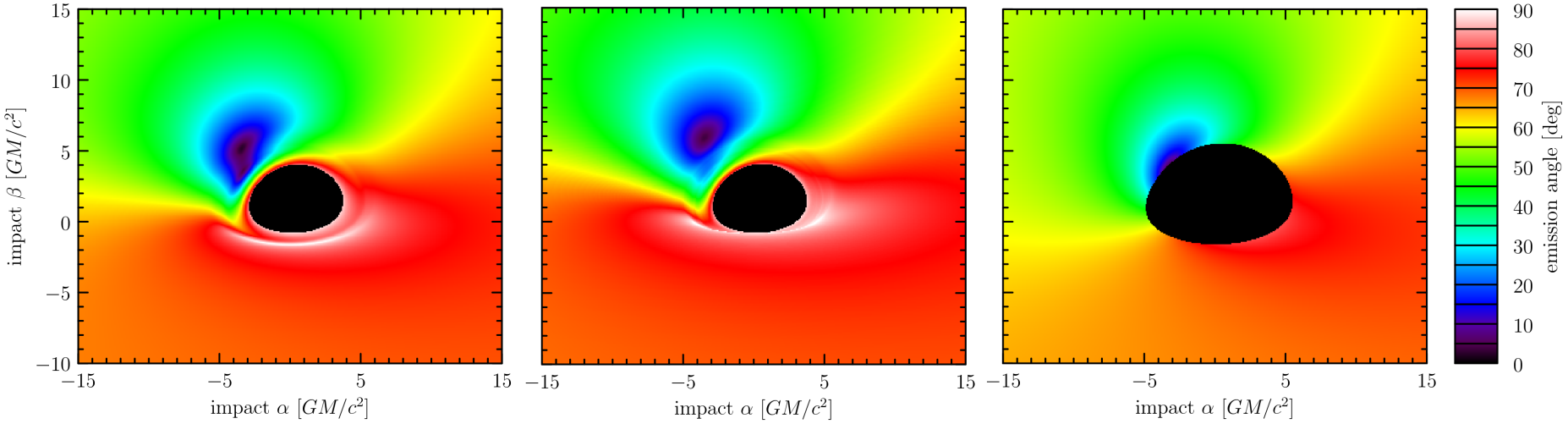
BH Accretion Disk Spectra: Are They Too Soft?



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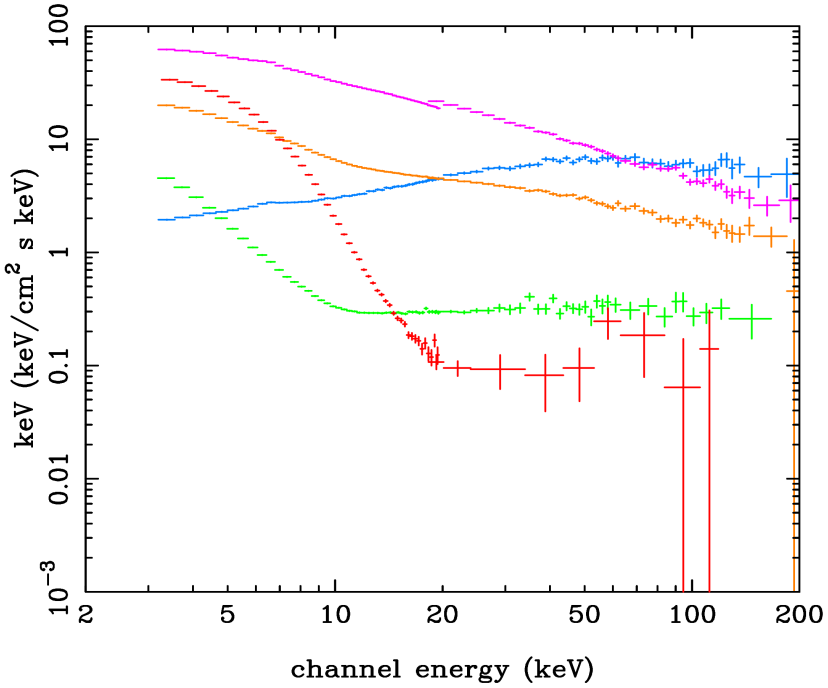
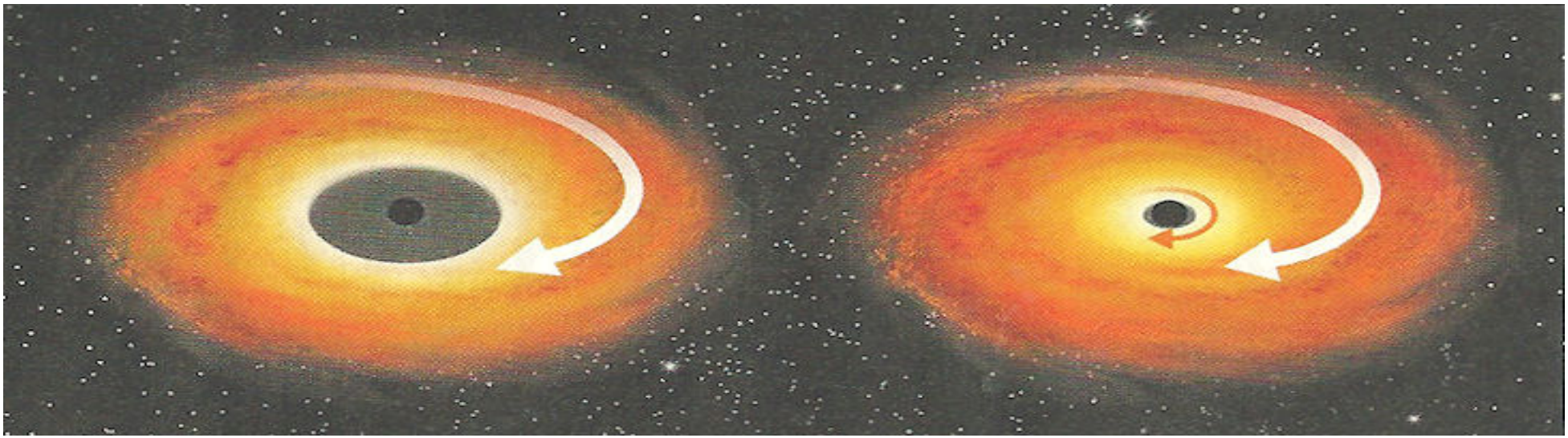
Measuring BH spins from X-ray continuum

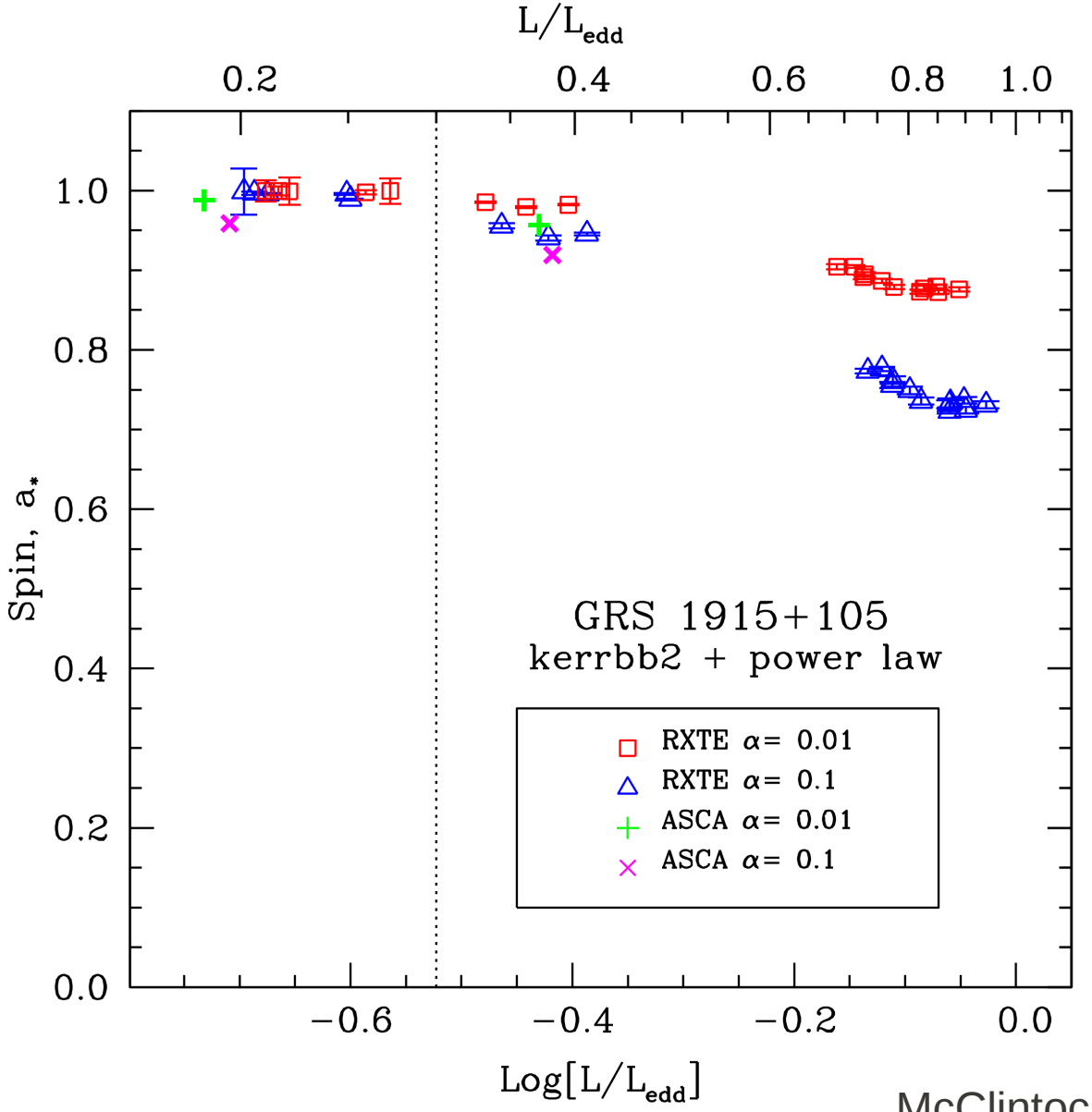
- from spectrum measure total flux and temperature
- knowing M, d, i calculate a
- must know disk model

e.g. McClintock et al. (2011)



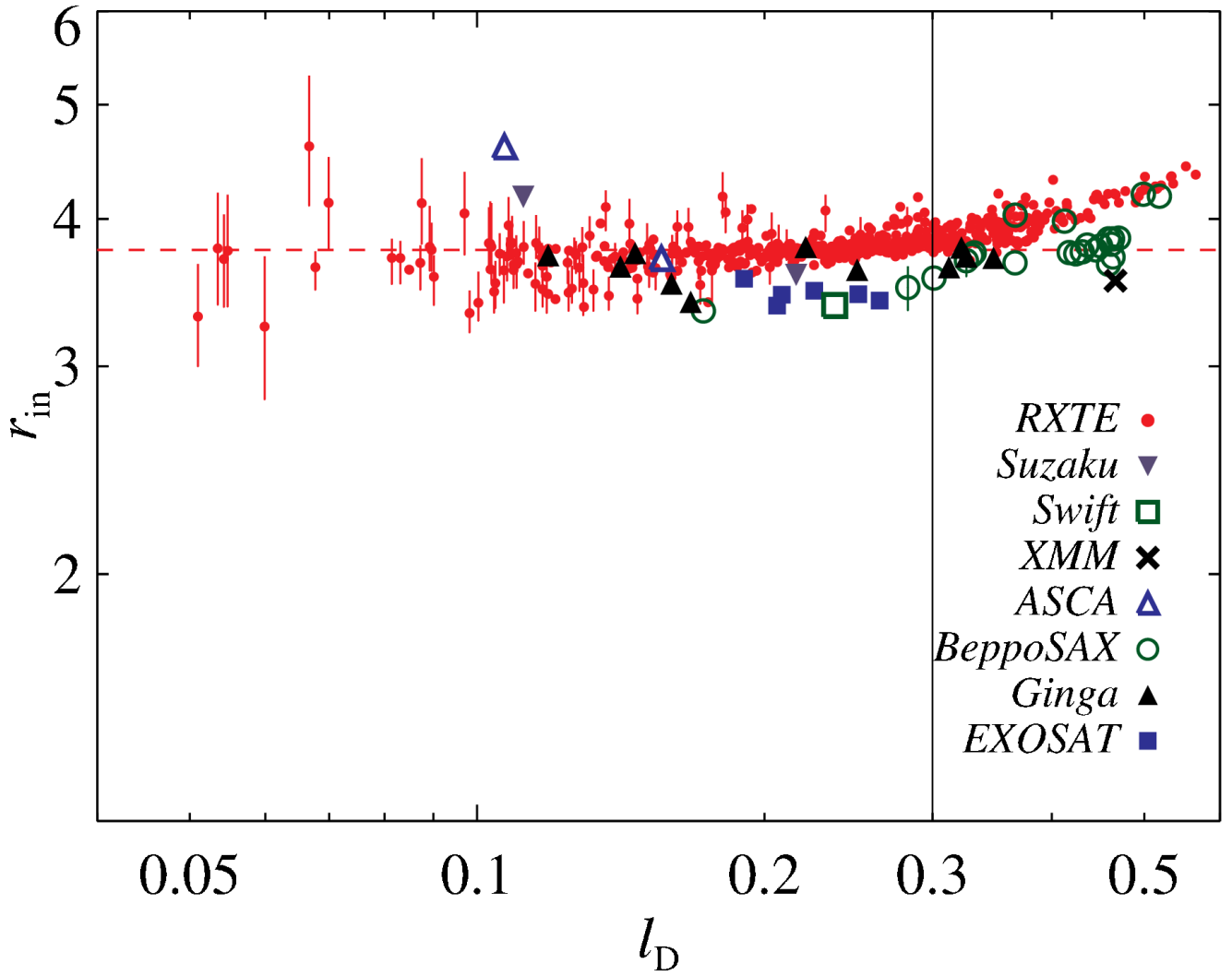


Spin measurements – GRS 1915+105



McClintock et al. (2006)

Spin measurements – LMC X-3



Steiner et al. (2010)

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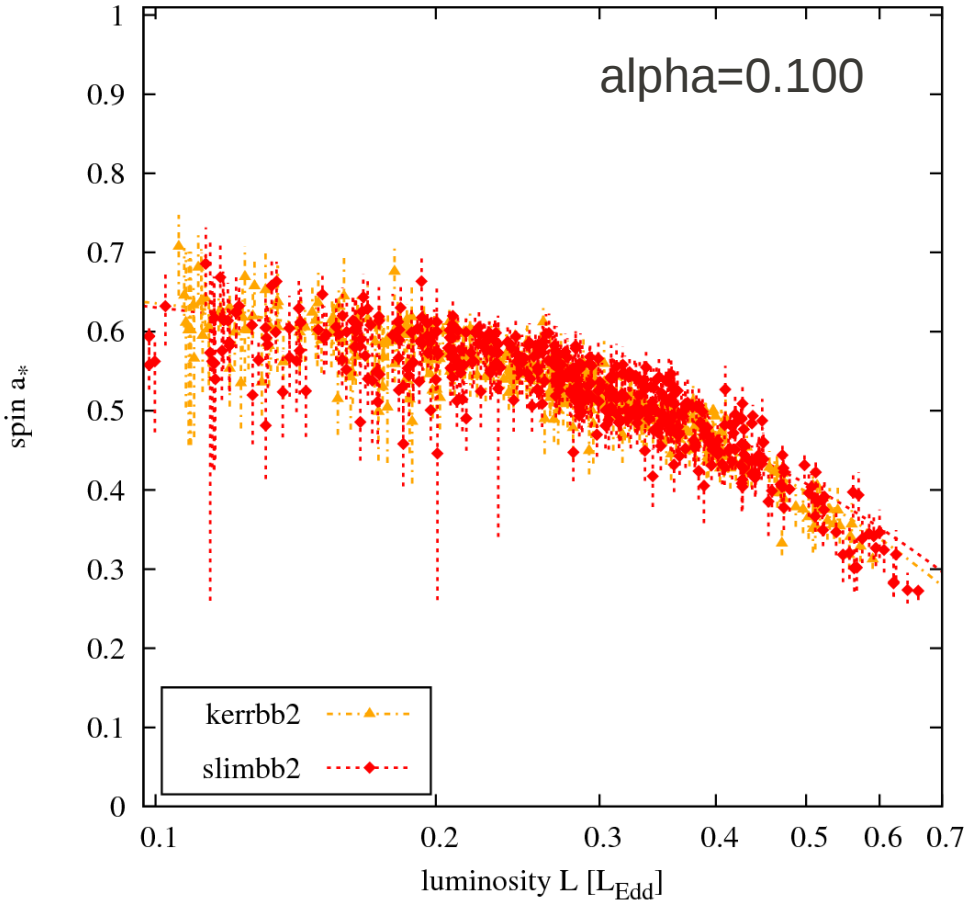
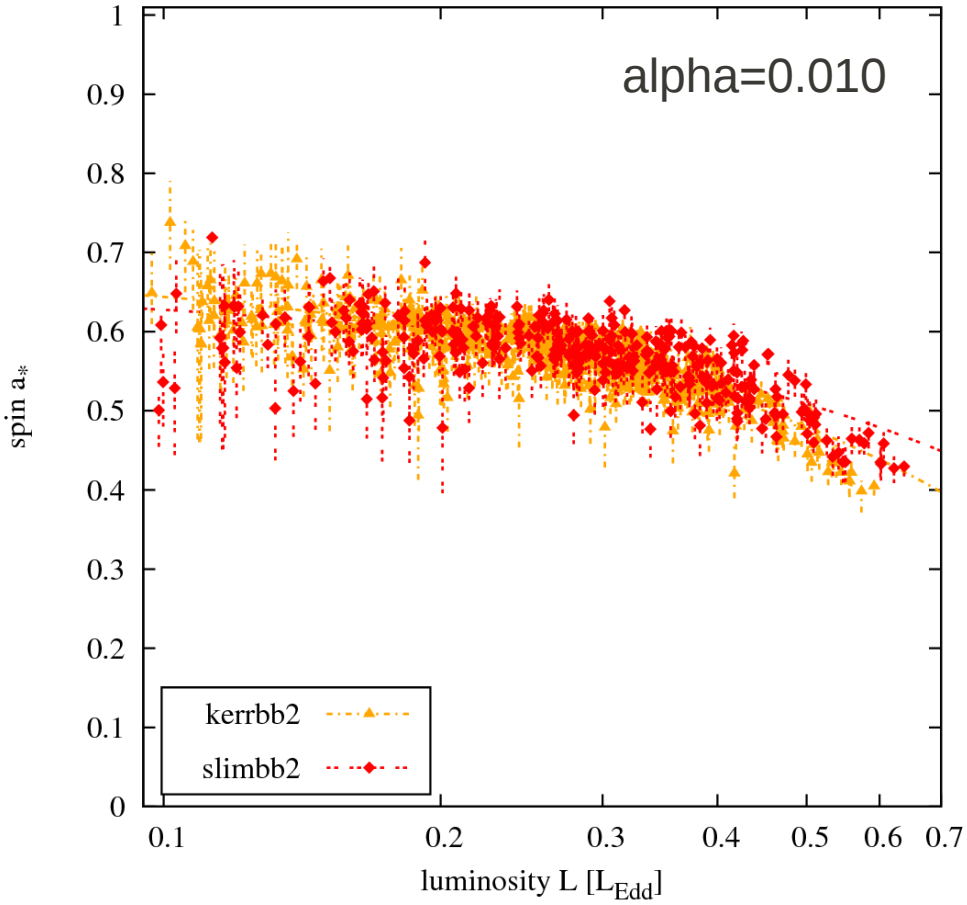
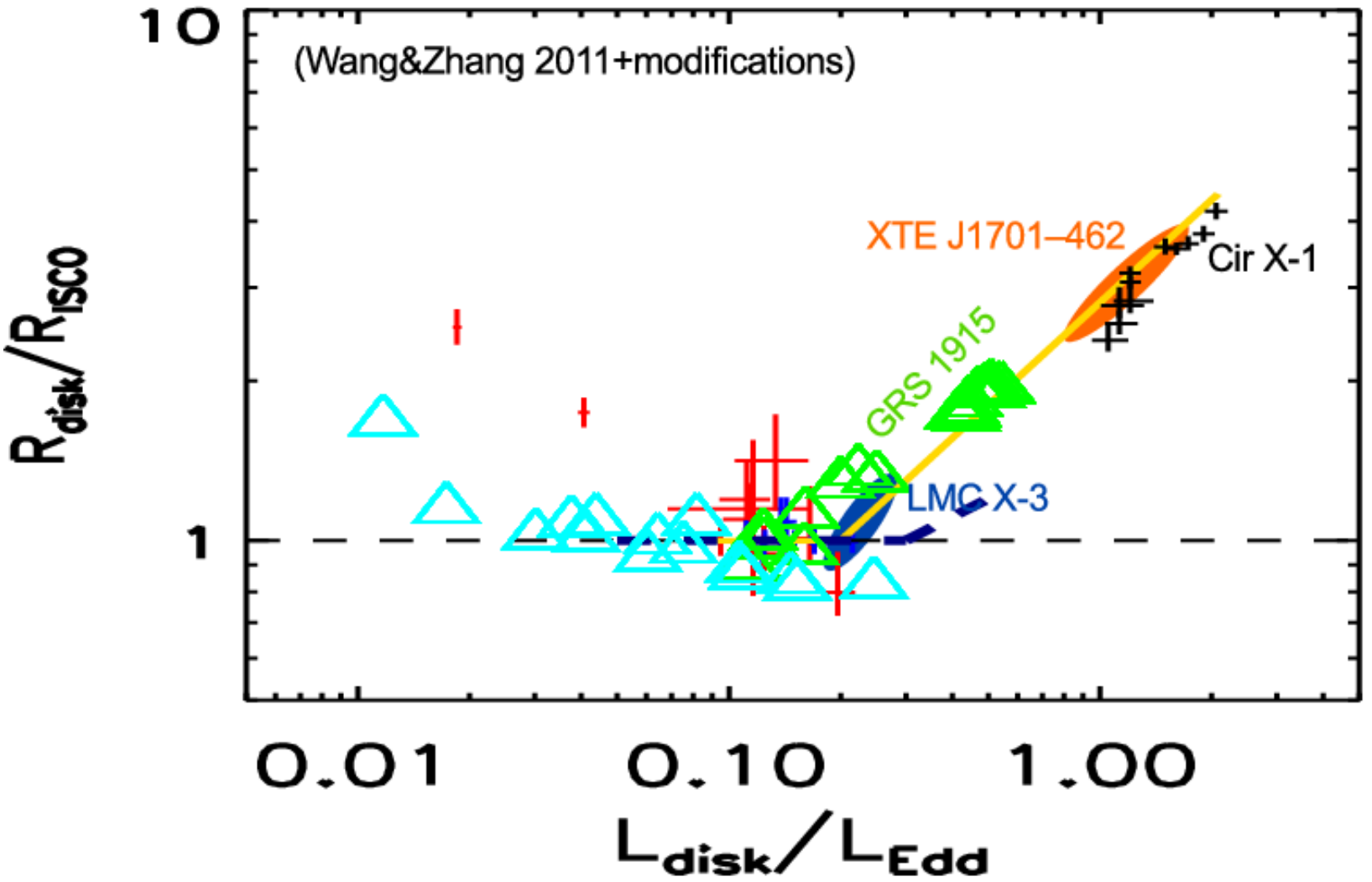




Straub et al. (2011)

Expanding inner disk radius?



Reasons for apparent spin drop/radius expansion:

1. inner disk radius expands

2. nature-produced high-luminosity spectra (L>0.3) are significantly softer than spectra predicted by our best models

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What's wrong with models?

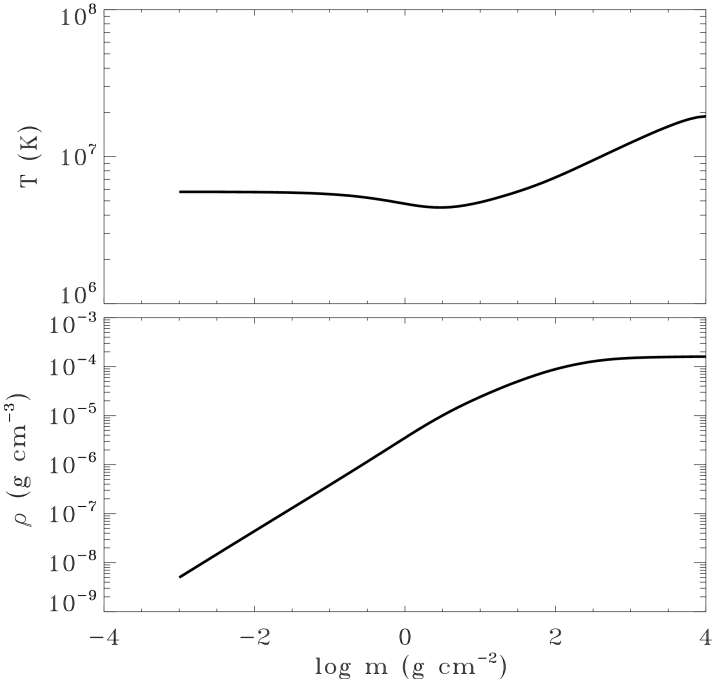
How to make model spectra softer?

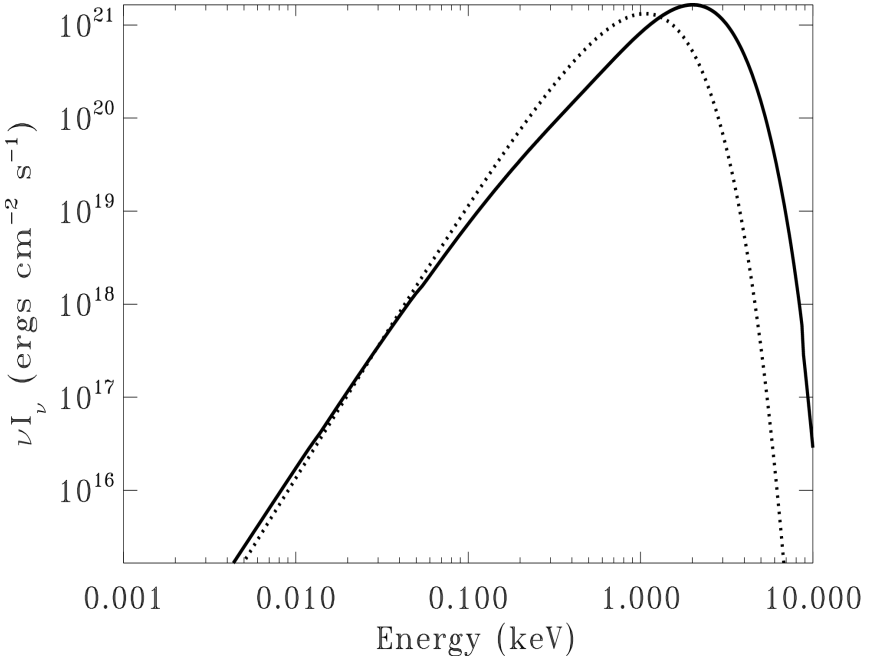
What's wrong with models?

Making accretion disk spectrum model:

1. radial disk structure (temperature/sf. density profile)

2. radiative transfer in vertical profile, surface integration, raytracing (observed emitted spectrum)





What's wrong with models?

Ad 1: **radial structure**

- Novikov-Thorne thin disk model is solid at L~0.1 (confirmed also by GRMHD sim); it is not supposed to work at higher L
- slim disk departs from NT only at L>0.5 but problems start at L~0.2-0.3

Sadowski (2009), Sadowski et al. (2011), Kulkarni et al. (2011)

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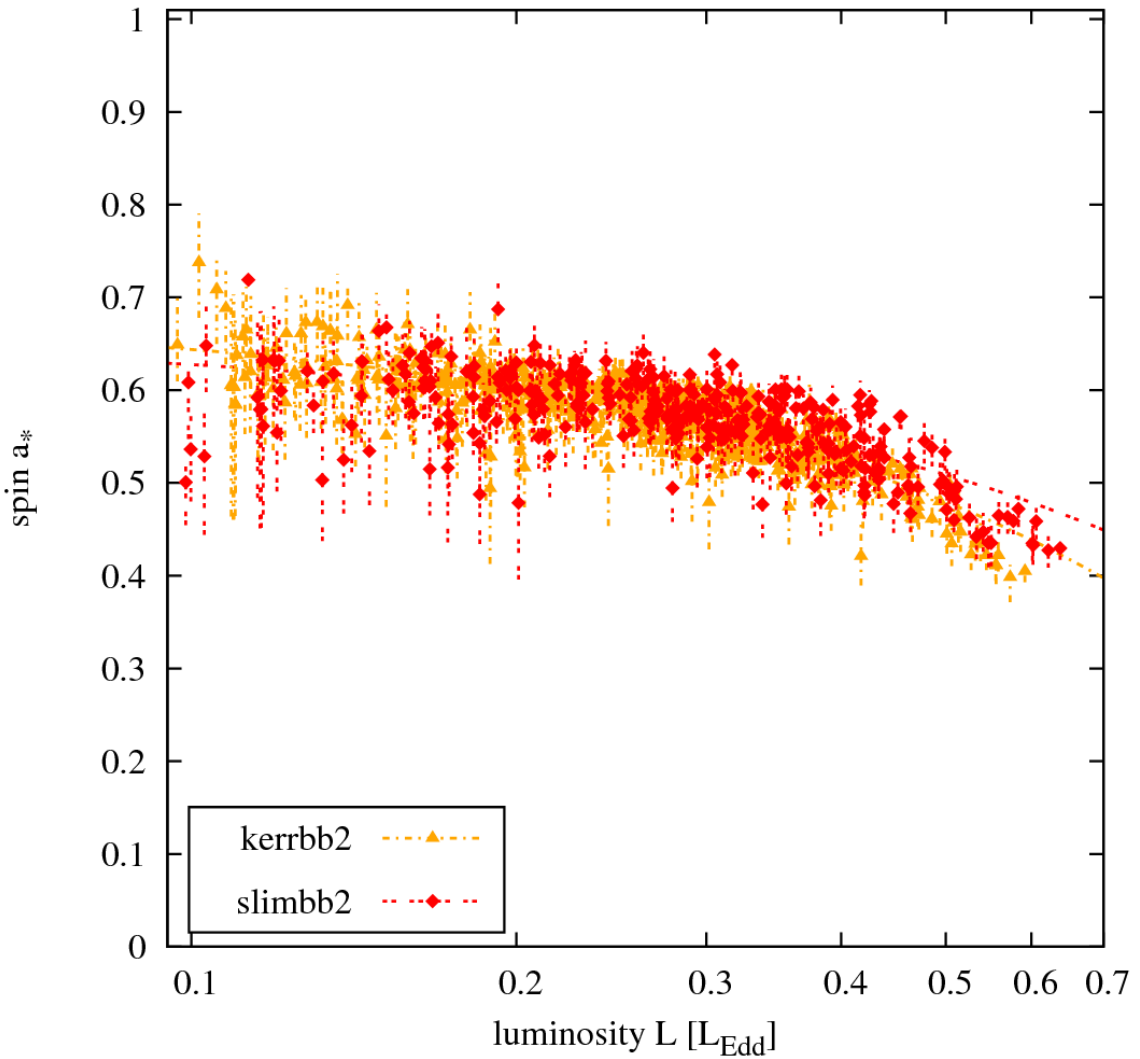
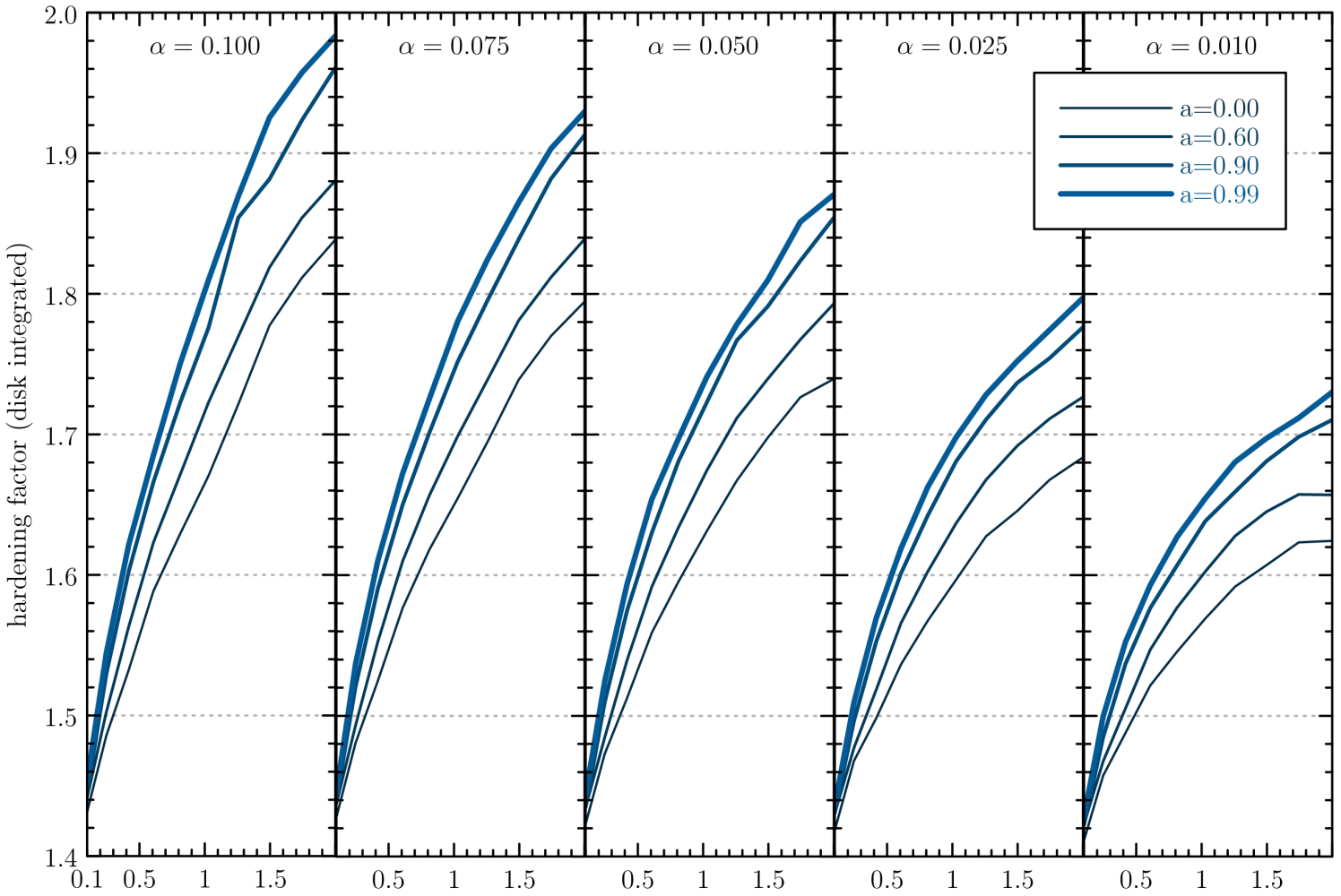
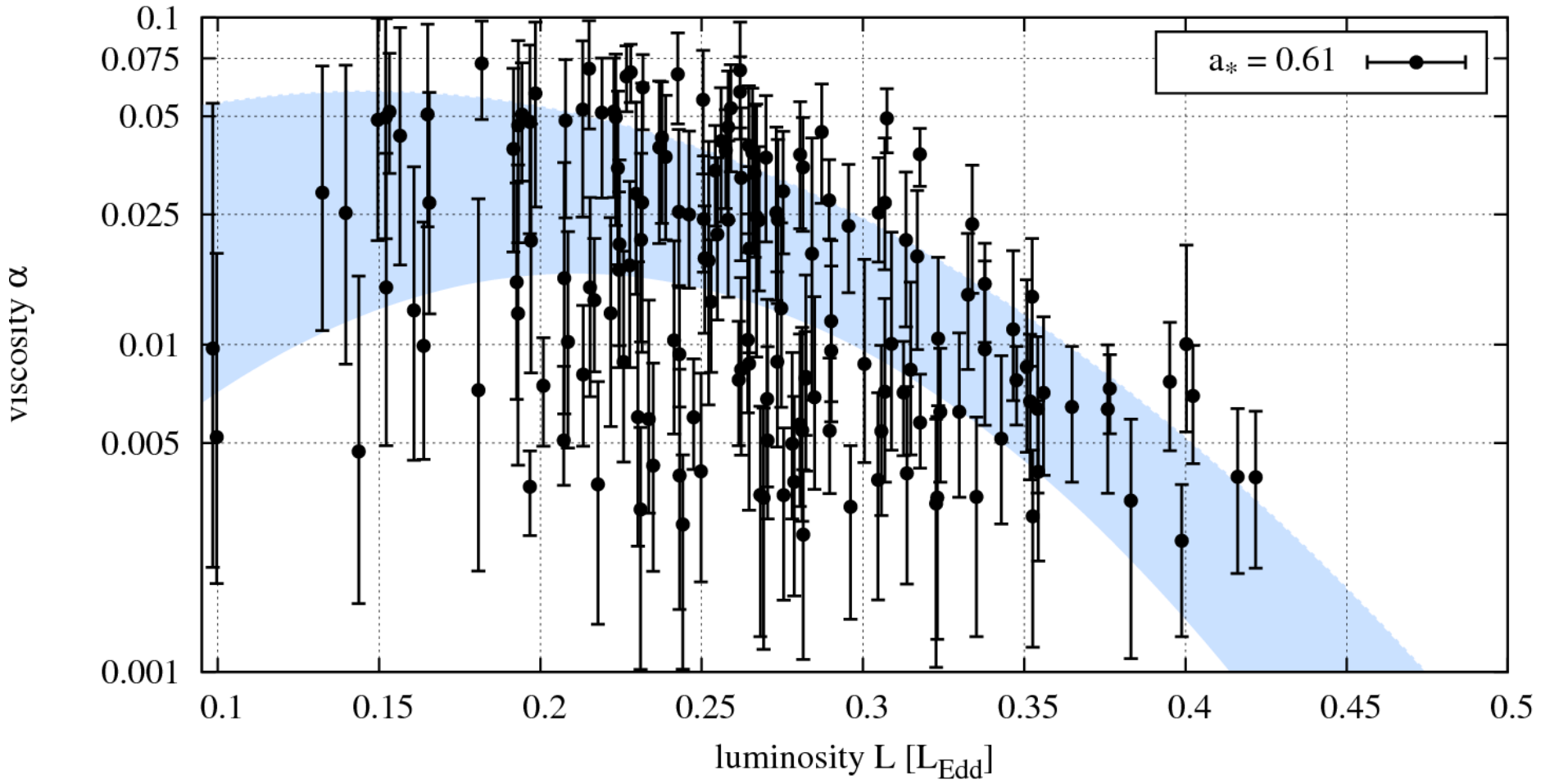


Spectral hardening vs. alpha



Fix? Changing alpha(L)



Straub et al. (2011)

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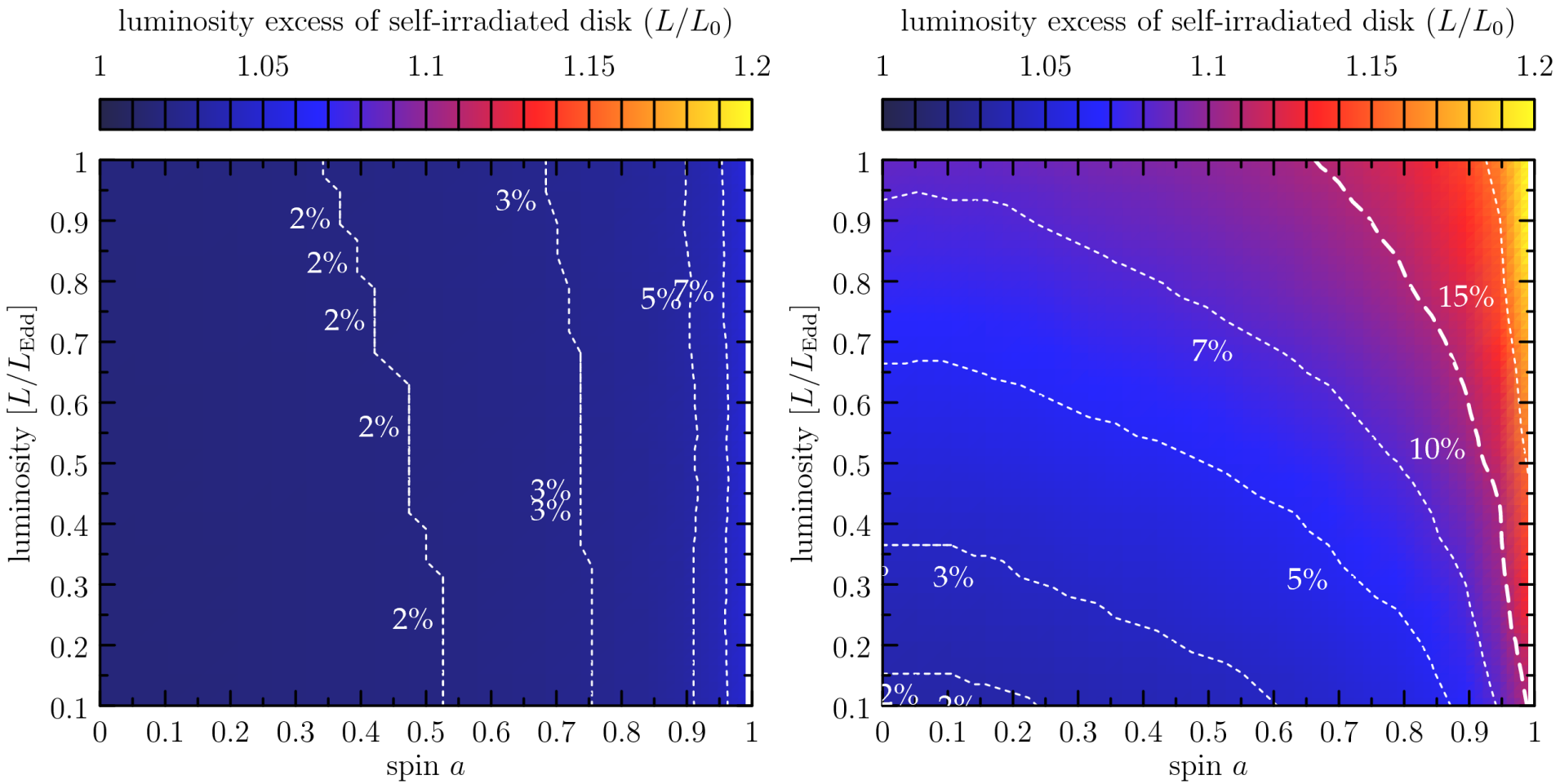
Ad 2: **vertical structure**

- high-L disks have large hardening factors several codes exist (TLUSTY, ATM, STOKES, ACDC), but for given setup they disagree on the results (h_f) thin, infinite, plane-parallel layer is not good approximation

Sadowski (2009), Sadowski et al. (2011), Kulkarni et al. (2011)

Percentage of returning radiation



Is there something else what matters?

1. disk outflows/winds

with increasing L, winds play more important role

GRS 1915: mixed primary disk radiation with thermally comptonized component

winds may actually soften spectra only if not very hot

Conclusions

- while thin accretion disks (L~0.1) seem to be well understood, high luminosity disks (L>0.2-0.3) still remain challenging in terms of accurate spectral modelling
- observed spectra are much softer then models
- advection **x** strong irradiation, low optical depth, increased hardening – improvements in rad. transfer needed
- disk winds shall become integral part of high-L spectral models

Luminosity – Temperature

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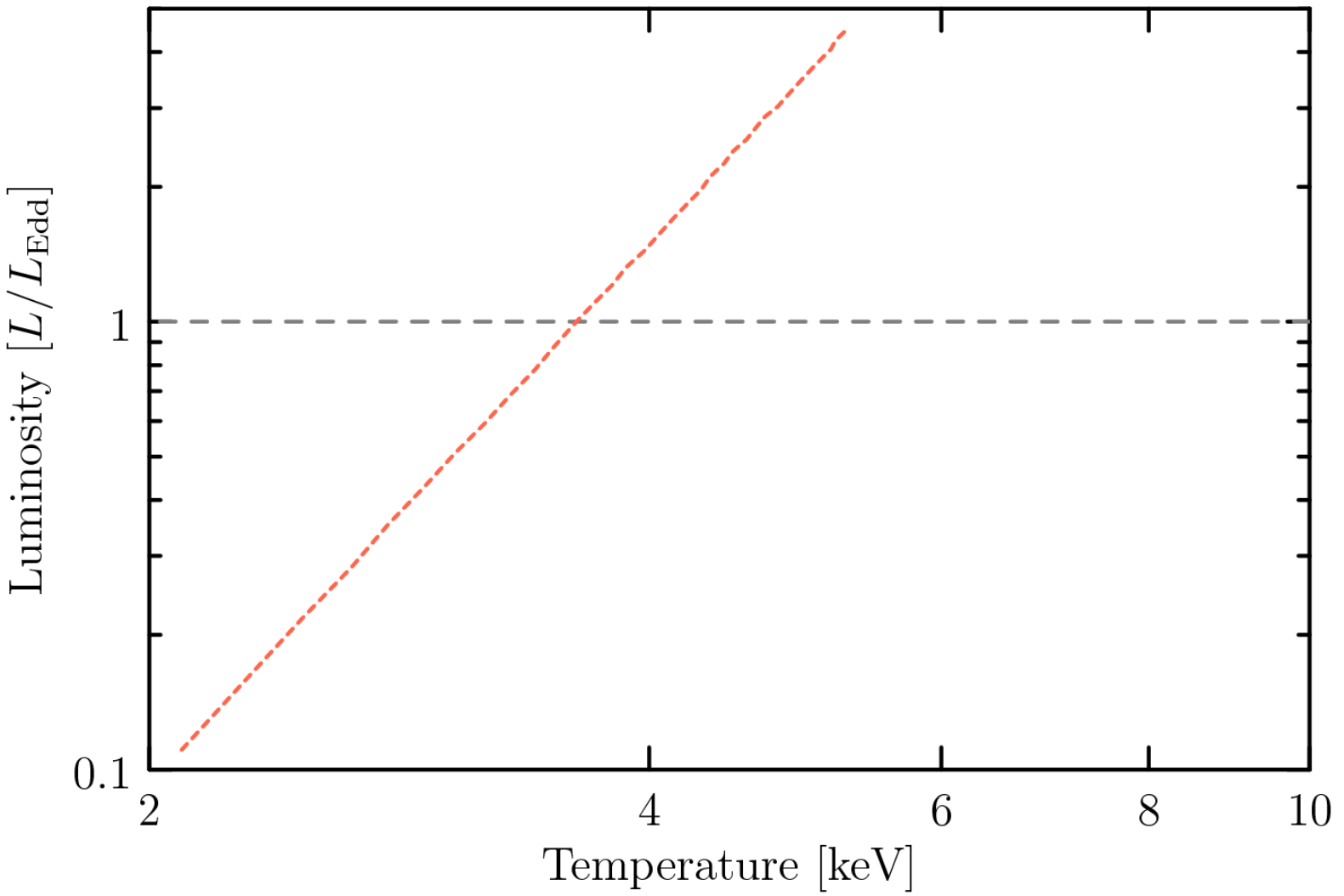

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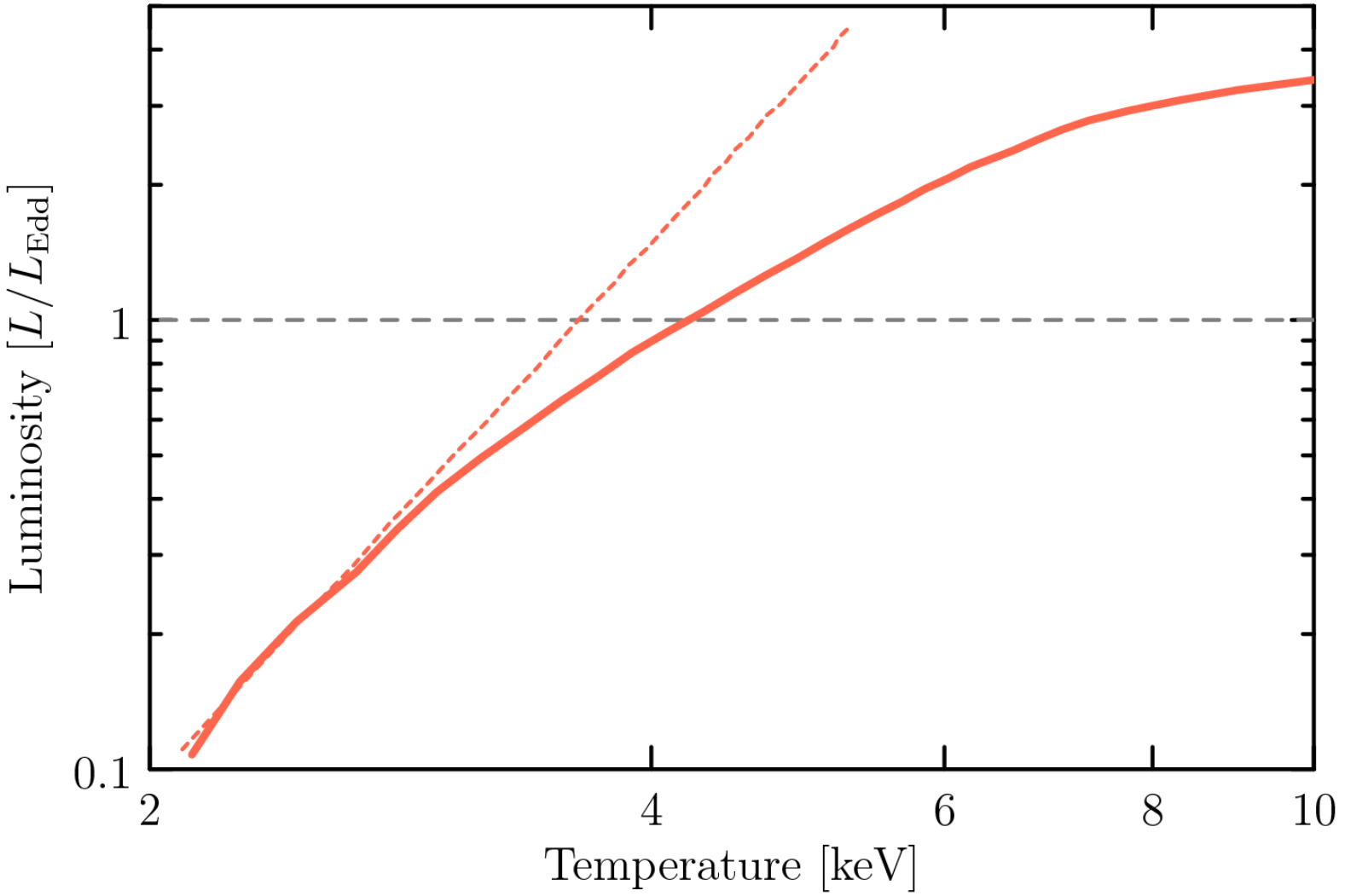

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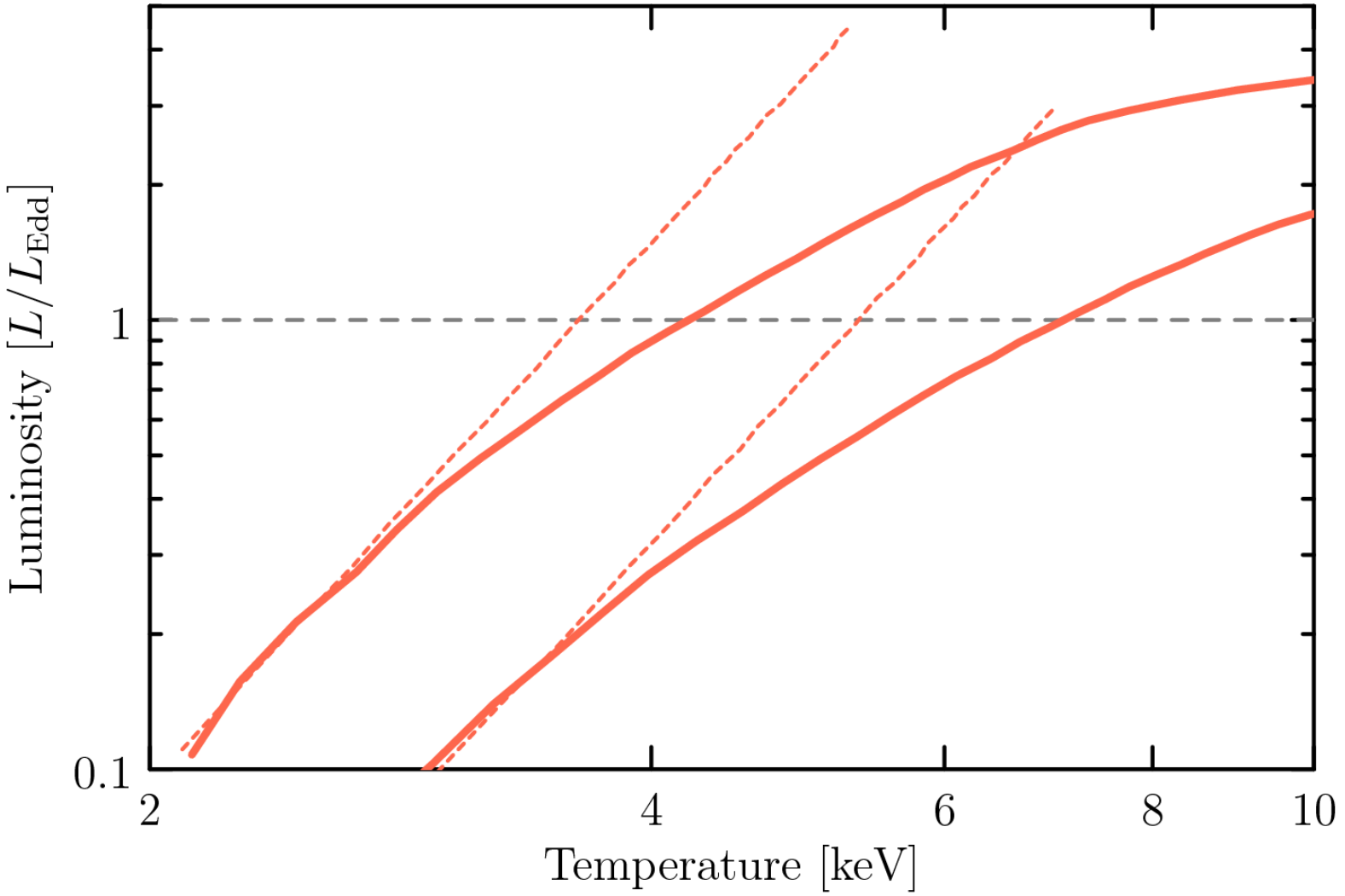

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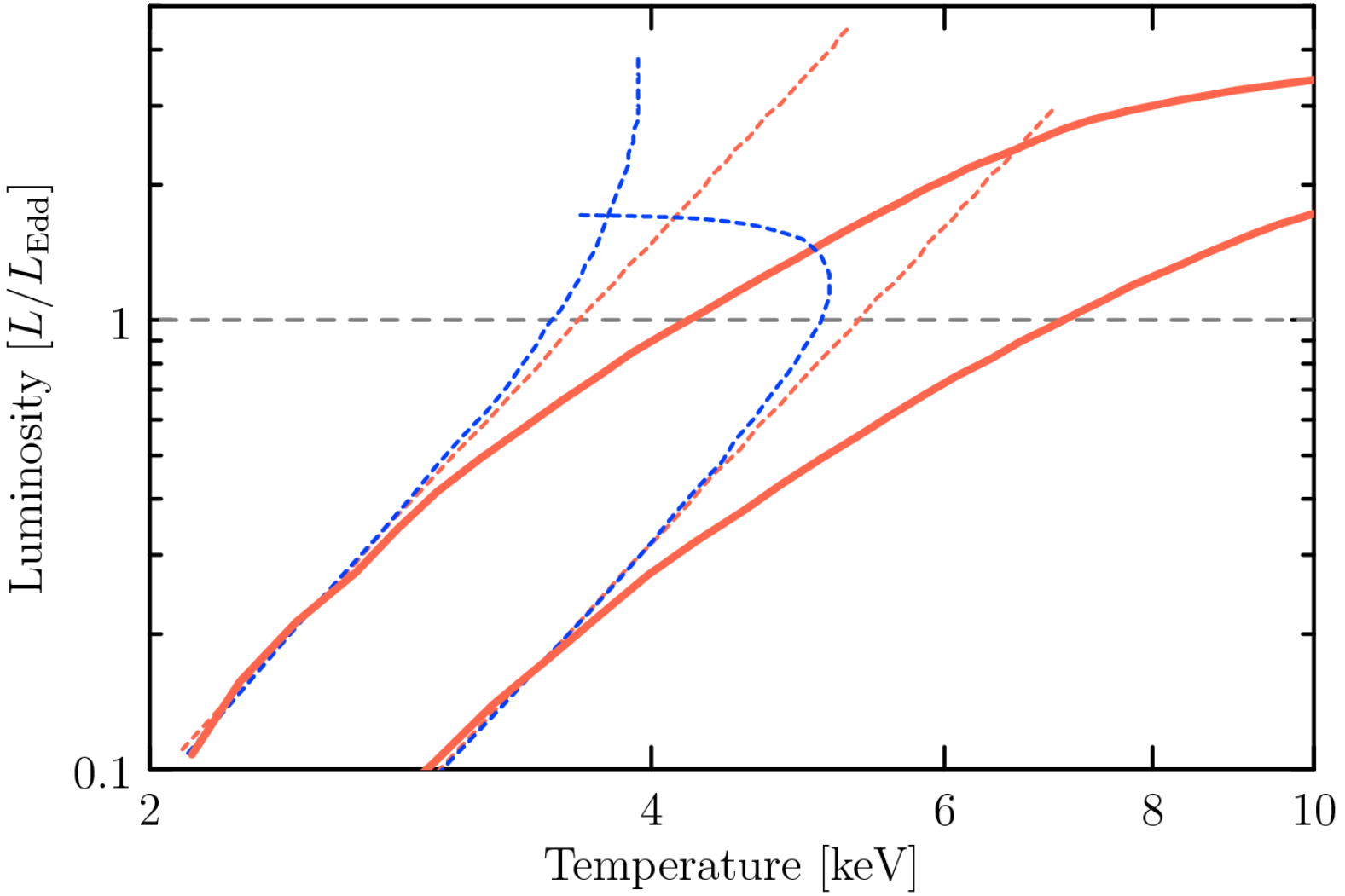

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