Bowen Lines
in
Extreme Accretion Flow

Extreme AGNs and Transients: When Black Holes Misbehave

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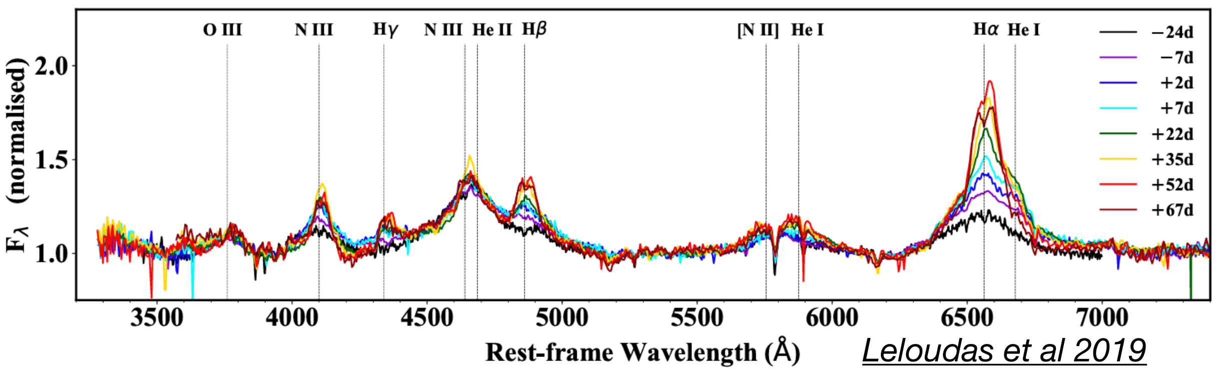
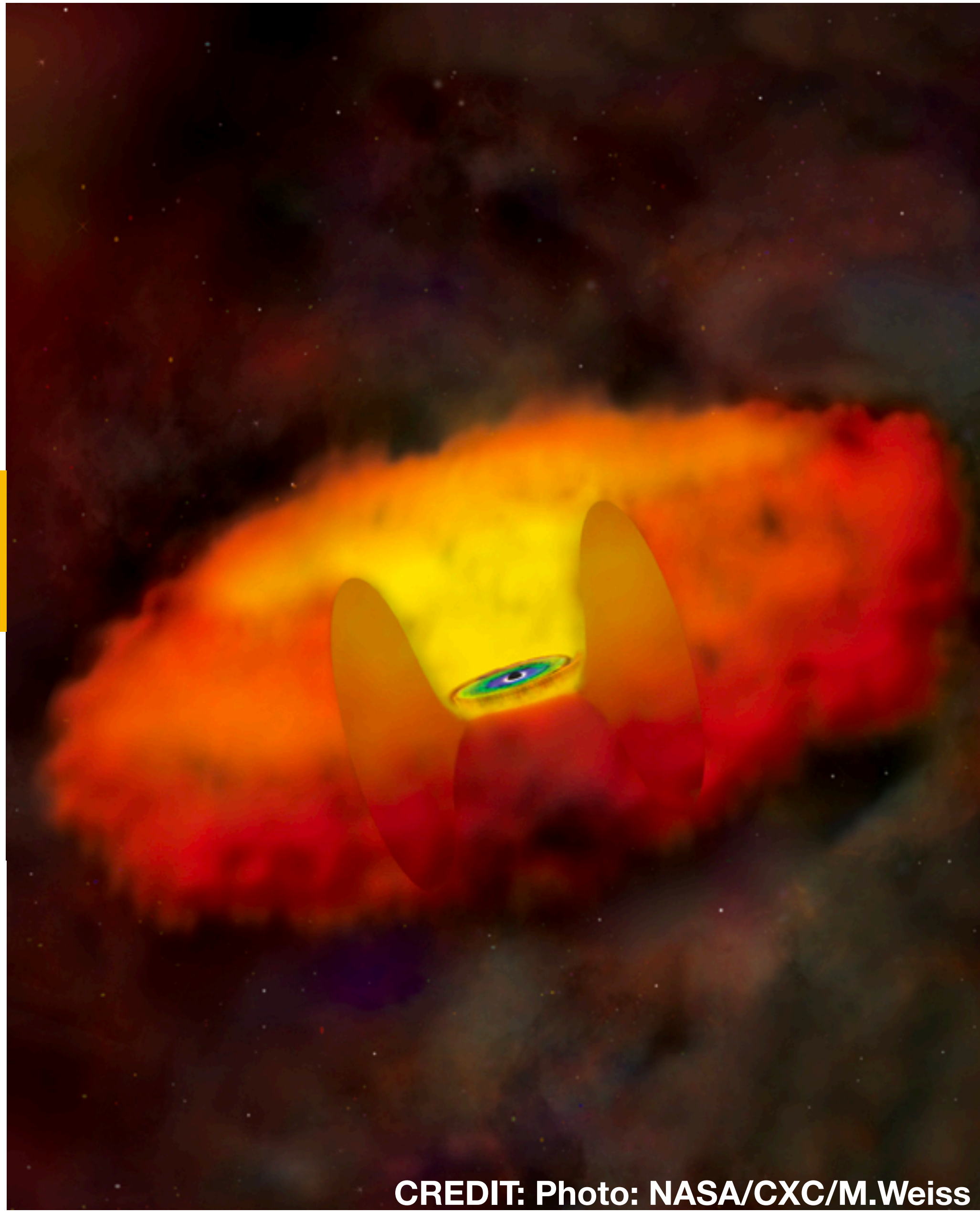


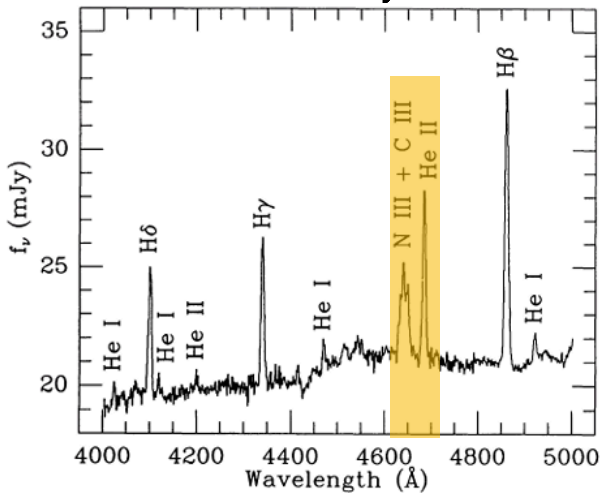
Leloudas et al 2019



NIII4640 in Stellar Mass Objects

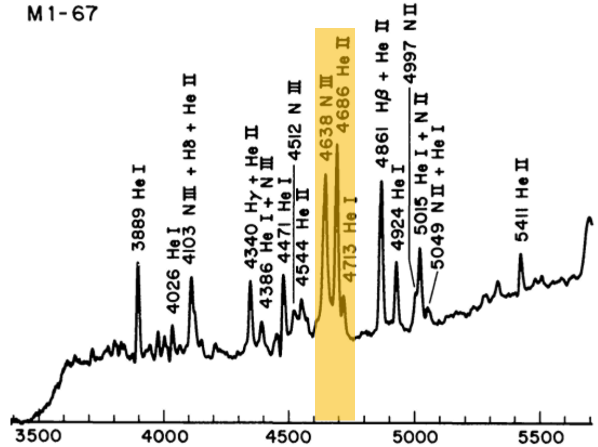
- **Observation**: Strong NIII4640 is seen in LMXRB (CV), WR, and SN.
- **Nitrogen Abundance**: Nitrogen makes up 0.009% of atoms;
  - NIII4640 requires super-solar abundance.

Low mass X-ray binaries



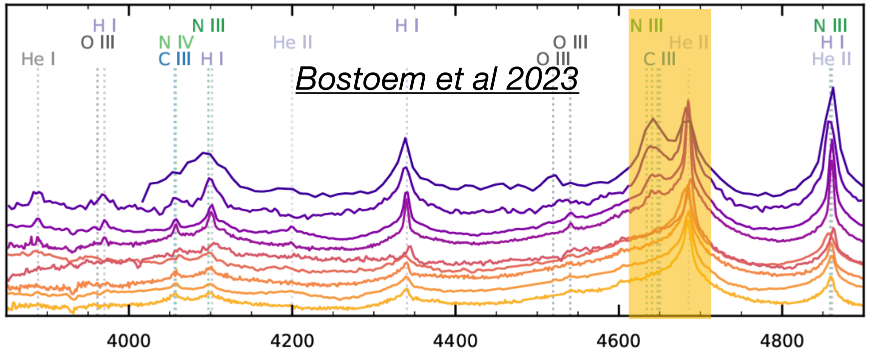
Shcachter et al 1989

Wolf-Rayet



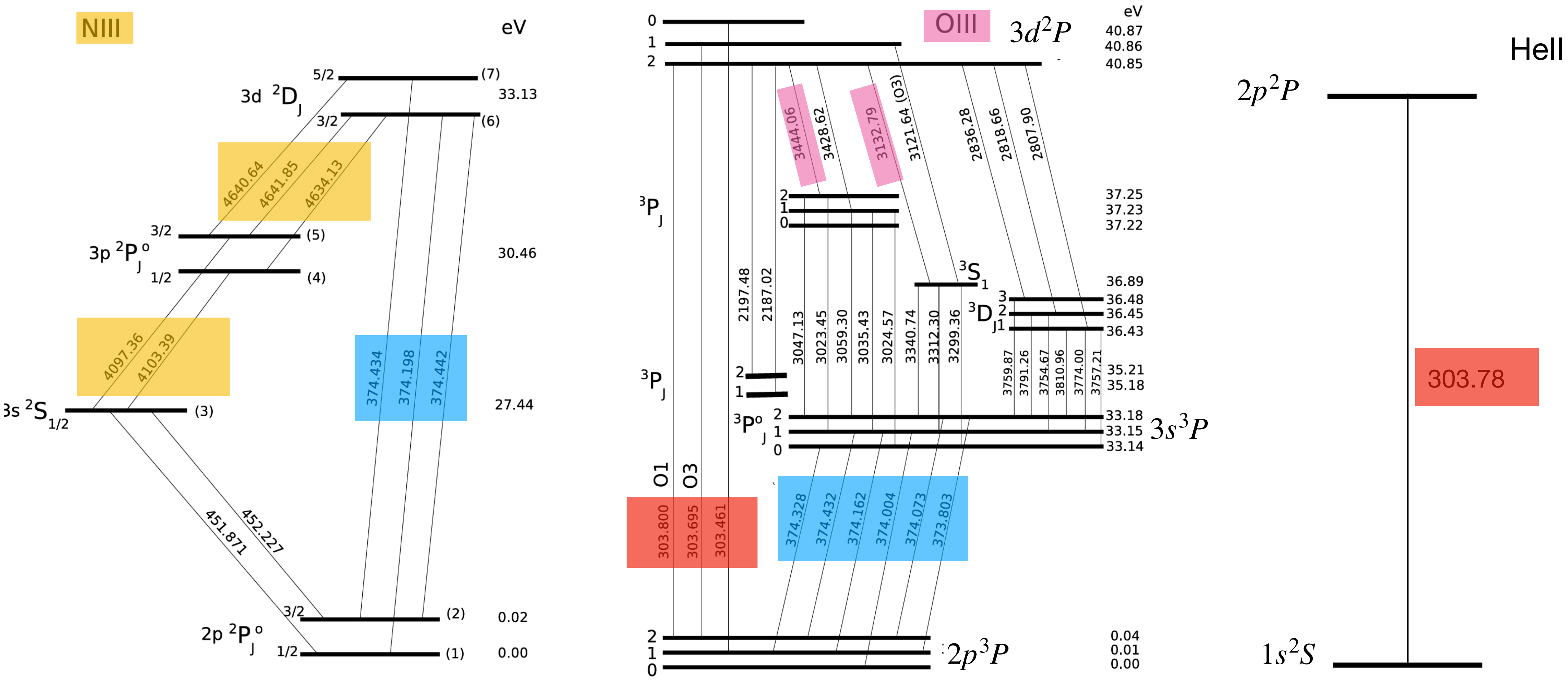
Weidmann et al 2015

Super-Novae



Bostoem et al 2023

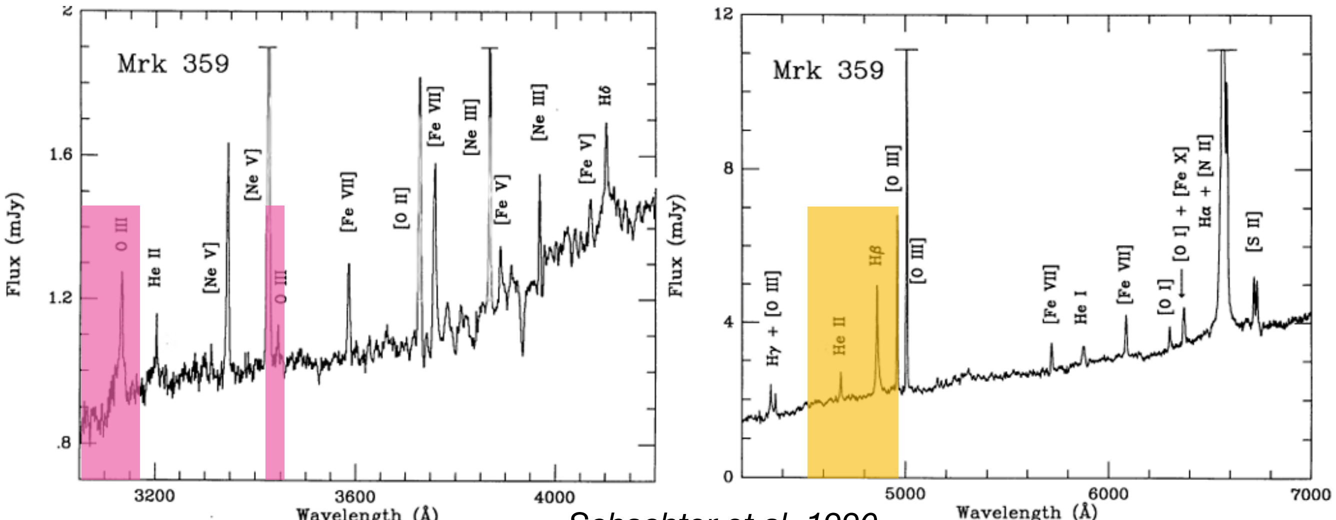
Bowen Lines



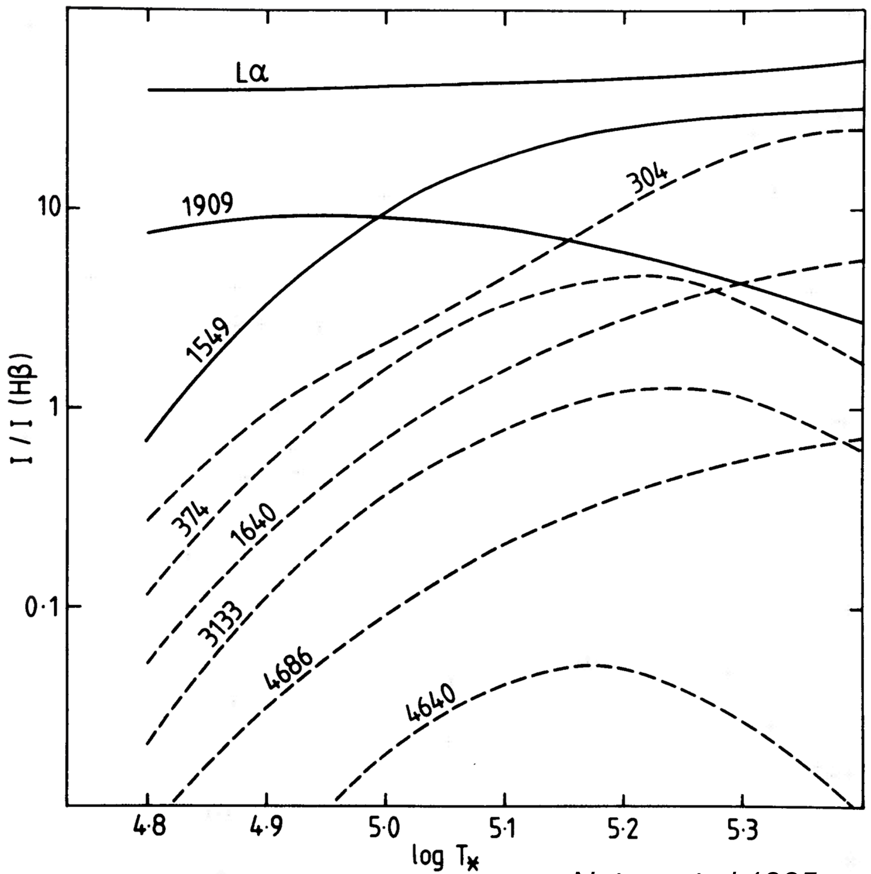
Bowen proposed in 1934-1935. Modified version from Selvelli et al. 2007

Bowen Lines in SMBHs

- **Predictions**: Netzer et al 1985 suggested SMBHs could show detectable NIII lines, 40-80% of HeII4686.
- **Observations**: HeII4640 and OIII3133 are observed; NIII4640 is not.



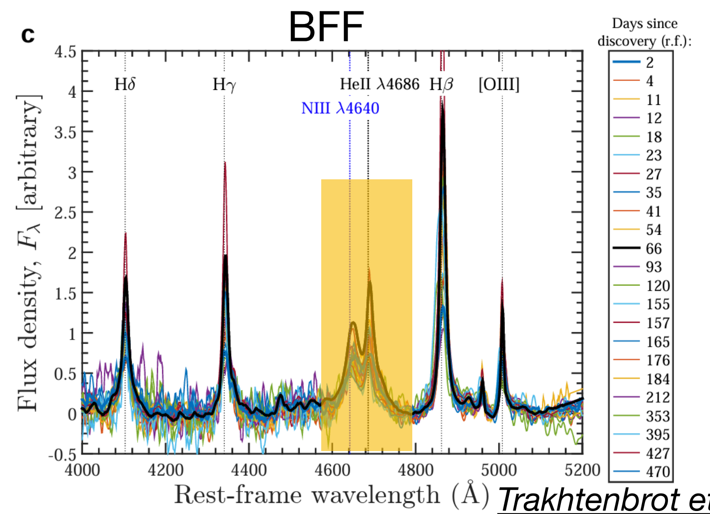
Schachter et al. 1990



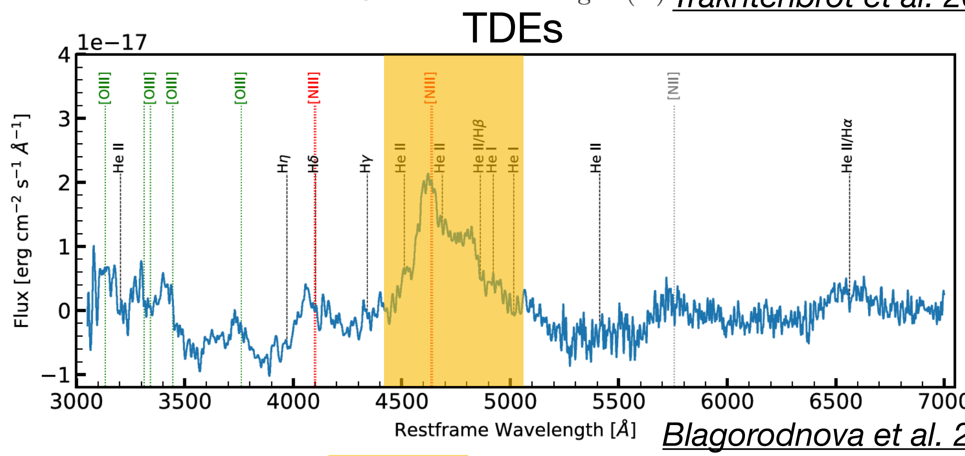
Netzer et al 1985

NIII4640 in SMBH

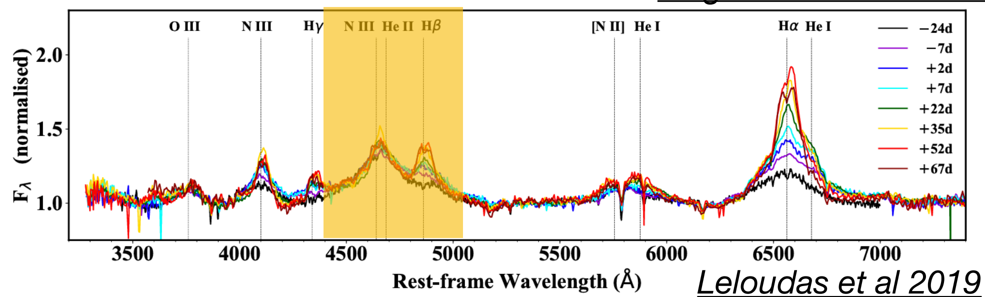
- **Detection**: In 2019, strong NIII4640 was found in BFF and TDEs.
- **Accretion Rates**: BFF and TDEs are close to Eddington or super-Eddington.
- **NIII4640**: Linked to extreme SMBH accretion rates.
- **Outflow Dynamics**: These conditions produce higher wind density and luminosity.
- **My work:** is to simulate emission lines under extreme accretion flows



Trakhtenbrot et al. 2019



Blagorodnova et al. 2019



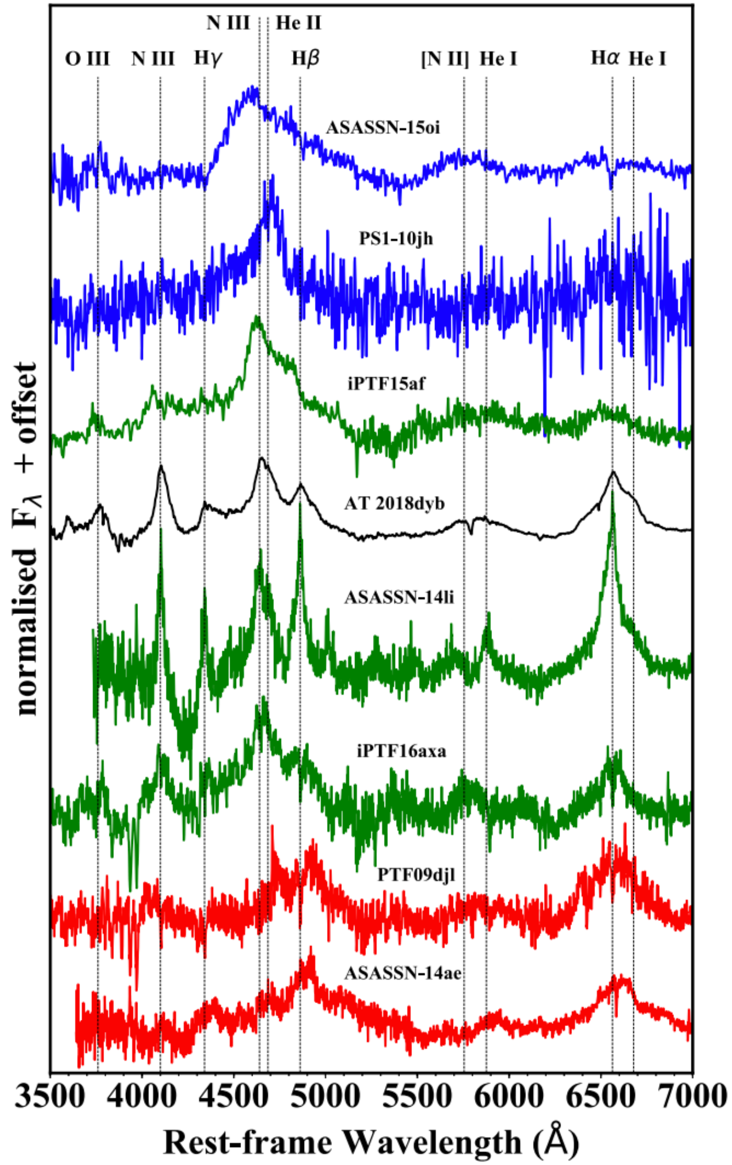
Leloudas et al 2019

Emission Lines in TDEs

I focus on TDEs but it can be generalised to any extreme accretion flow.

TDE Characteristics: Typically show strong emission lines with broad widths ~10^4 km/s, classified into four categories.

- **TDE He**: Helium only emission lines.
- **TDE H+He**: Strong hydrogen and helium lines (includes TDE Bowen with NIII and/or OIII), narrowest.
- **TDE H**: Hydrogen only emission lines, broadest.
- **TDE Featureless**: No line features observed (not shown in the figure).

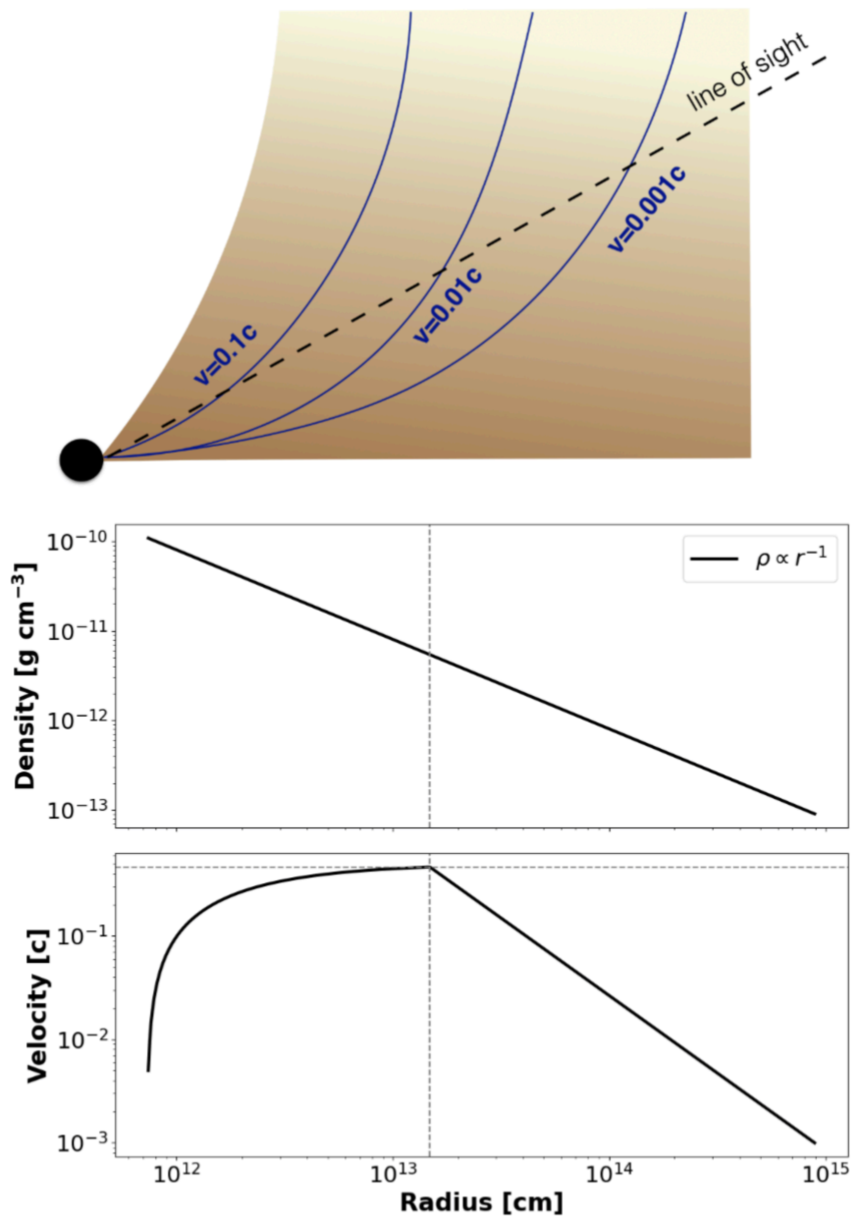


Leloudas et al 2019

Toy-Model

- **Modelling Assumptions**: Spherical symmetry, density is modelled as a shallow power law with an index of -1 based on accretion modes.
  - **ADAF**: Yuan et al. (2012)
  - **Super-Eddington**: Dai et al. (2018)
  - **Zero Bernoulli Accretion**: Coughlin & Begelman (2014)

- **Winds**: Often collimated, especially with strong magnetic fields; includes phases of acceleration and deceleration.



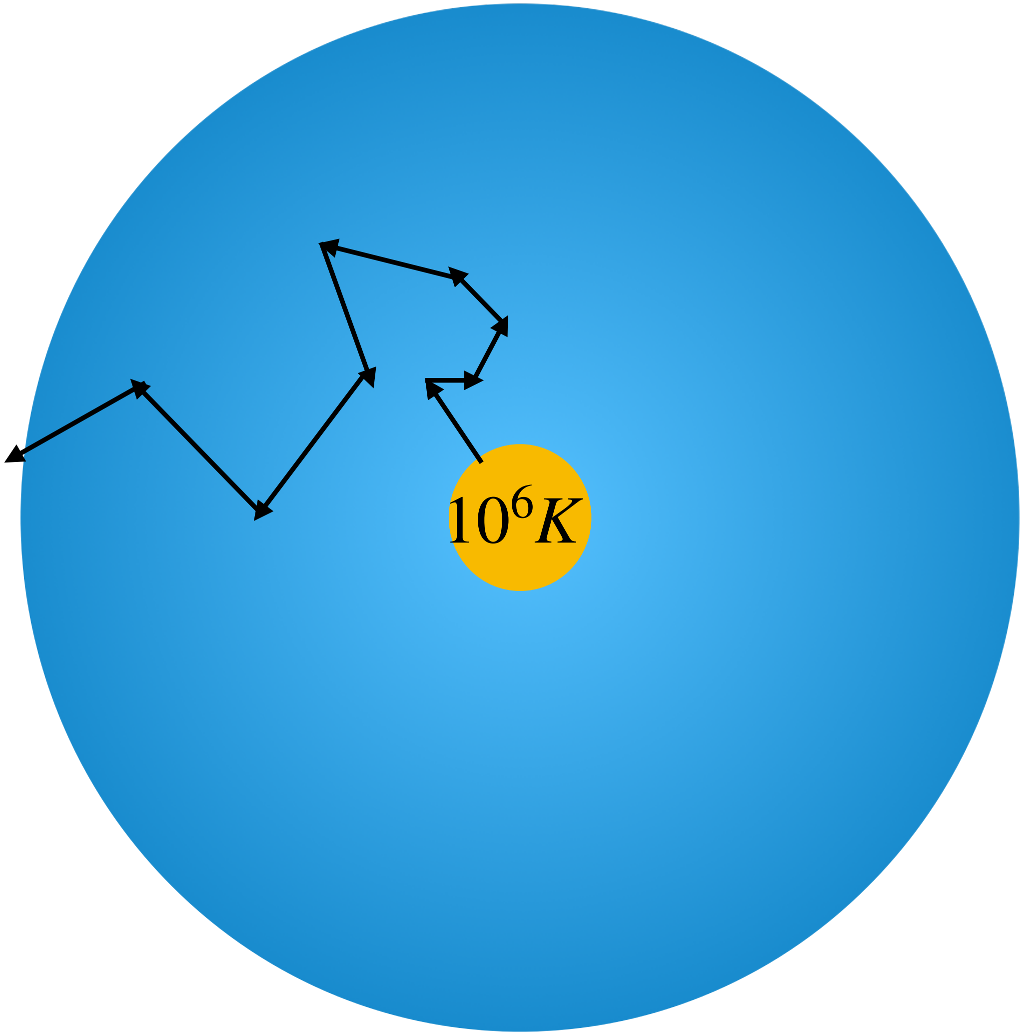
Simulation

Variable parameters

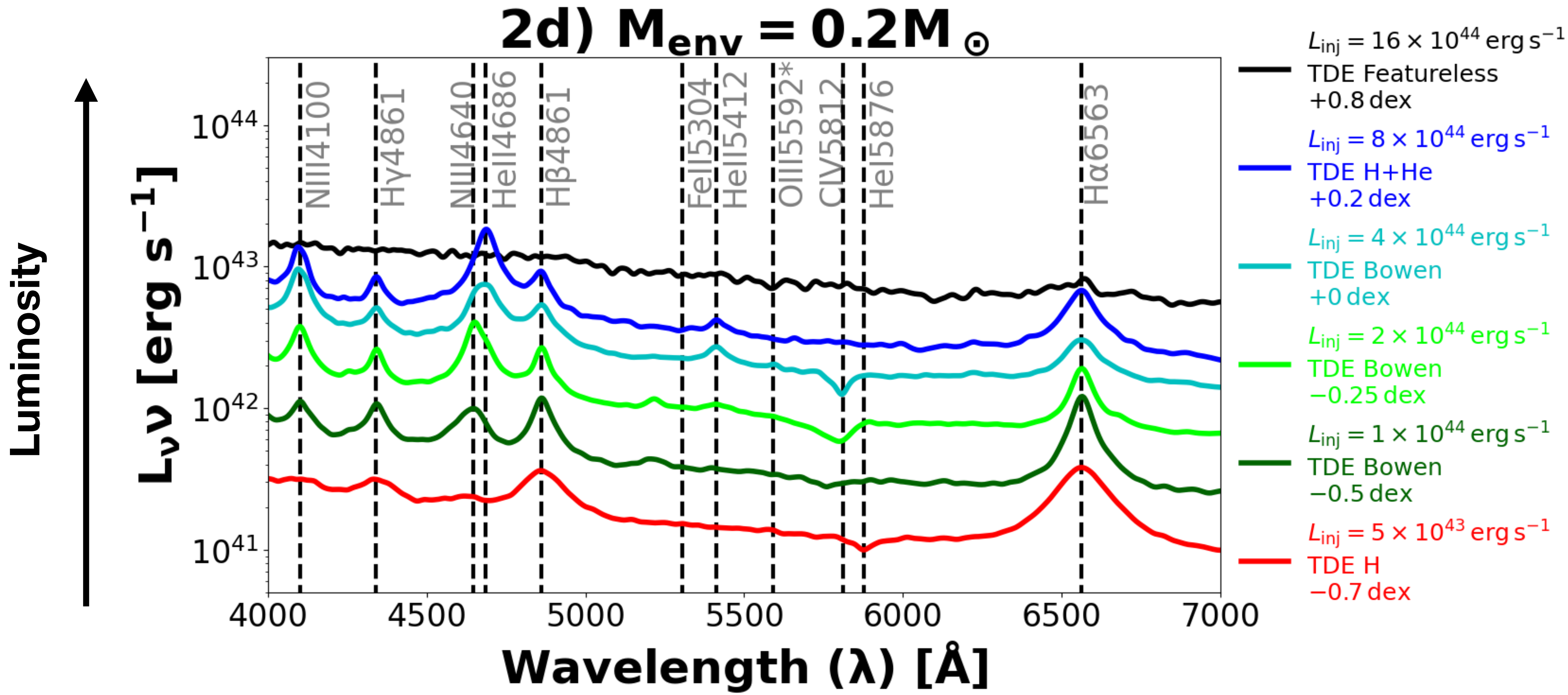
- Envelope mass
- Injected luminosity

Fixed parameters:

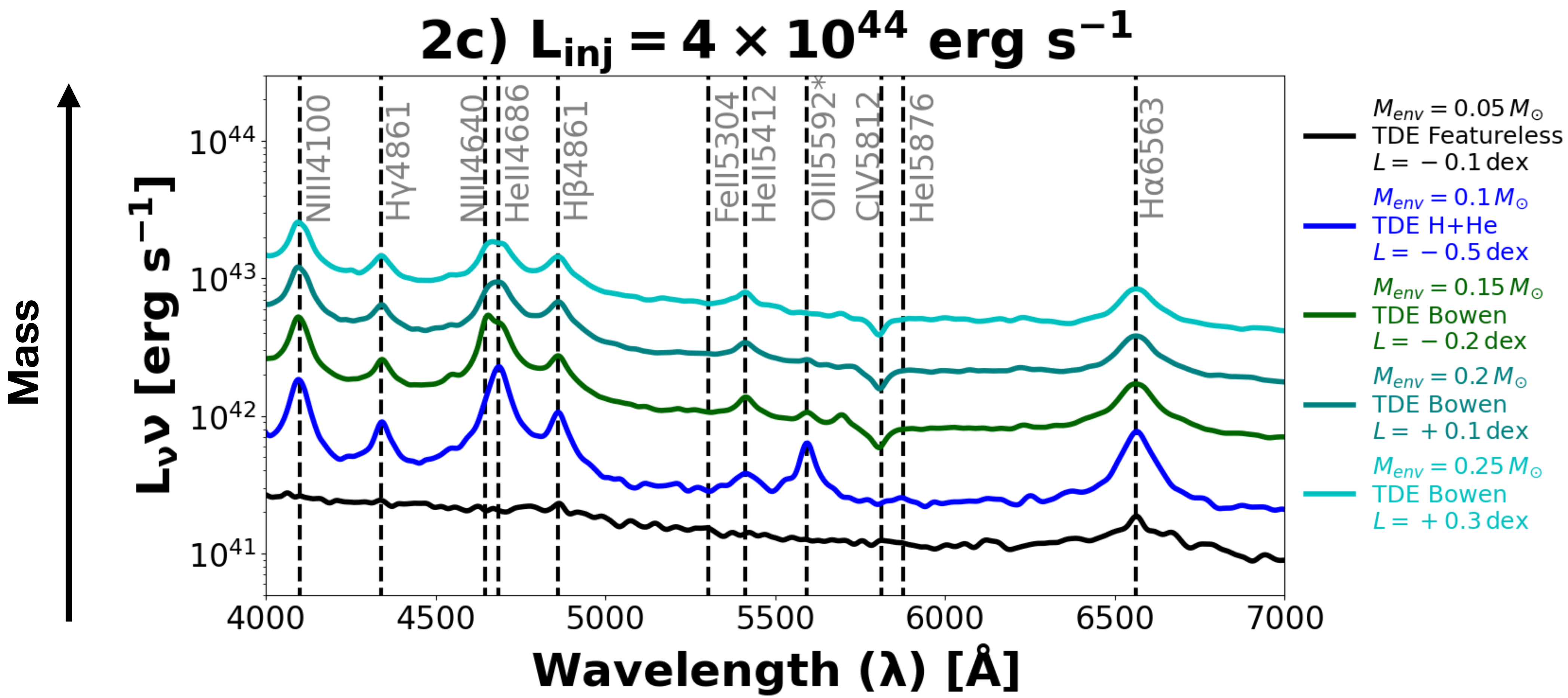
- Radiation Temperature $(10^6 K)$
- Initial gas temperature
- Velocity profile
- Density slope
- Inner and outer boundary
- Elemental abundance (solar)



Results: Spectra as a Function of Luminosity



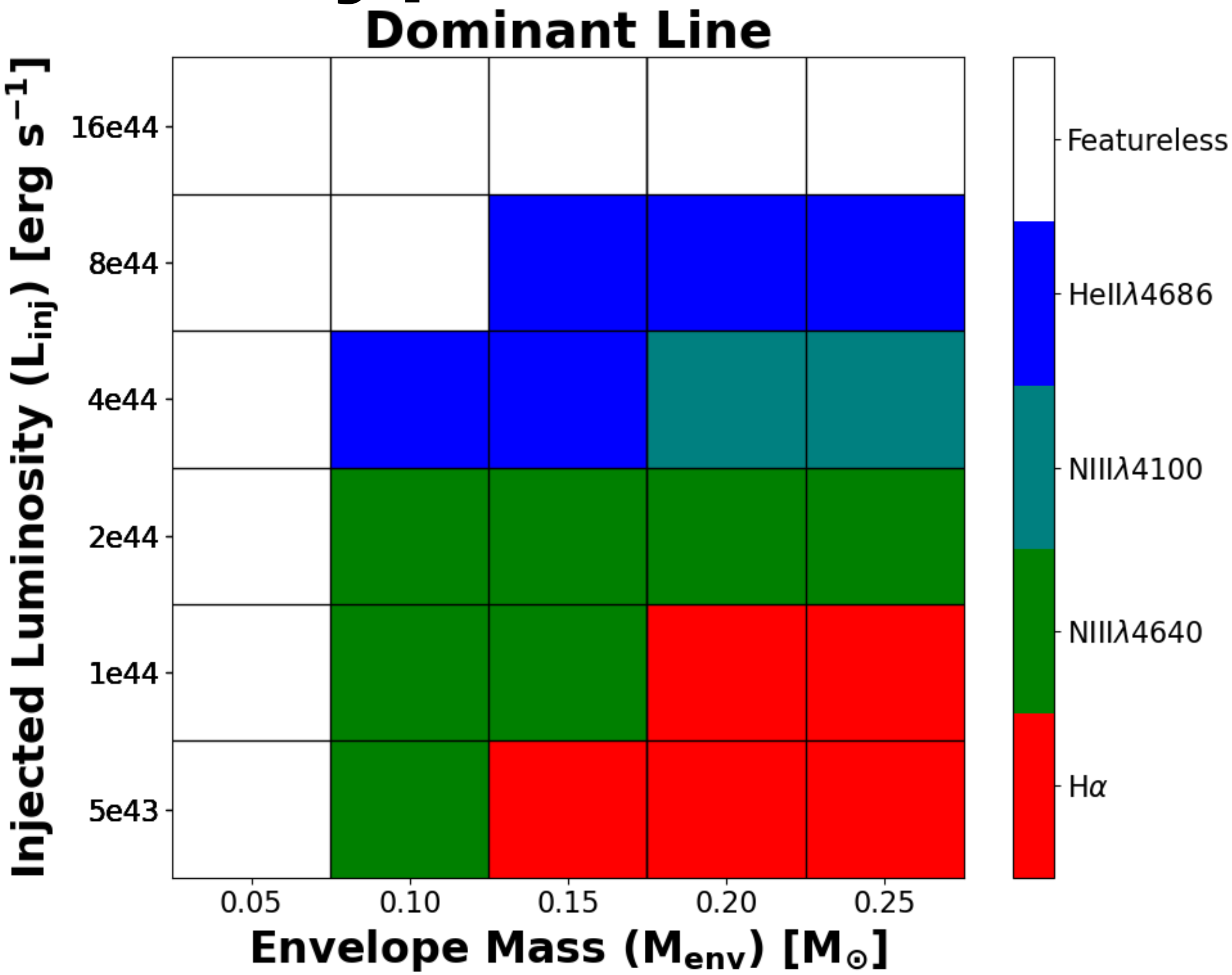
Results: Spectra as a Function of Mass



Results: Type

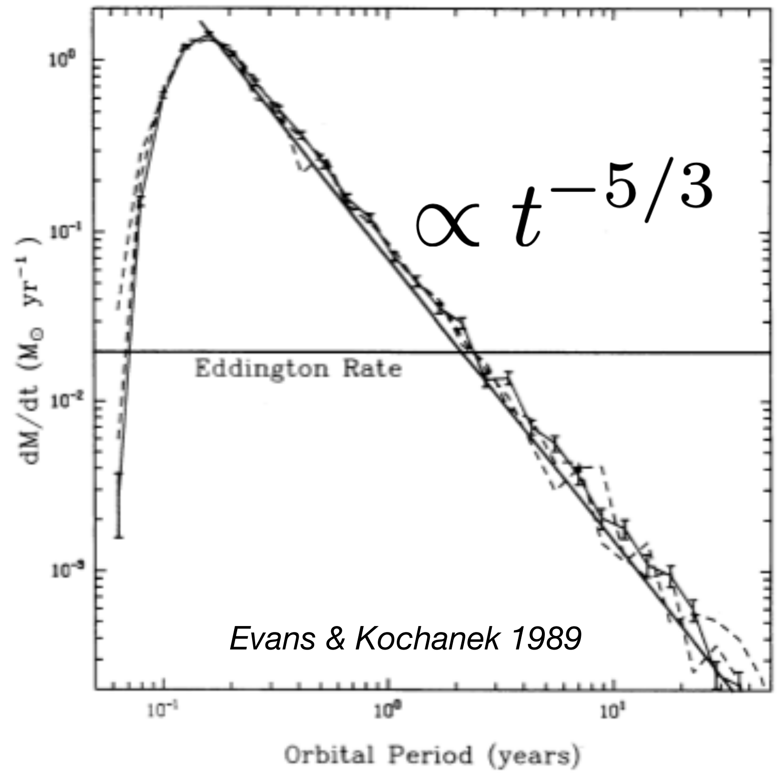
The spectral type depends on the **ionization**

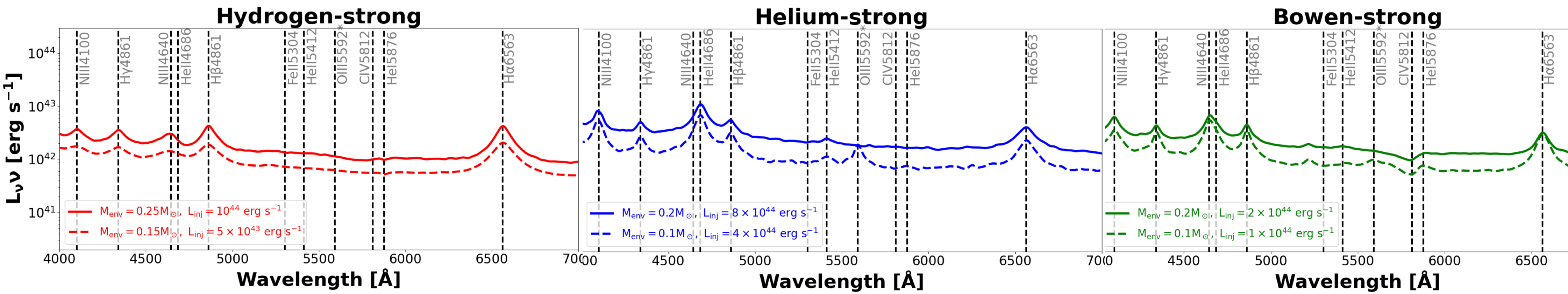
- **Featureless**
- **Helium dominant**
- **Bowen dominant**
- **Hydrogen dominant**



Results: Evolution

- **Model**: Injected luminosity and envelope mass (wind mass) follow the fallback rate.
- **Ionization**: Remains relatively constant.
- **Spectral Type**: Can remain unchanged even with a tenfold decrease in luminosity

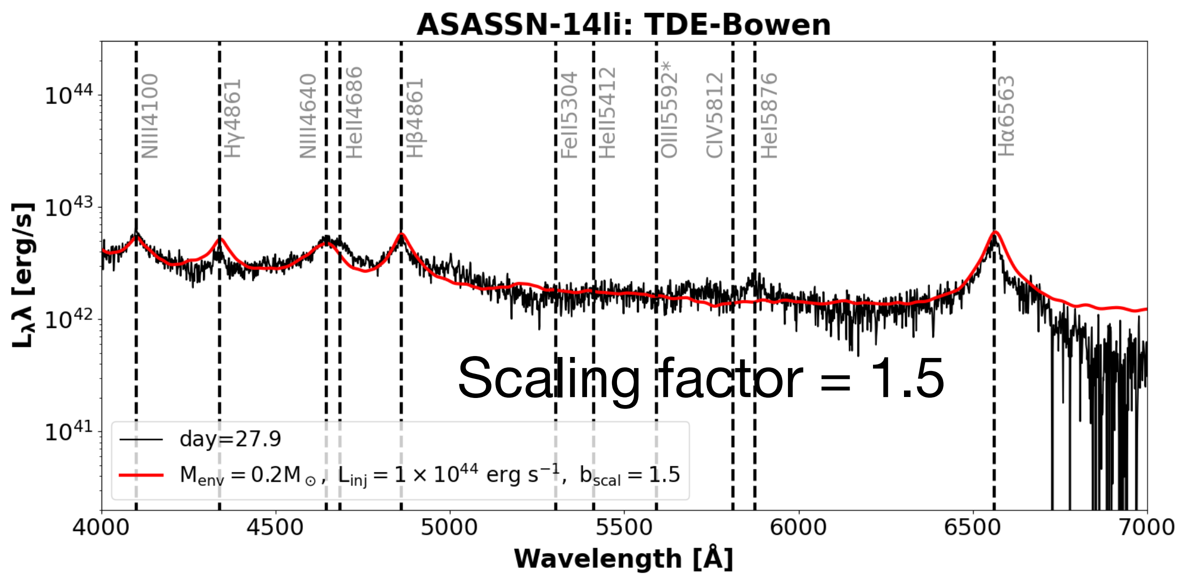


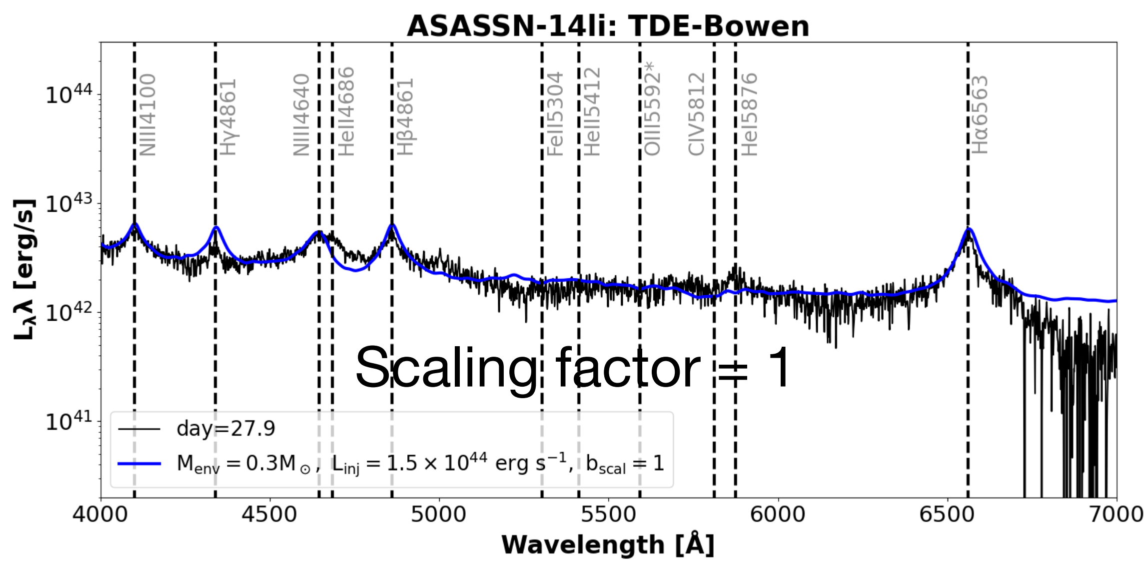


Results: Fitting

Fit Simulations to Observations:

- Match the continuum slope and spectral lines using the simulation grid.
- Determine the scaling factor.
- **Best fit:**
  - Envelope mass × scaling factor
  - Injected luminosity × scaling factor
- Remains somewhat linear if the scaling factor is less than 3-5.





Key takeaways

- Ionization determines the spectral category of TDEs.
- **Bowen lines emerge naturally in extreme accretion flows.**
- Observations align well with this model where only two parameters were changed.