

MEASURING SUPERMASSIVE BLACK HOLE WITH FUV AND X-RAY OBSERVATIONS



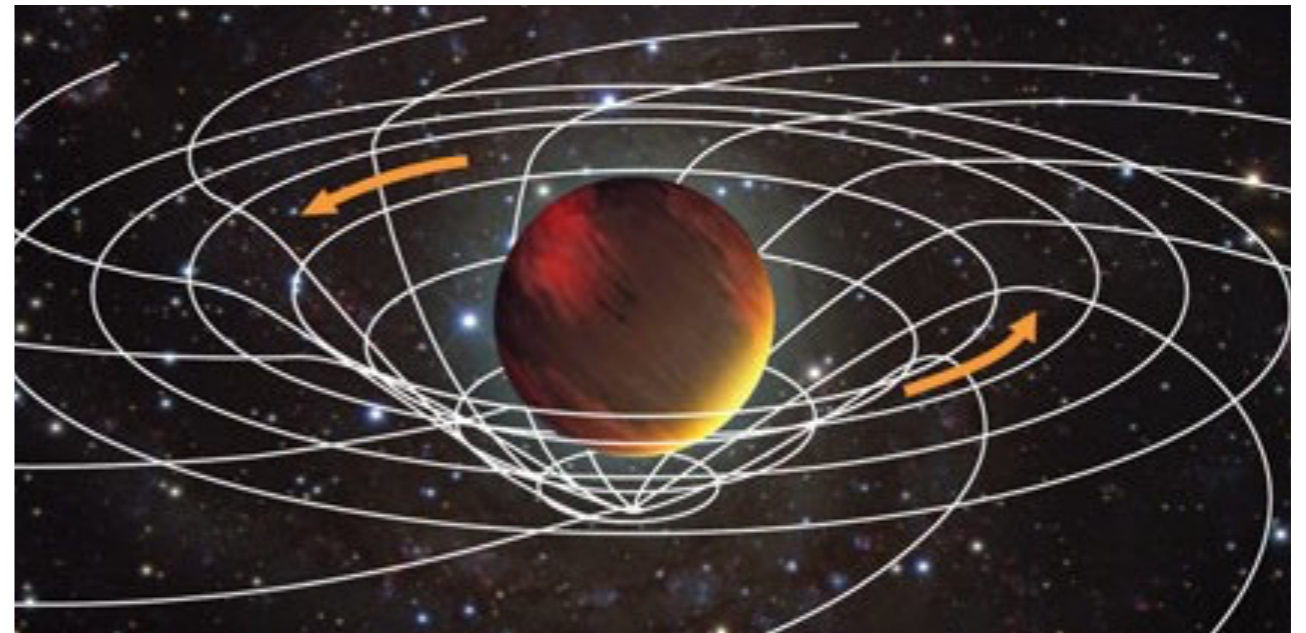
Mojegan Azadi

Center For Astrophysics | Harvard-Smithsonian

No-Hair Theorem



- The no-hair theorem of GR: An isolated BH is fully characterized by
 - Mass
 - Spin
 - Electrical Charge

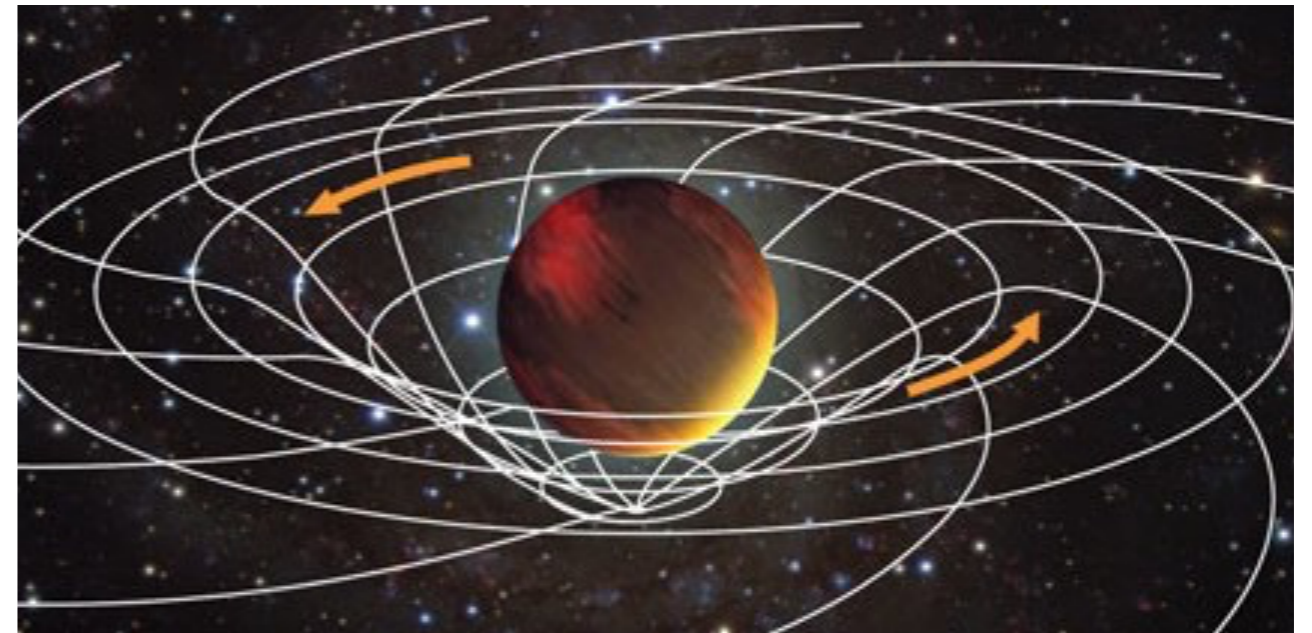


No-Hair Theorem



- The no-hair theorem of GR: An isolated BH is fully characterized by

- Mass
- Spin
- Electrical Charge $\Rightarrow 0$



- BH Mass

- stellar-mass black holes: companion stars

- Supermassive Black Holes (SMBH): Reverberation mapping, stellar velocity dispersion,

Width of the broad emission line, etc



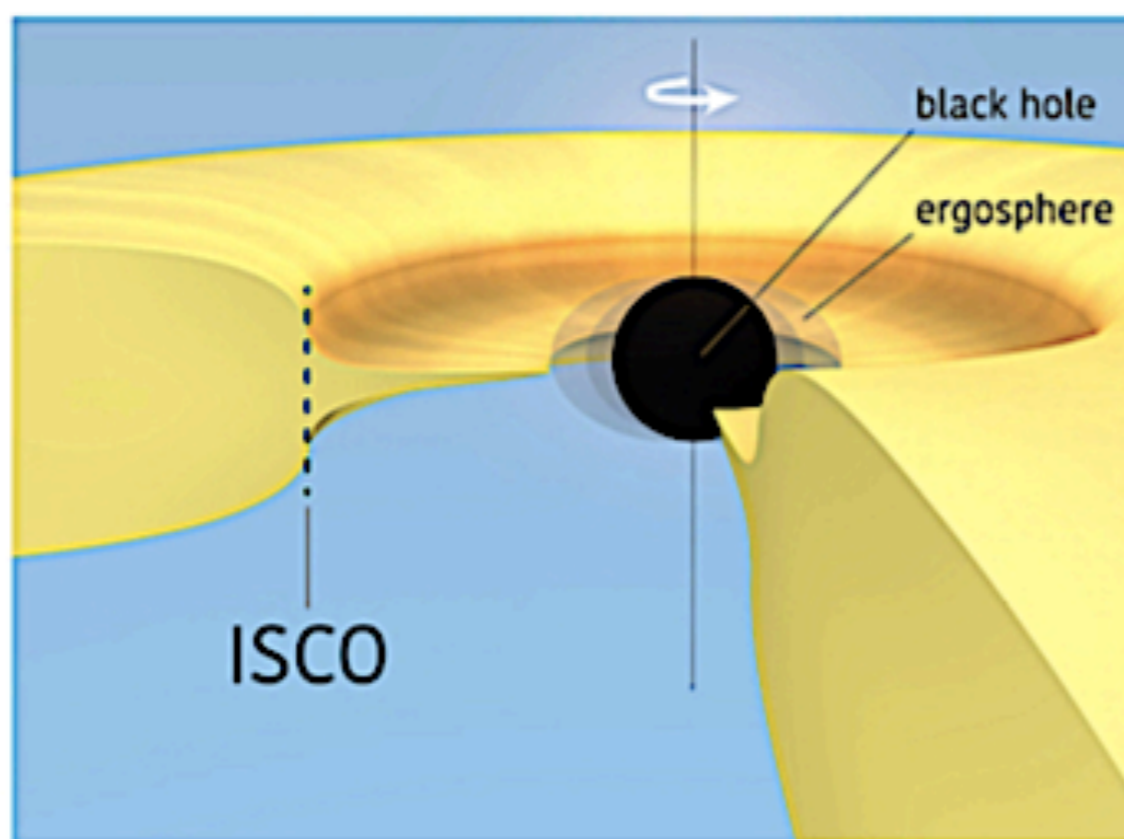
Spin: A Fossil Record of SMBHs Formation

- **Low spin: A history of chaotic accretion processes such as major mergers**
- **High spin: A history of dry mergers or steady accretions**

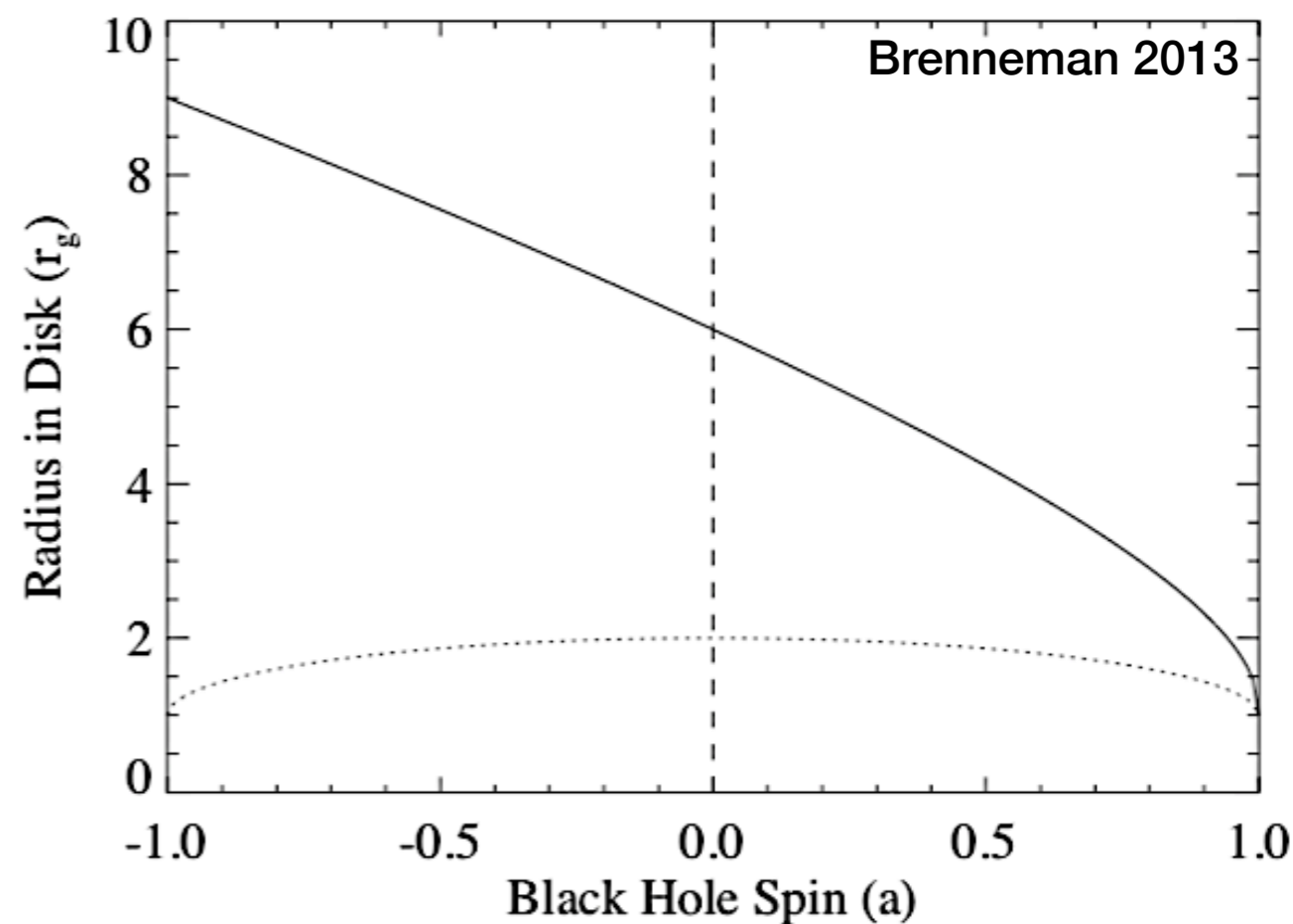


Spin: A Fossil Record of SMBHs Formation

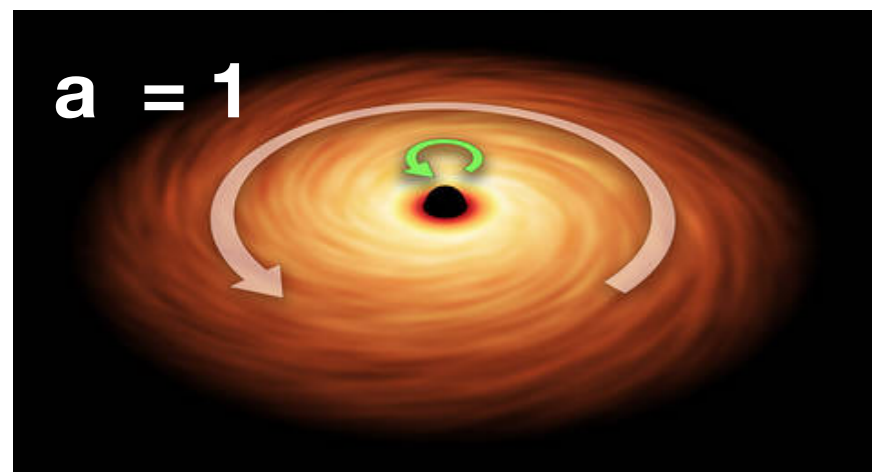
- Low spin: A history of chaotic accretion processes such as major mergers
- High spin: A history of dry mergers or steady accretions
- Spin determines the size of the Innermost Stable Circular Orbit (ISCO)



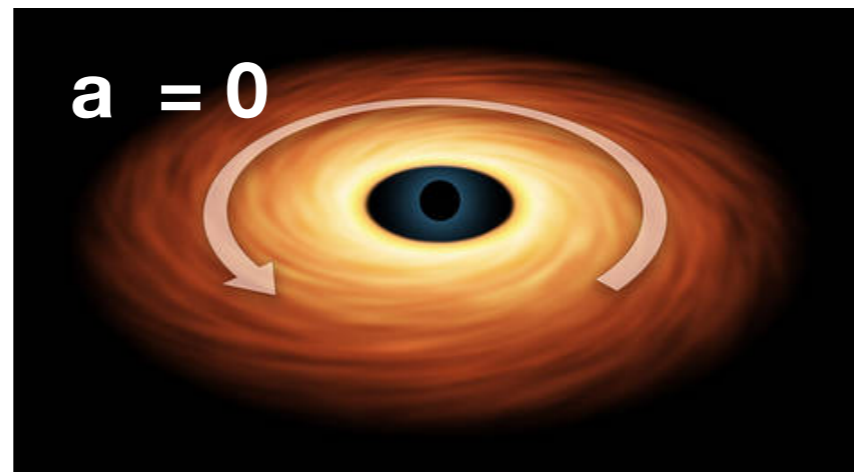
Reynolds 2019



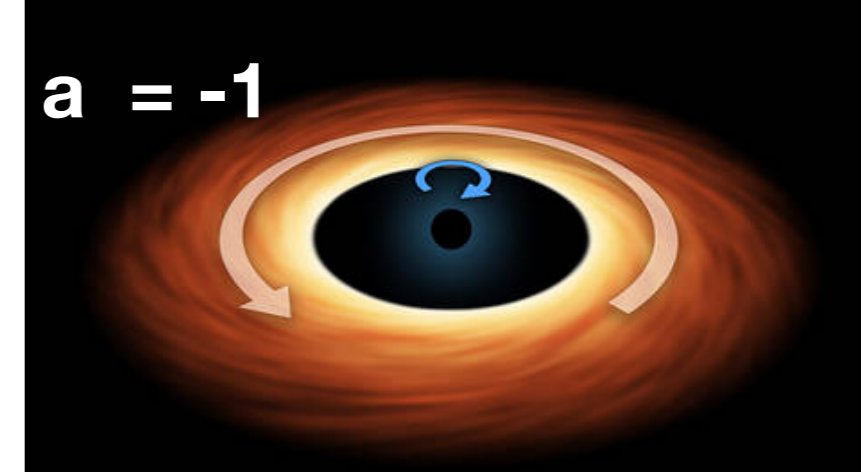
The Innermost Circular Orbit (ISCO)



- Maximally-spinning prograde BH (spinning in same direction as disk).
- $R_{\text{ISCO}} \sim 1 \text{ GM}/c^2$.



- Non-spinning BH.
- Accretion disk still rotates!
- $R_{\text{ISCO}} \sim 6 \text{ GM}/c^2$.

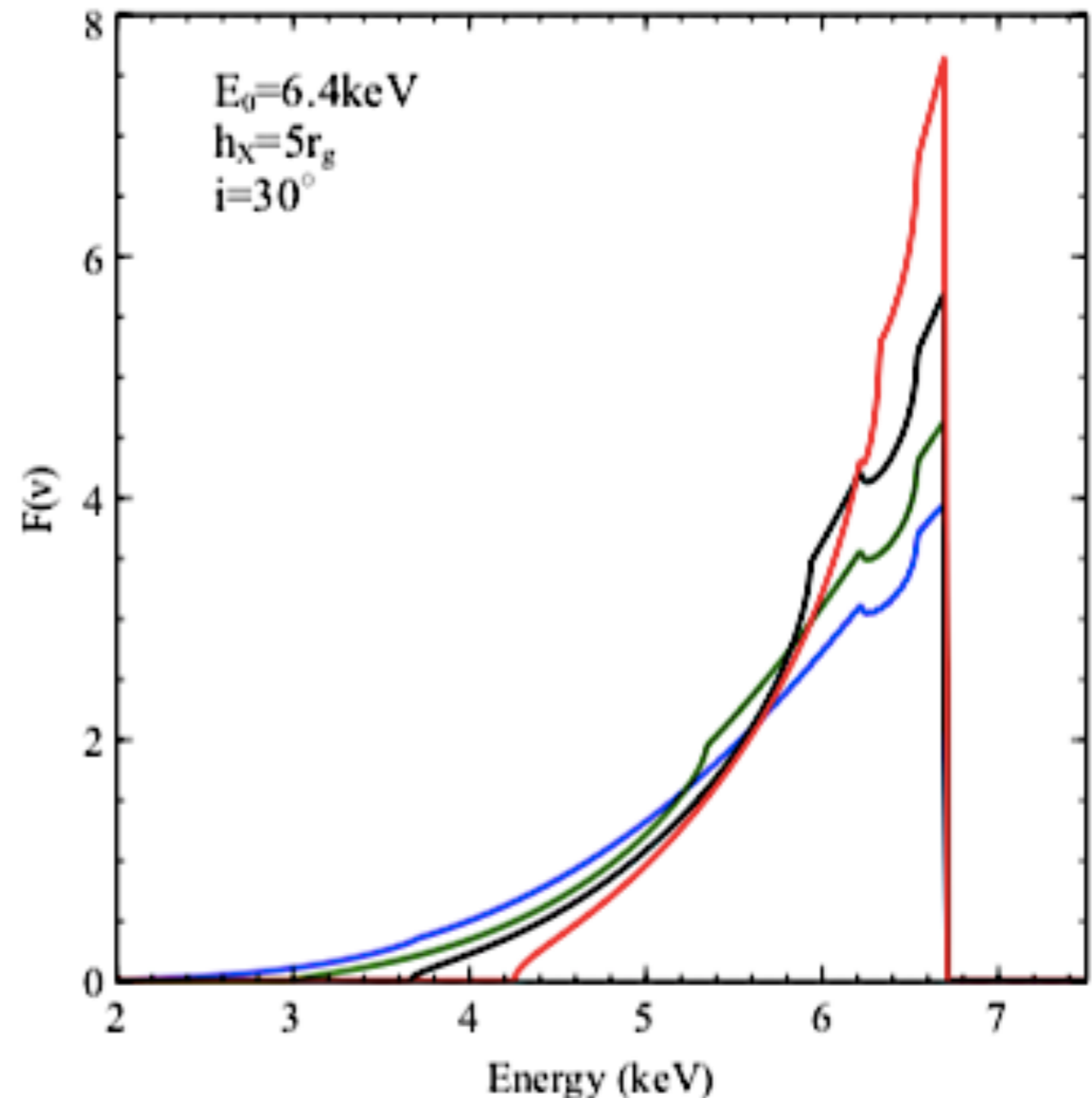


- Maximally-spinning retrograde BH (spinning in opposite direction as disk).
- $R_{\text{ISCO}} \sim 9 \text{ GM}/c^2$.

Common Techniques for Measuring SMBHs Spin



- X-ray reflection spectroscopy
- Thermal Continuum Fitting
- Quasi-Periodic Oscillations
- Radiative Efficiency
- Jet power
- Quasar microlensing
- Direct imaging



Reynolds 2019

Thermal Continuum Fitting

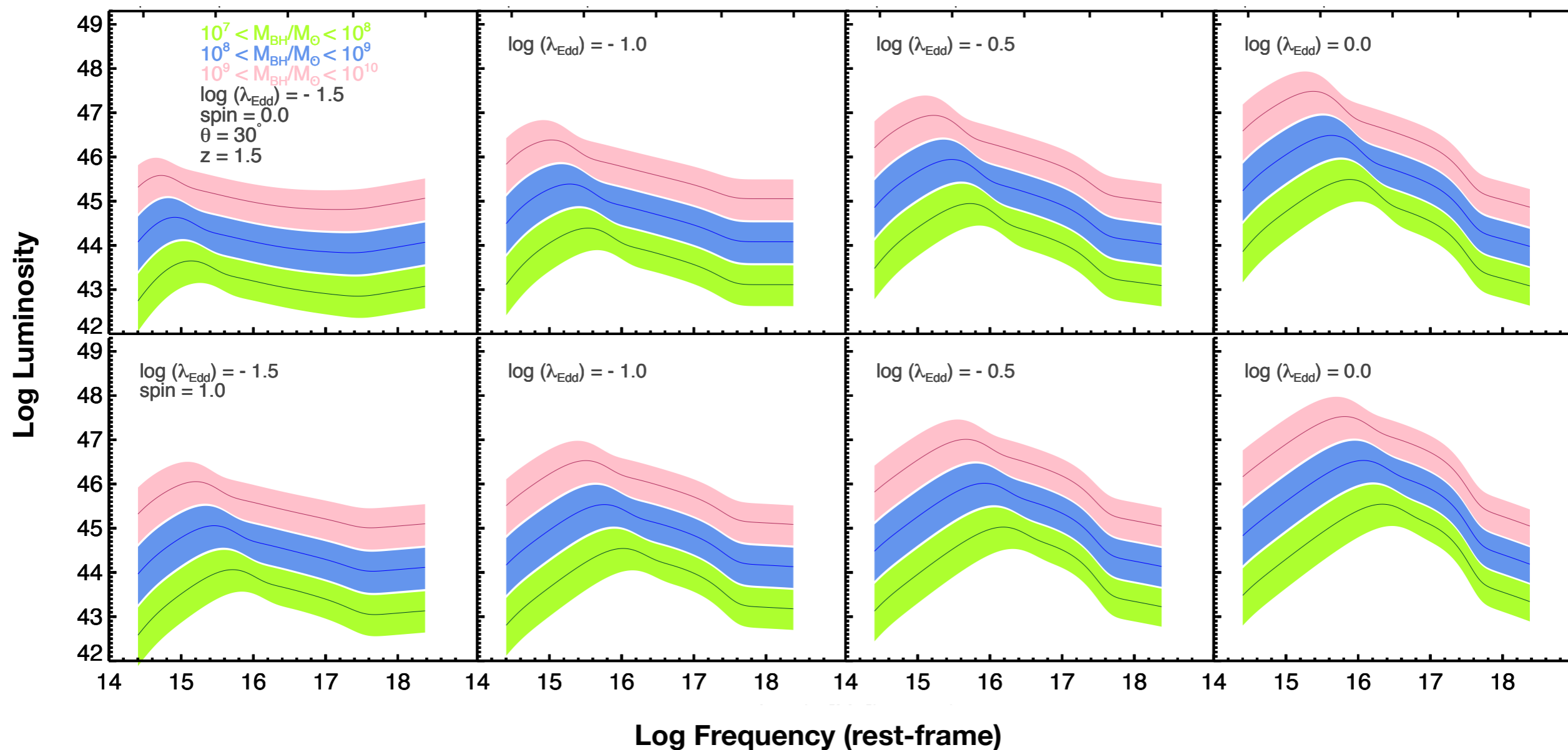


- Simultaneously Fitting the Optical to X-ray SED: kerBB, OPTXAGNF, QSOSED
- Geometrically thin but optically thick accretion disk
- $0.01 < \text{Eddington Ratio} < 0.3$
- Independent BH mass, disk inclination and distance estimates



Accretion disk SED

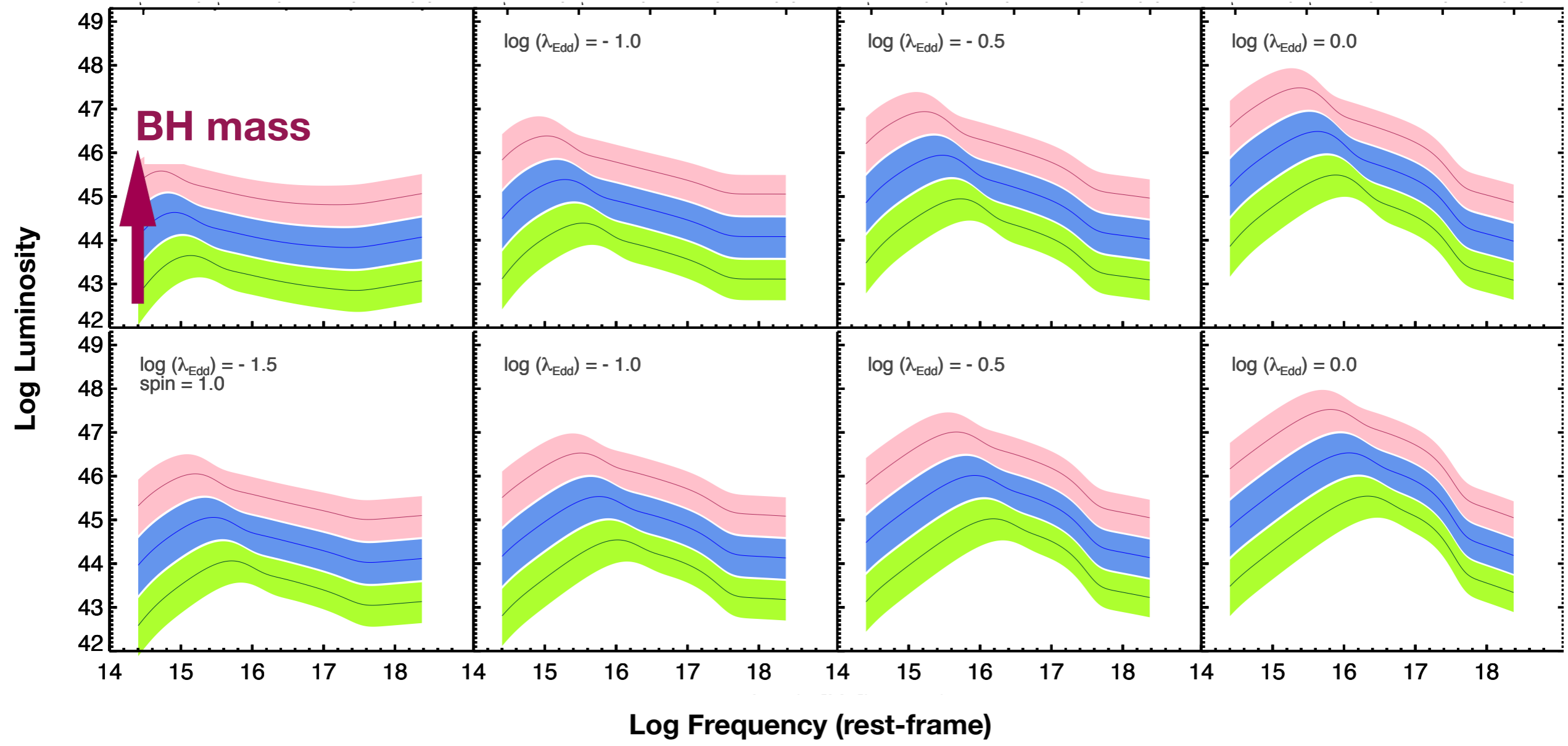
- Accretion disk SED templates using QSOSED model of Kubota & Done 2018





Accretion disk SED

- Accretion disk SED templates using QSOSED model of Kubota & Done 2018

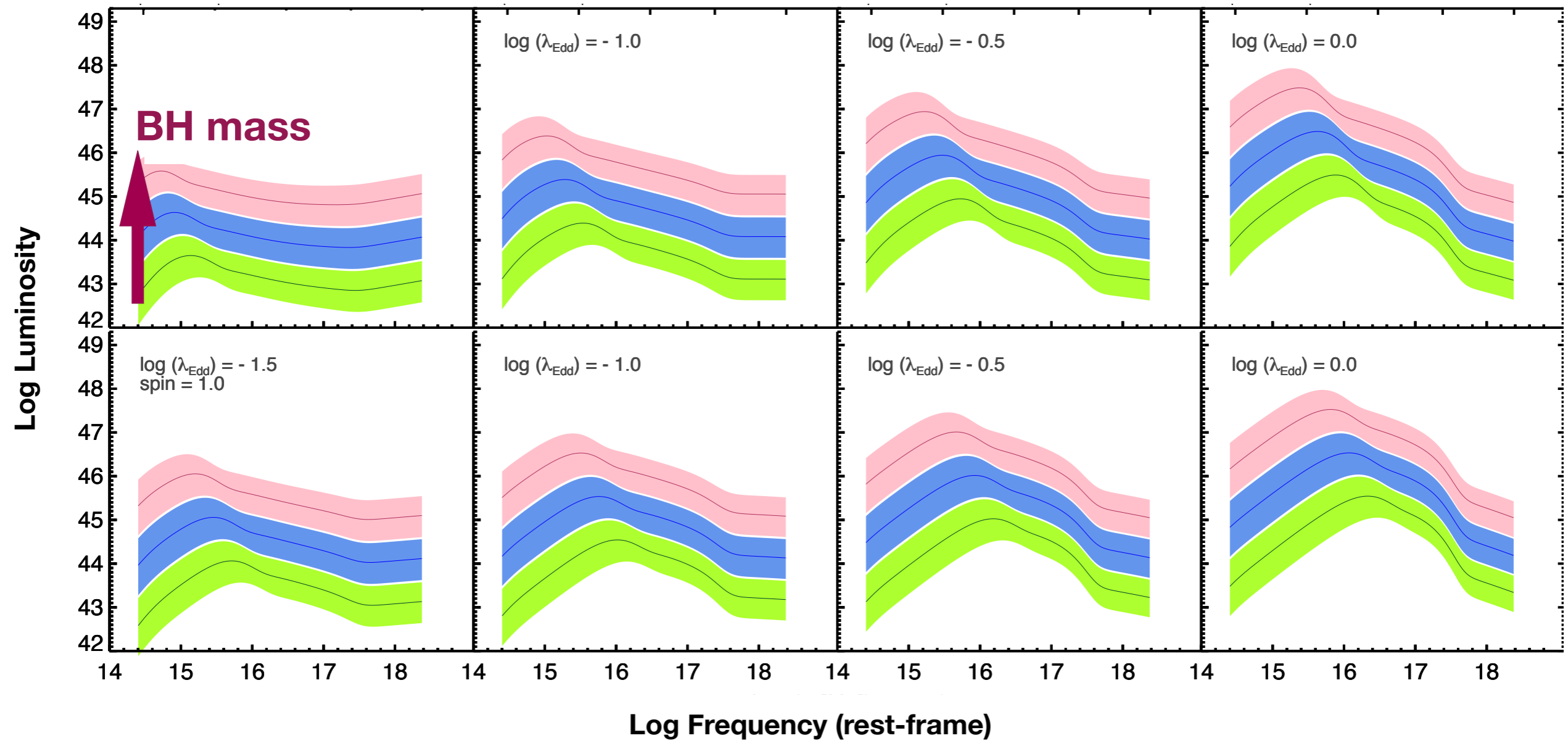




Accretion disk SED

- Accretion disk SED templates using QSOSED model of Kubota & Done 2018

Eddington ratio

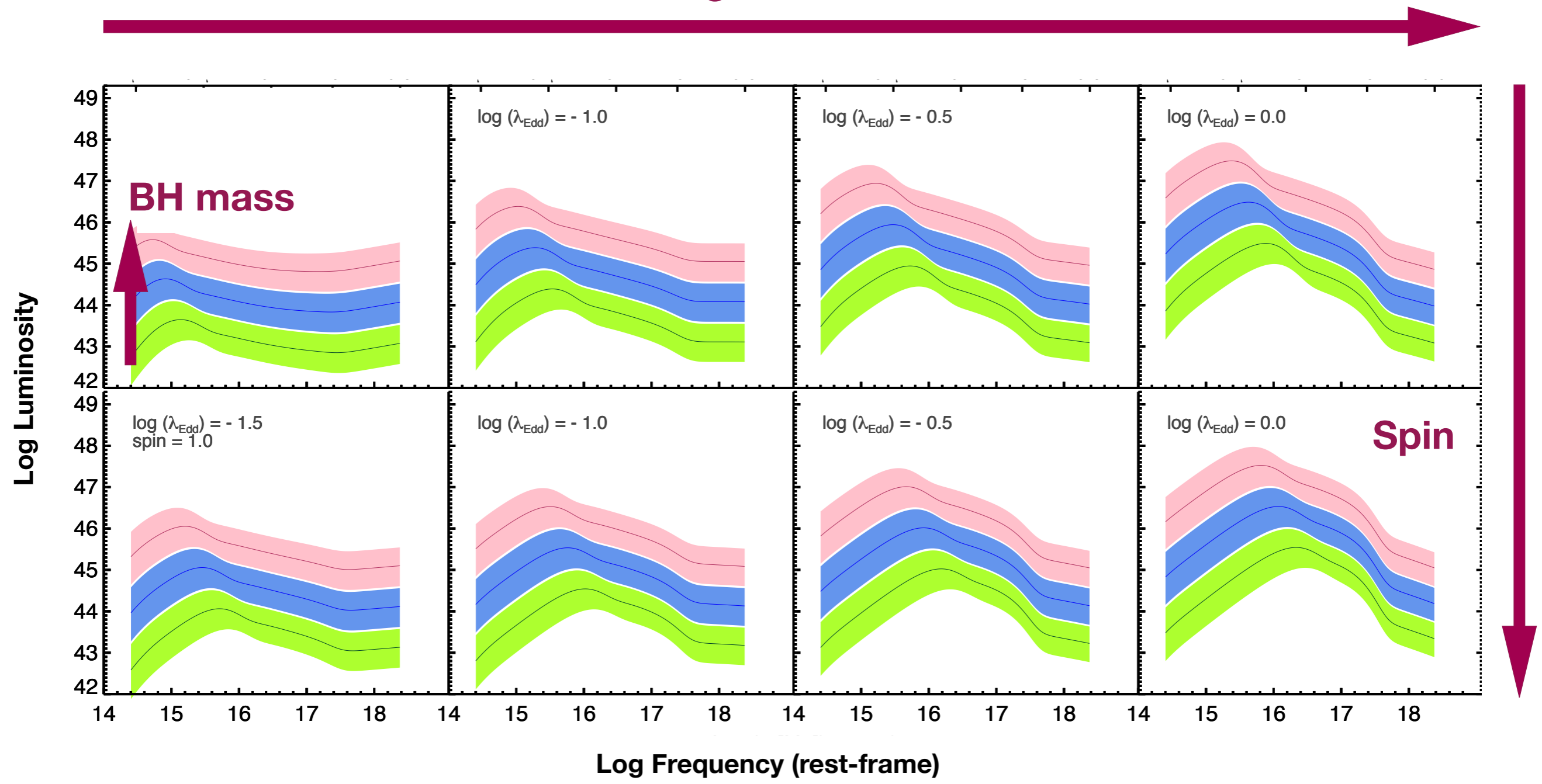




Accretion disk SED

- Accretion disk SED templates using QSOSED model of Kubota & Done 2018

Eddington ratio

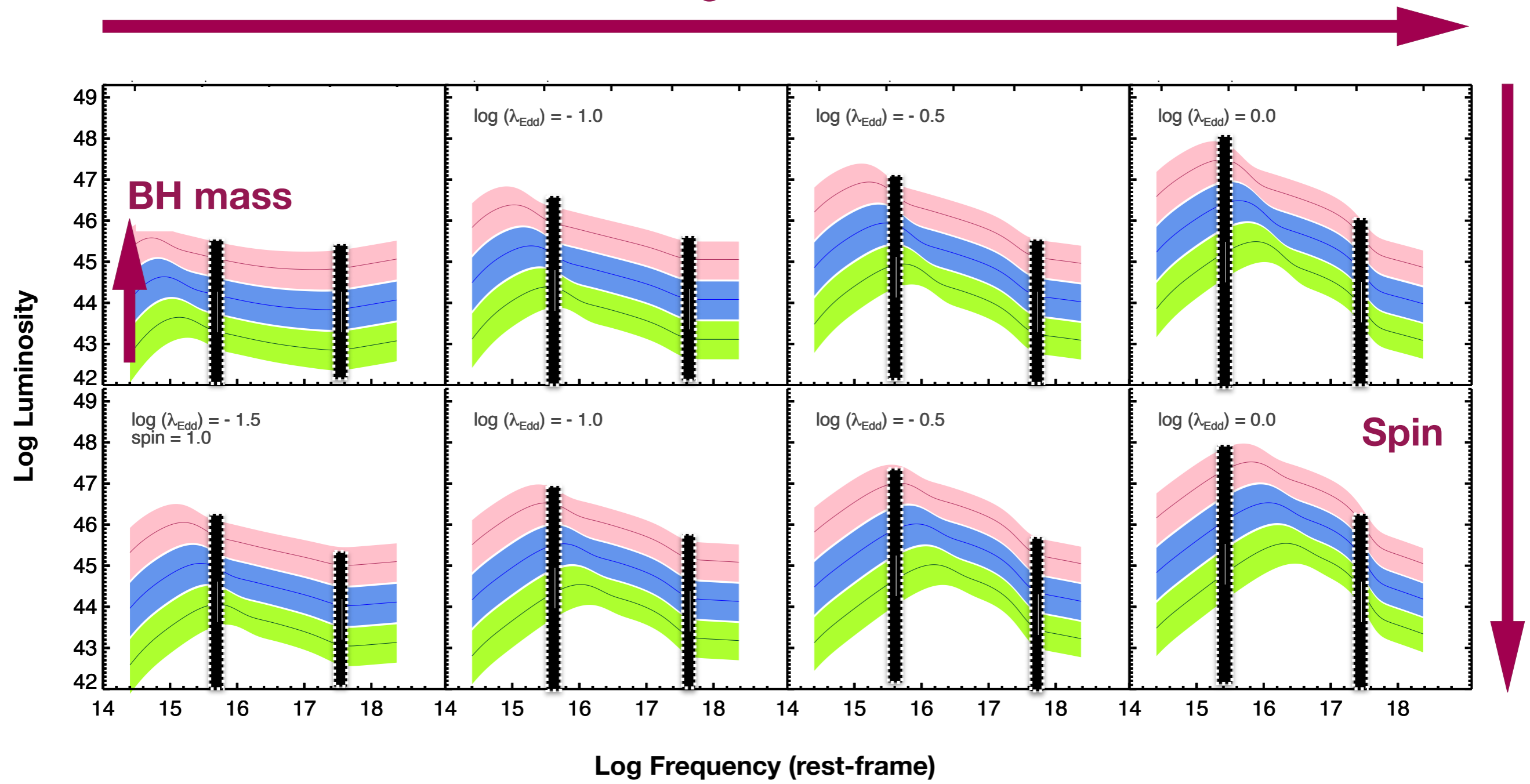




Accretion disk SED

- Accretion disk SED templates using QSOSED model of Kubota & Done 2018

Eddington ratio



Example of Continuum Fitting Technique

