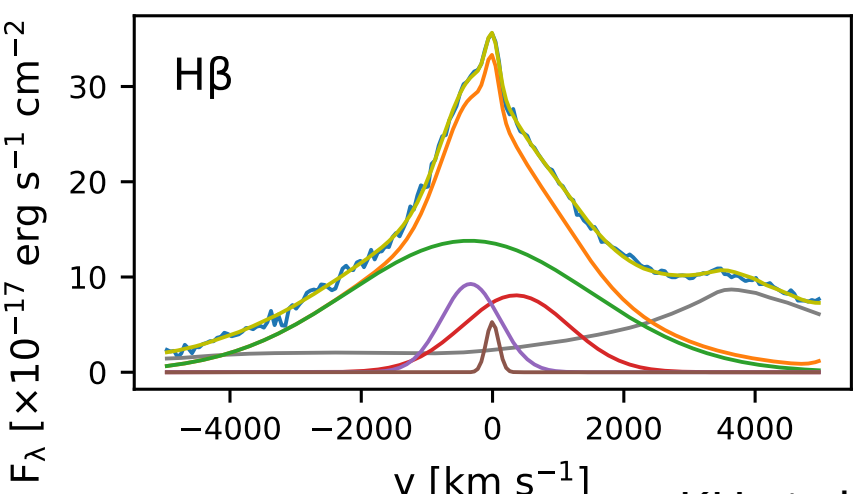
KH et al. 2022

HE 0435-5304

Quasar and ultra-luminous infra-red galaxy at the same time.
Most probably interacting/merging pair of galaxies.

NASA, ESA, Hubble

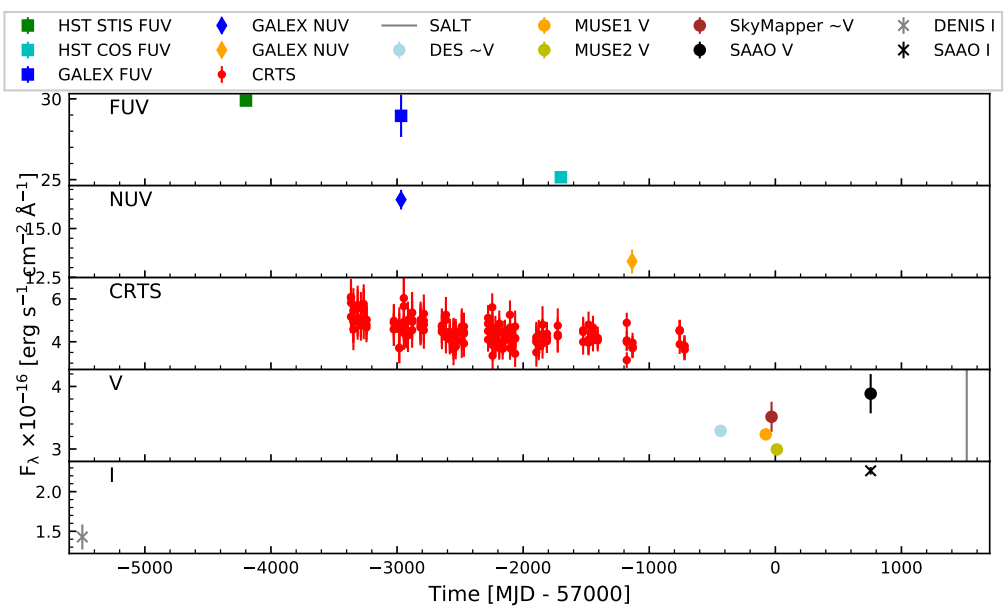




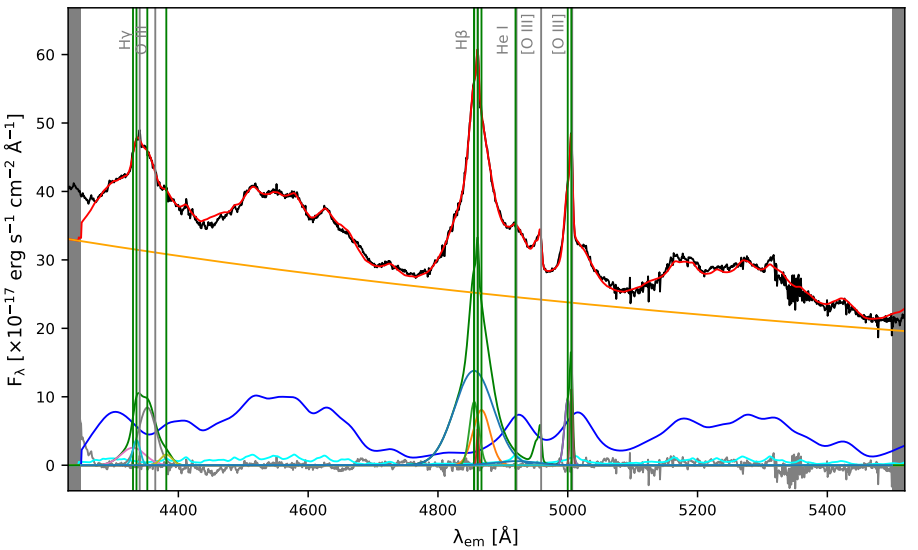
KH et al. 2022

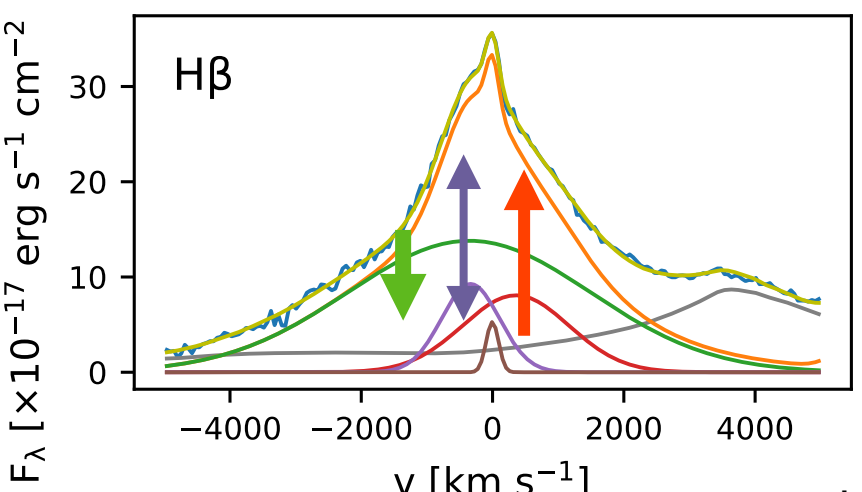
HE 0435-5304

“Long monotonic” variability across bands and “medium” change in emission line profiles.



days

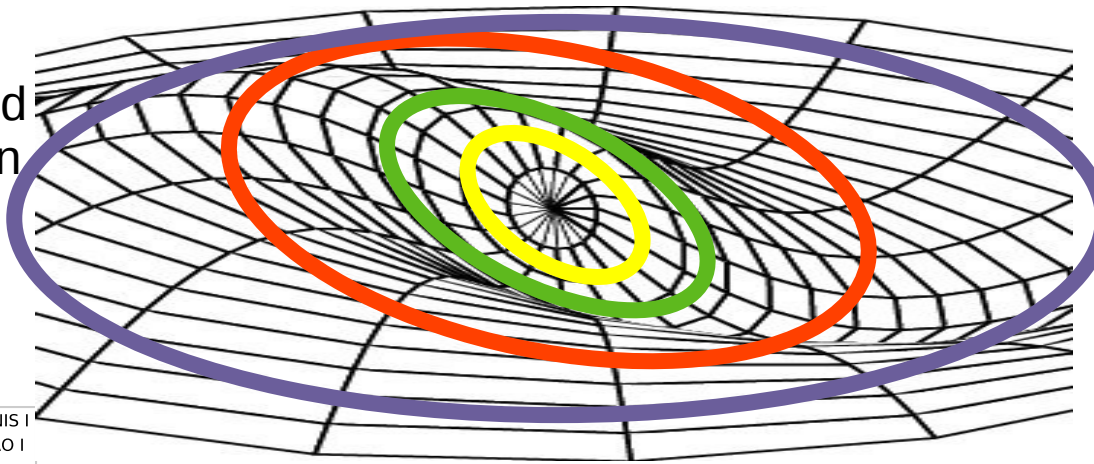




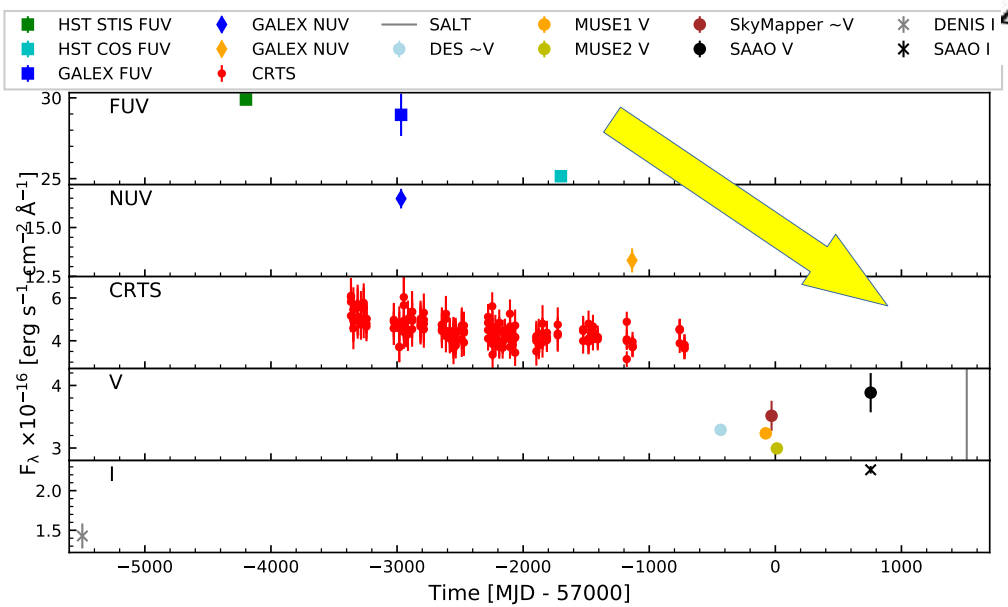
KH et al. 2022

HE 0435-5304

“Long monotonic” variability across bands and “medium” change in emission line profiles can be interpreted as warped precession of the inner structure. Probably result of the tidal interaction between galaxies.



Background: Hartnoll & Blackman



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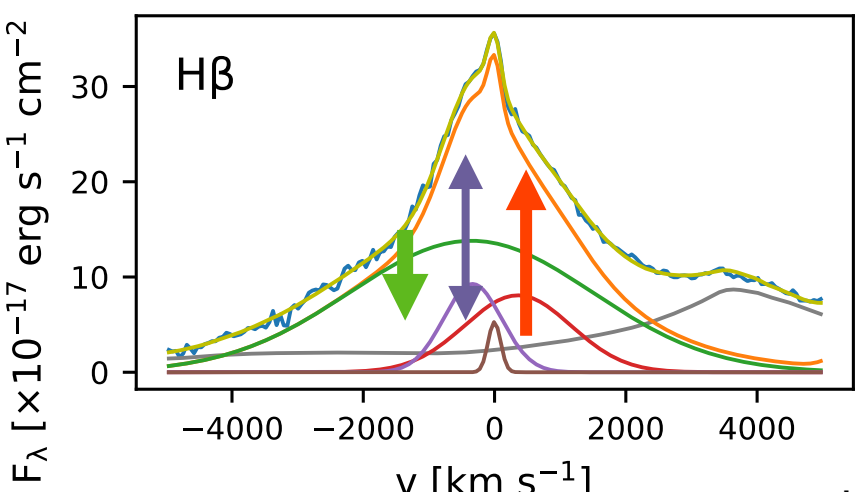

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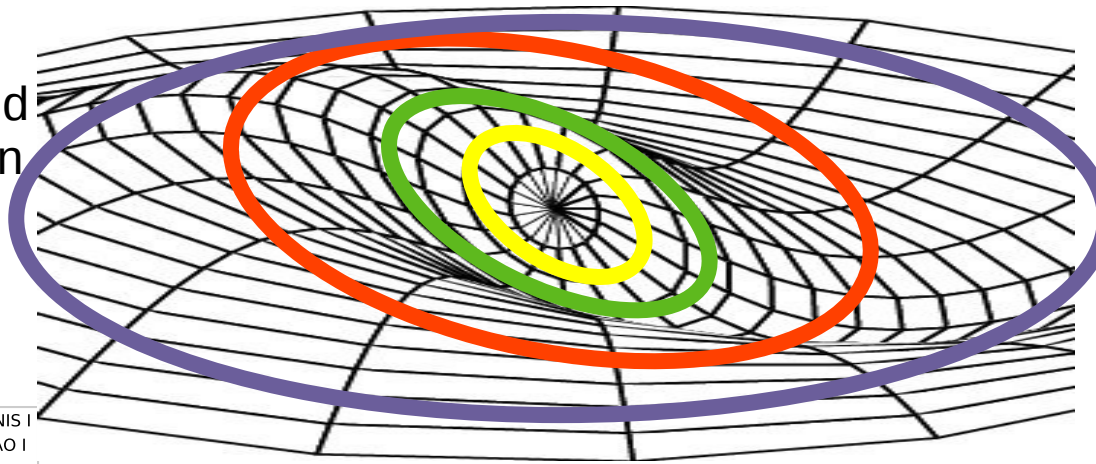

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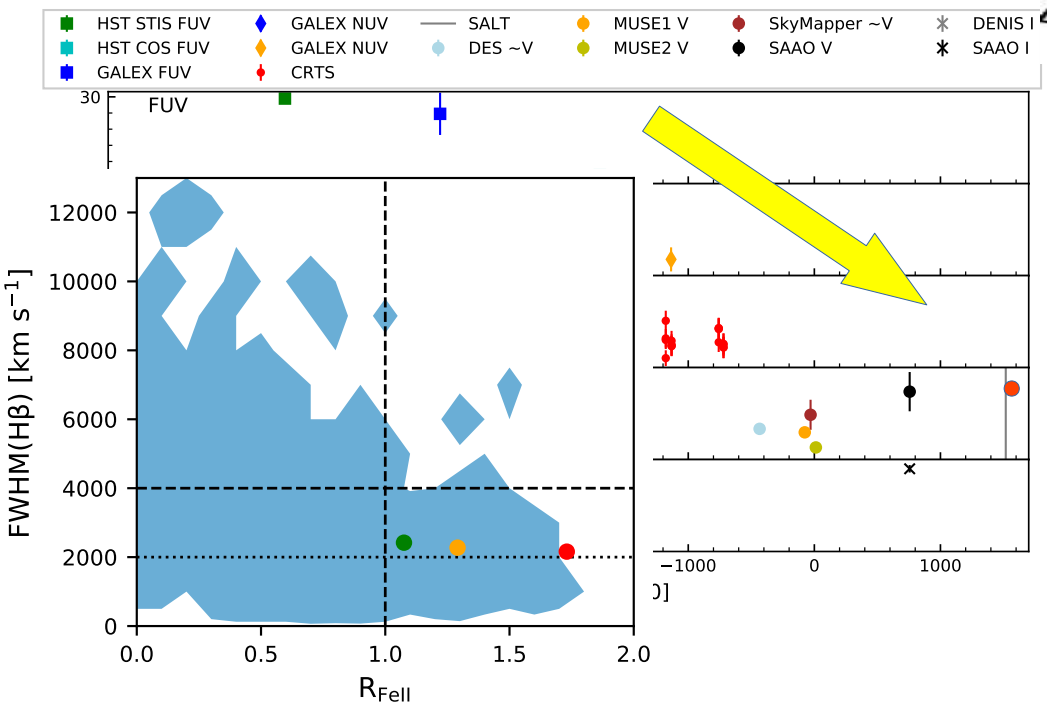
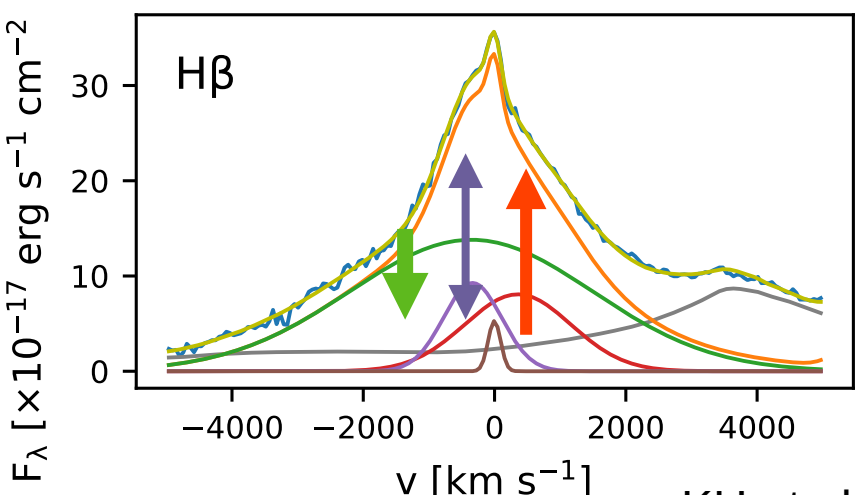
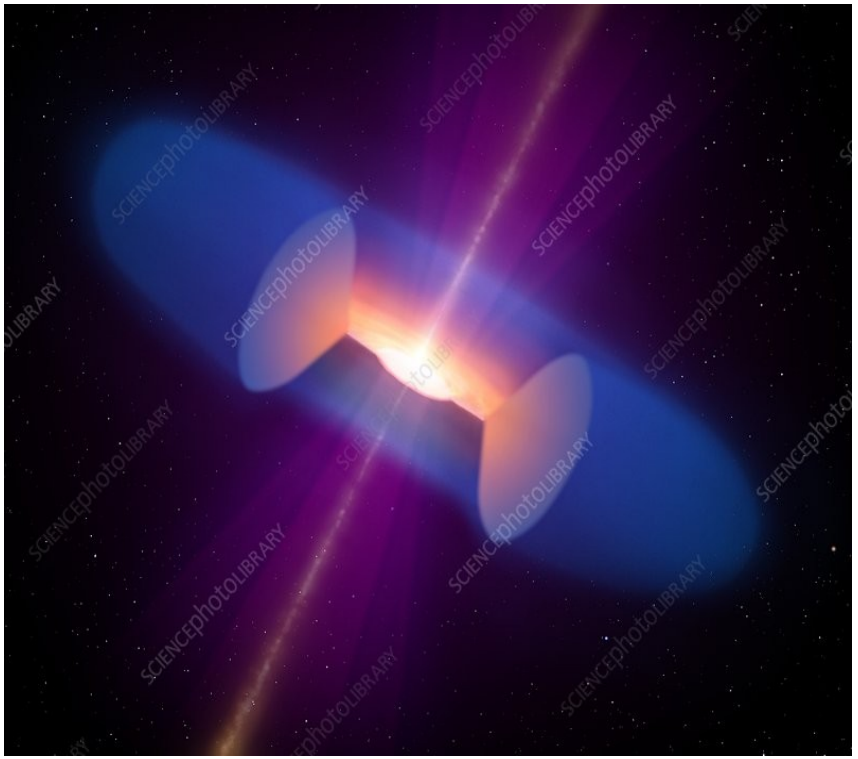


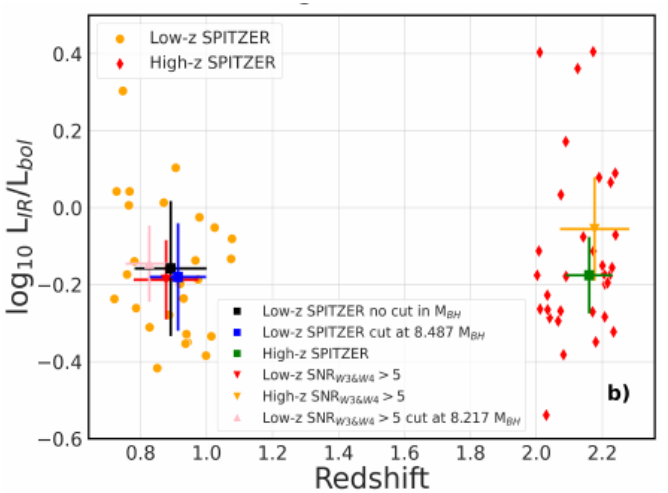


KH et al. 2022

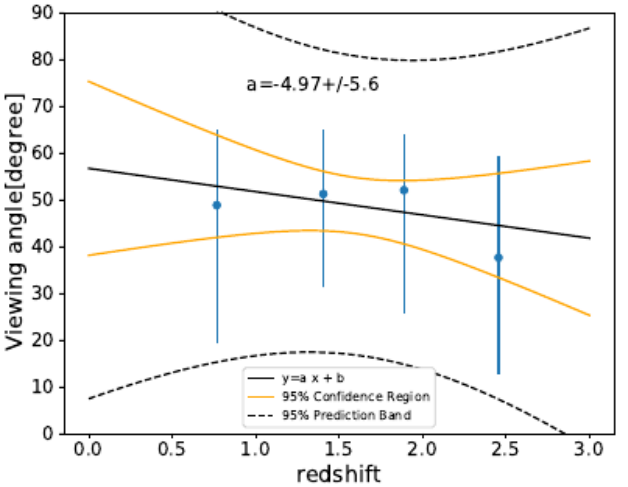
Torus across population



Dusty torus properties stable across redshift.



Rałowski, KH et al. subm.



Prince, KH, et al. 2022

Summary

- Spectroscopy and variability analysis are powerful tools to probe quasars inner structure.
- Extreme sources like HE 0453-5304 introduce additional scatter due to its complexity and “medium” timescale variability.
- Inner structure of quasars is more complex that it seems at first sight.
- Quasar population properties across redshift seems to confirm possibility of standardization as cosmic standard candles.

Thank you!

BLR as the failed wind

Starting from observed relation

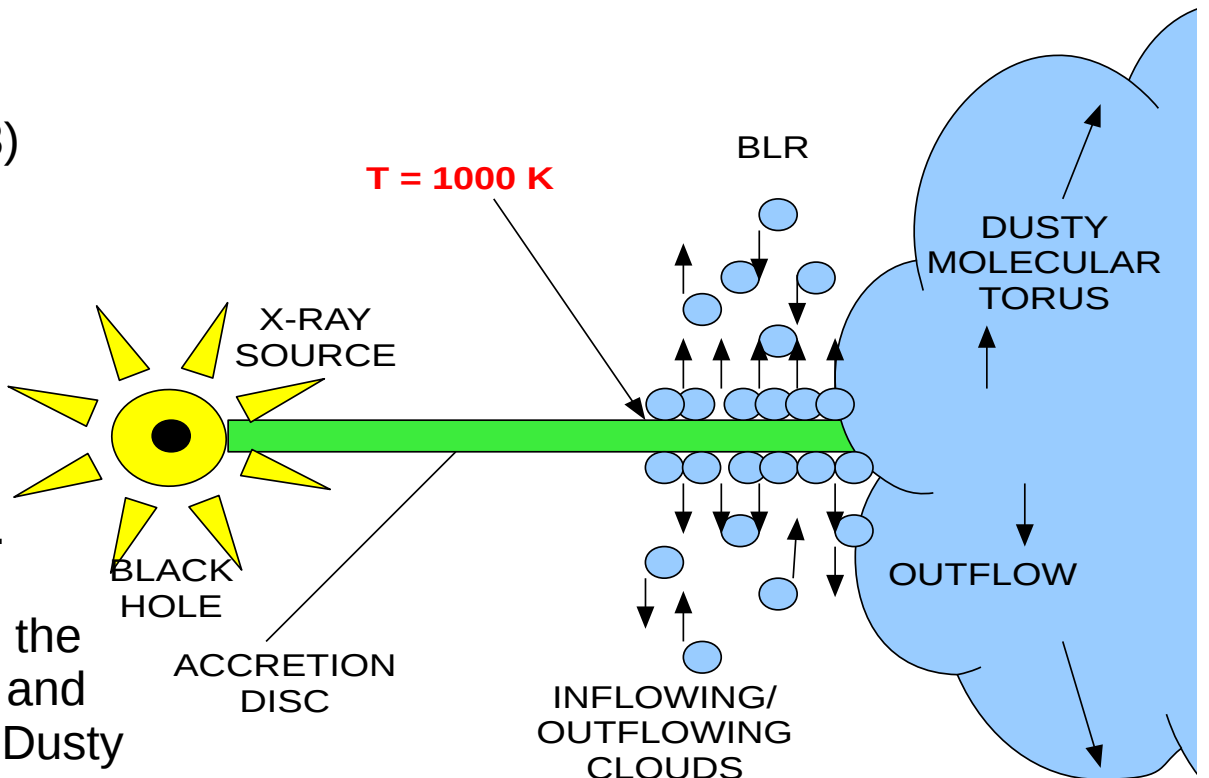
$R_{BLR} \sim L_{5100A}^{0.5}$

And assuming the standard disc model (optically thick geometrically thin, SS73) with know temperature distribution.

We derive the disc temperature of the ring corresponding to R_{BLR}.

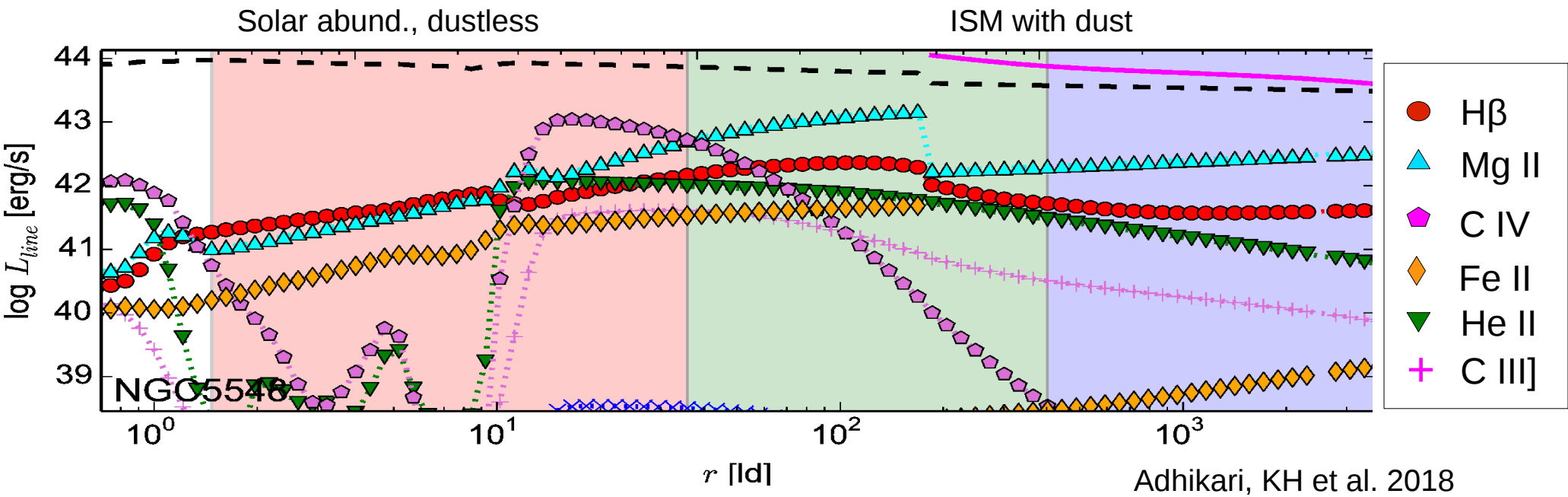
This temperature is around 1000 K, so below dust sublimation temperature.

It means that at this radius dust exist in the disc. Disc is warm and irradiates in red and near IR. Radiation pushes dust grains. Dusty wind emerges but exposed to still strong soft X-rays/UV radiation.



Czerny & KH 2011

Emission lines: model predictions

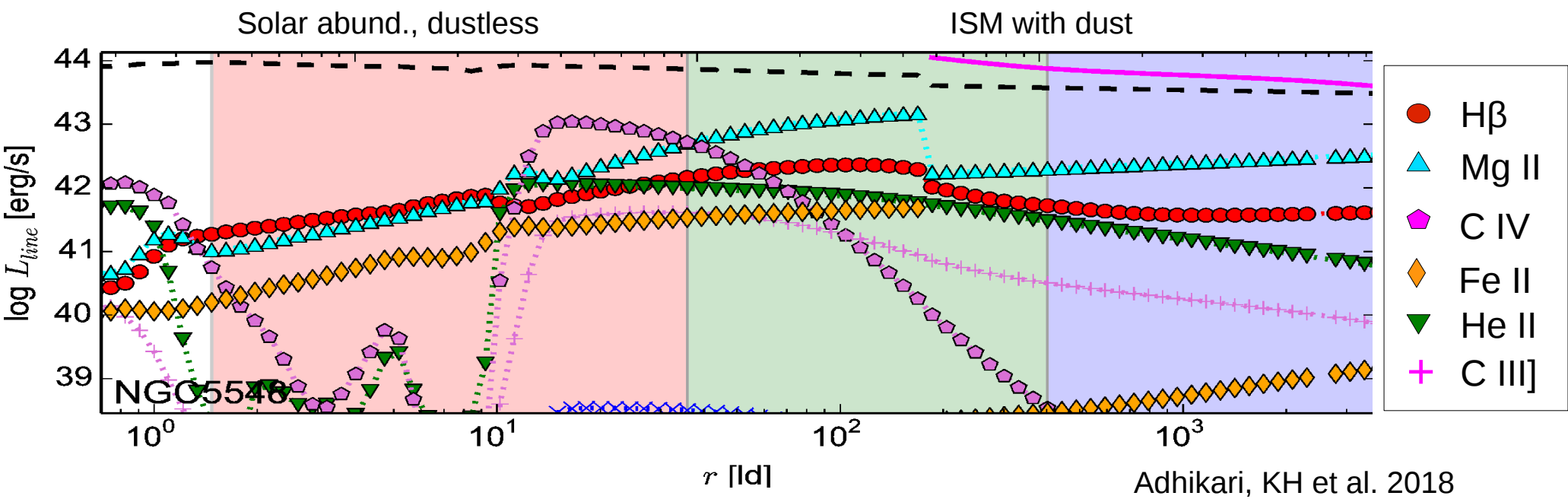


Adhikari, KH et al. 2018

We produce photoionization model of radial emissivity of the most common emission lines. Started from continuous matter distribution.

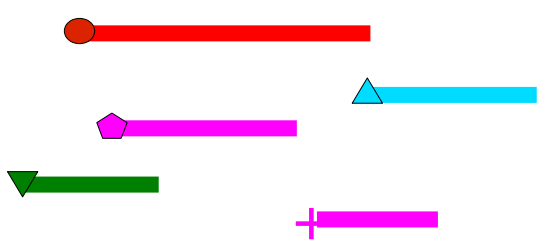
Distinct regions dominates mimicking separate components of the emission lines.

Emission lines: model vs observations



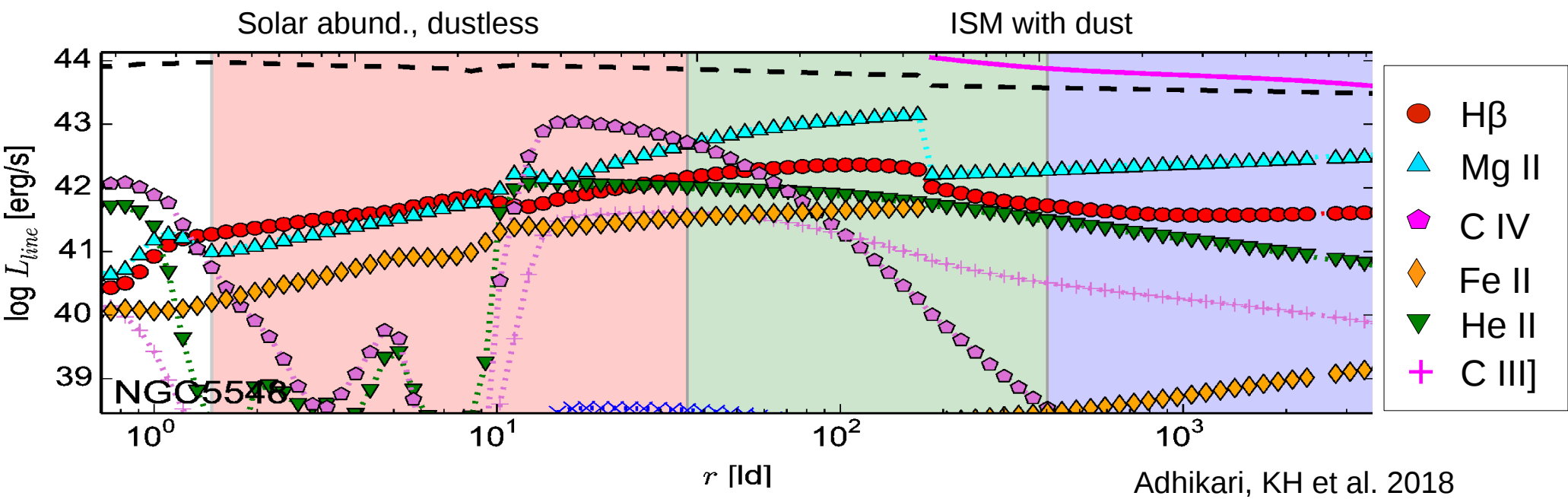
Adhikari, KH et al. 2018

Measured delay in emission line response in NGC 5548



Affected by geometry and different epochs

Emission lines: model vs observations



Adhikari, KH et al. 2018

Measured
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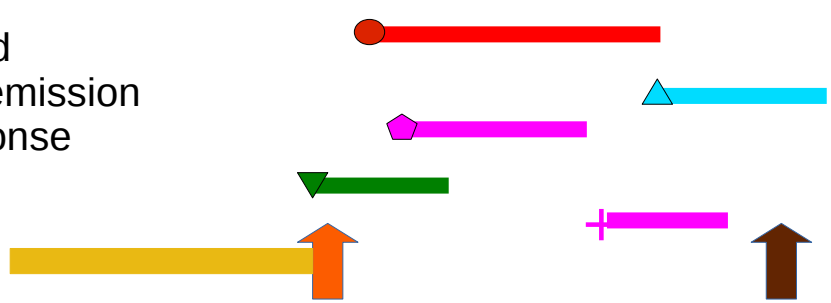

continuum
Cackett et al. 2007

1000 K
Czerny & KH 2011

dusty torus from Koshida et al. 2014