

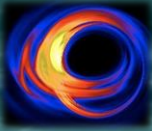
High Throughput X-ray Astronomy in the eXTP Era

X-Ray Polarization and Black Hole Spin

Ye-Fei YUAN

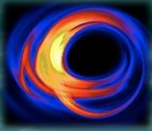
Department of Astronomy, USTC

02-07-2017

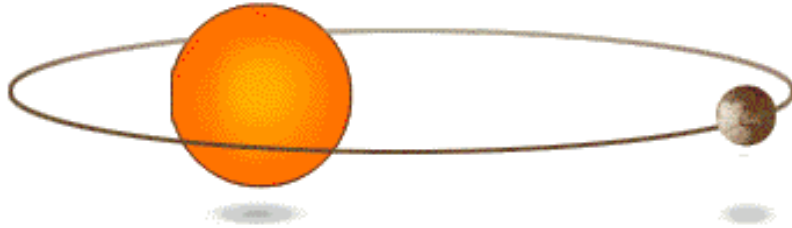


- ◆ Measuring Black Hole Spin
- ◆ X-ray Polarization and Black Hole Spin
- ◆ **Conclusion and Discussion**

Measuring Black Hole Spin



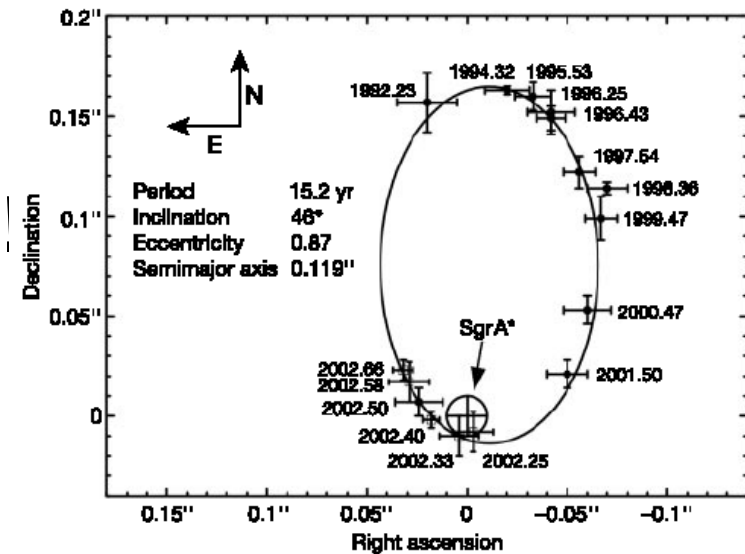
BH Mass measurement: Newtonian limit



BH Spin Measurement: difficult

- ✓ Pure GR Effect
- ✓ Short Distance Effect

Near the Event Horizon



Schödel, Ott, Genzel+ 2002

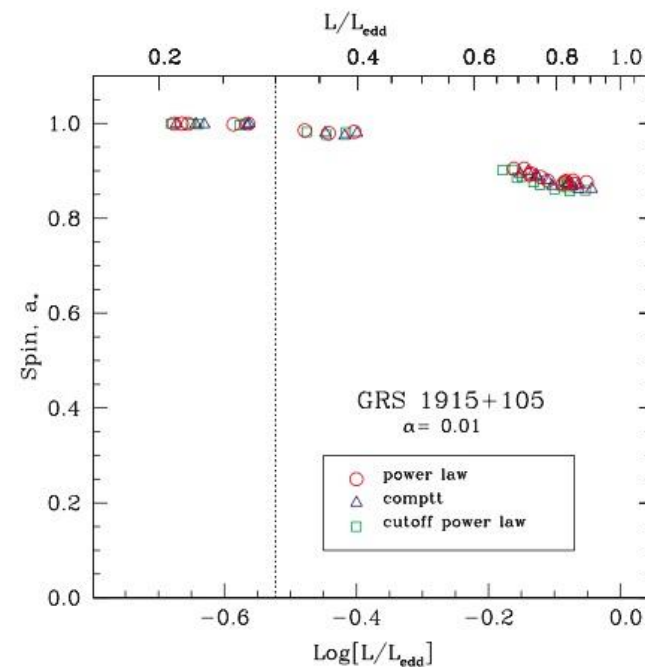
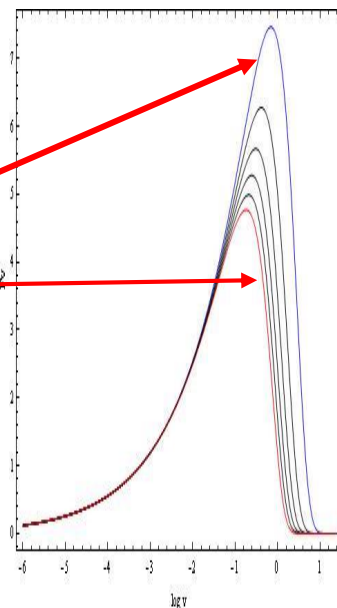
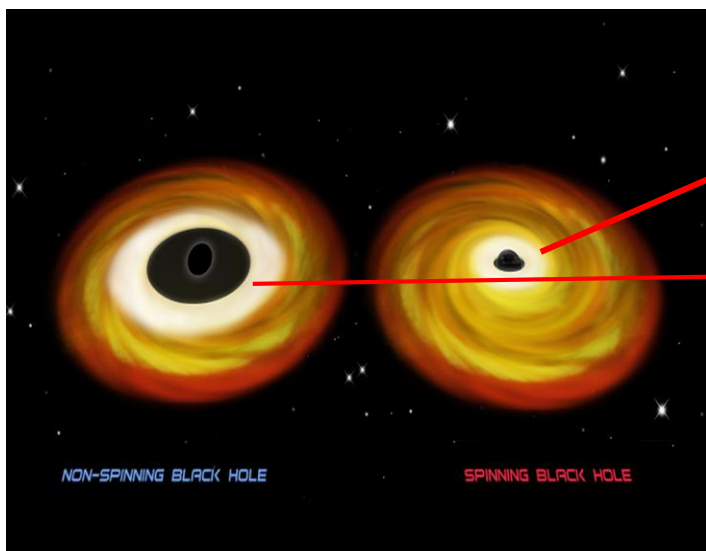
Mass Potential: $\sim M / r$ "Spin Potential": $\sim aM / r^3$

Measuring Black Hole Spin



Continuum-Fitting Method

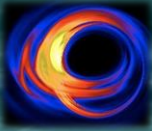
The original idea is from Zhang, Cui & Chen 1997



Also see Gou Lijun's talk

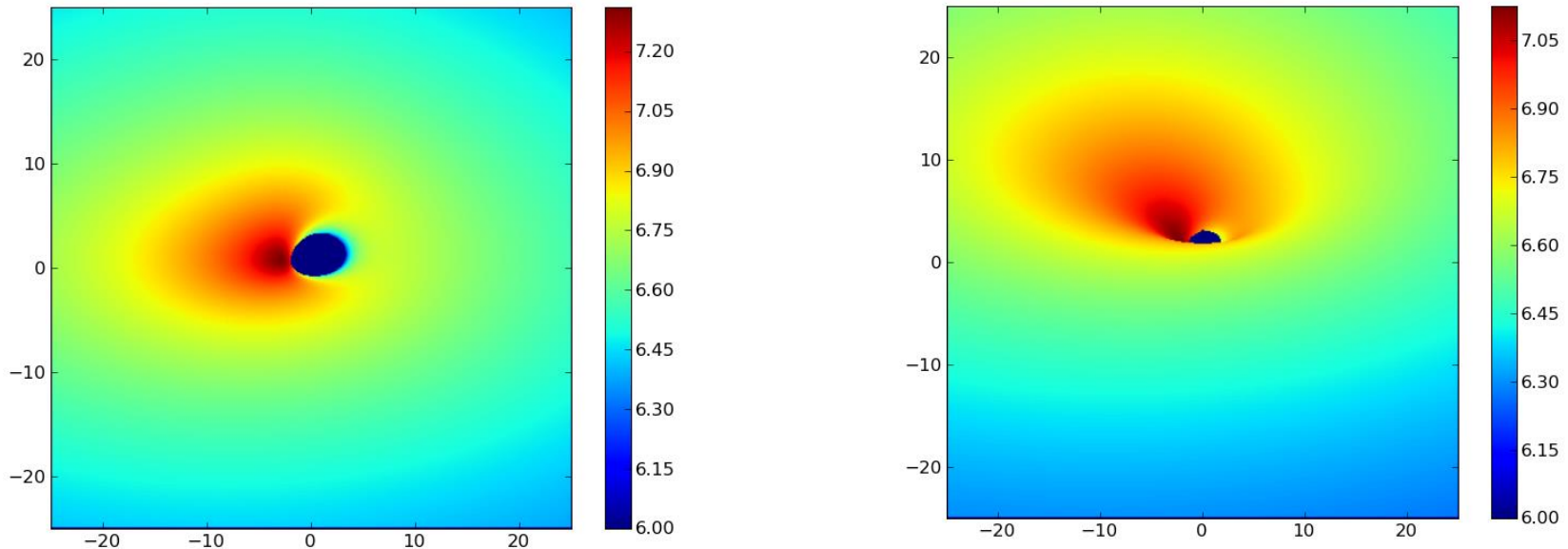
McClintock et al. 2006, ApJ

Measuring Black Hole Spin



Continuum-Fitting Method

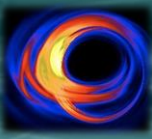
Self-shadowing effect of the accretion disks
with high $\dot{M}$



Li, Yuan*, Cao, 2010, ApJ

• *Left: No Thickness, Right: With Thickness, $\dot{M}=2$, $a=0.98$, 60°*

Measuring Black Hole Spin



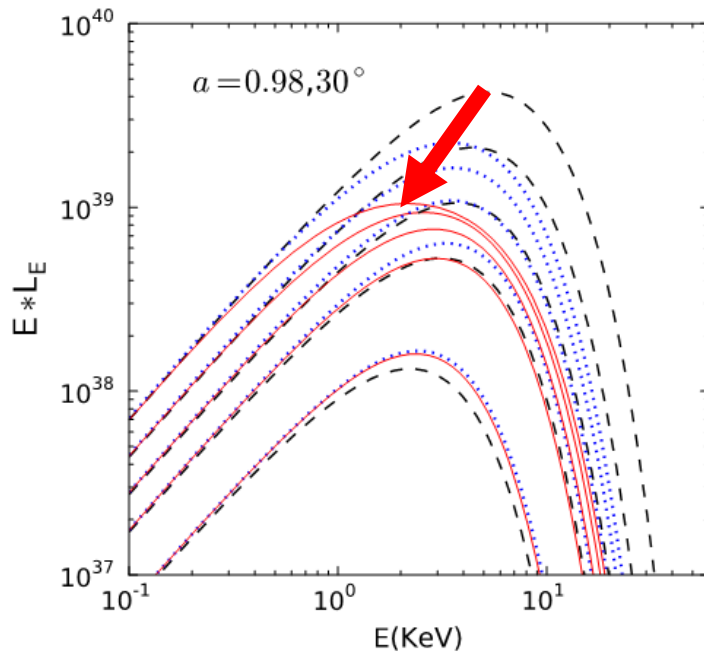
Continuum-Fitting Method

SED for disks with high $\dot{M}$

Self-shadowing

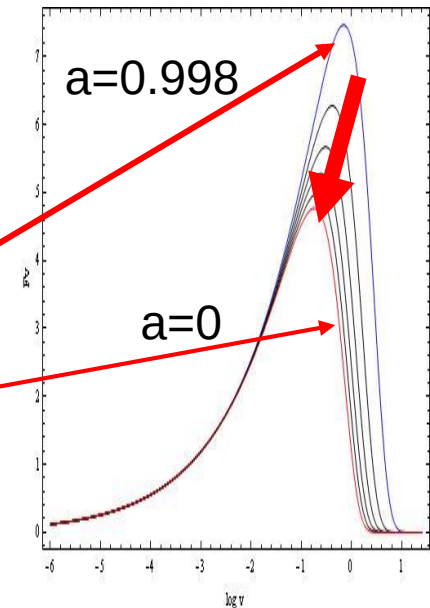
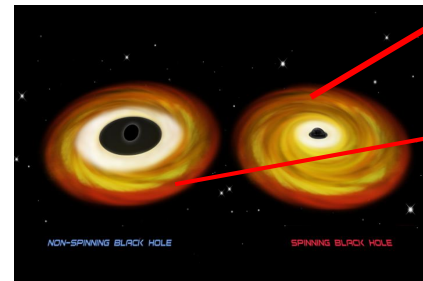


Decrease of BH spin

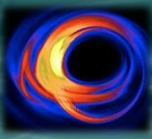


Li, Yuan*, Cao, 2010, ApJ

Thin Disk

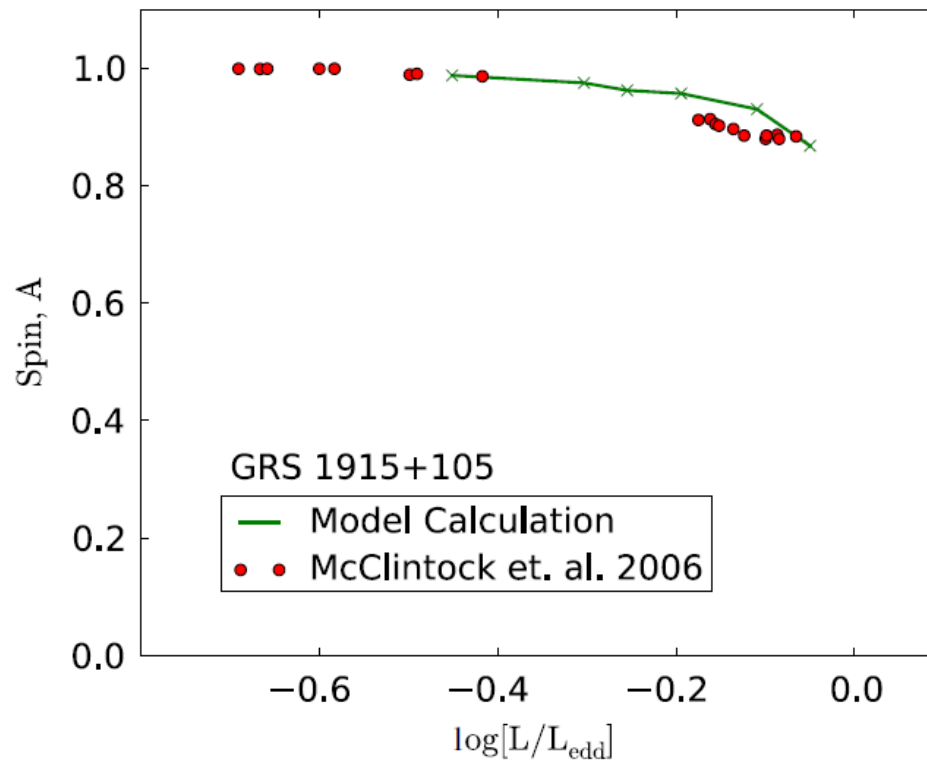


Measuring Black Hole Spin

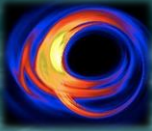


Continuum-Fitting Method

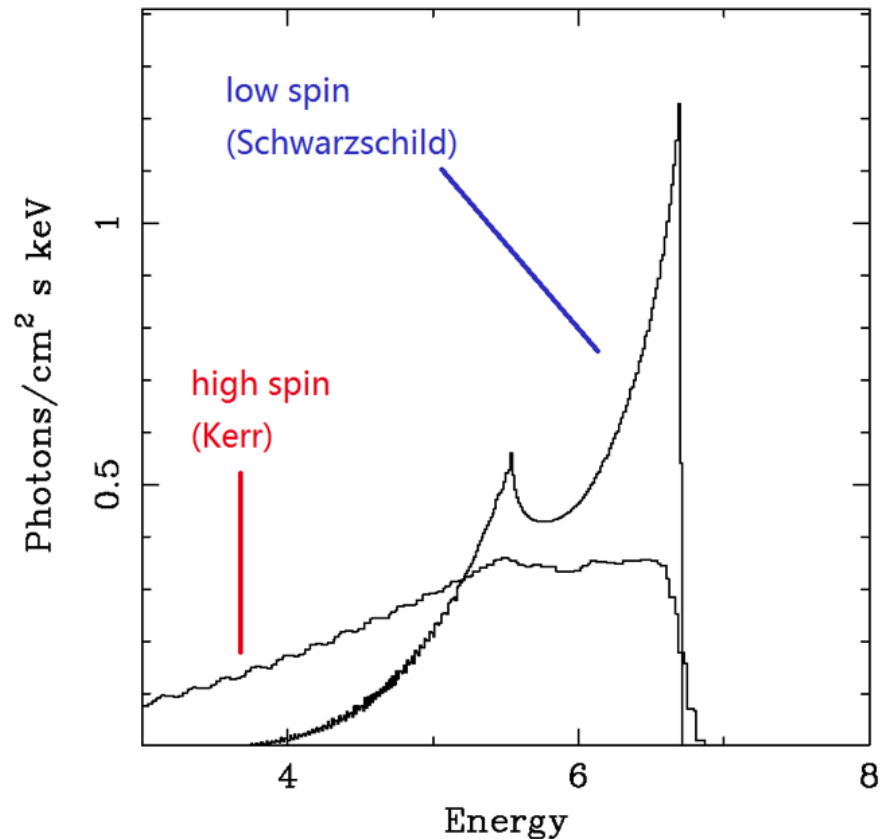
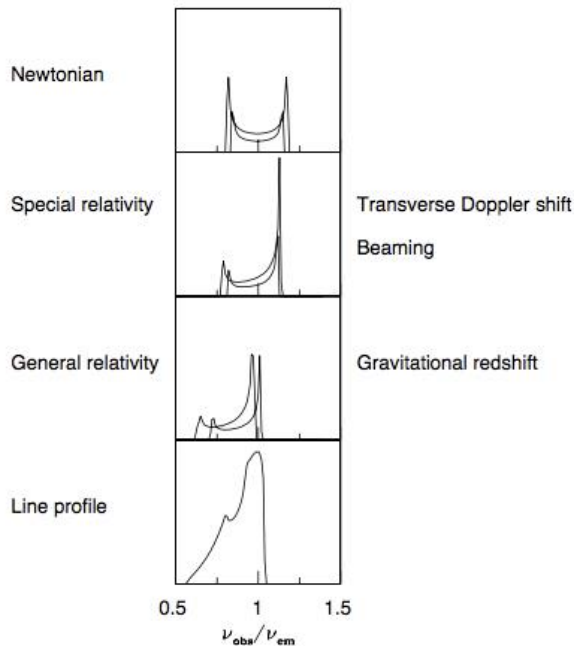
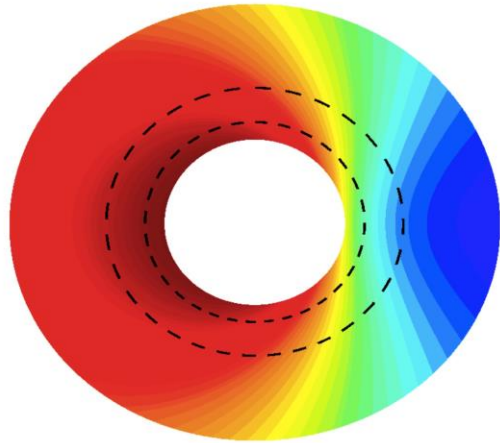
BH spin measurement for disks with high accretion rates



Measuring Black Hole Spin



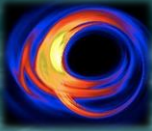
Relativistic Broad Emission Line (Fe K alpha) Method



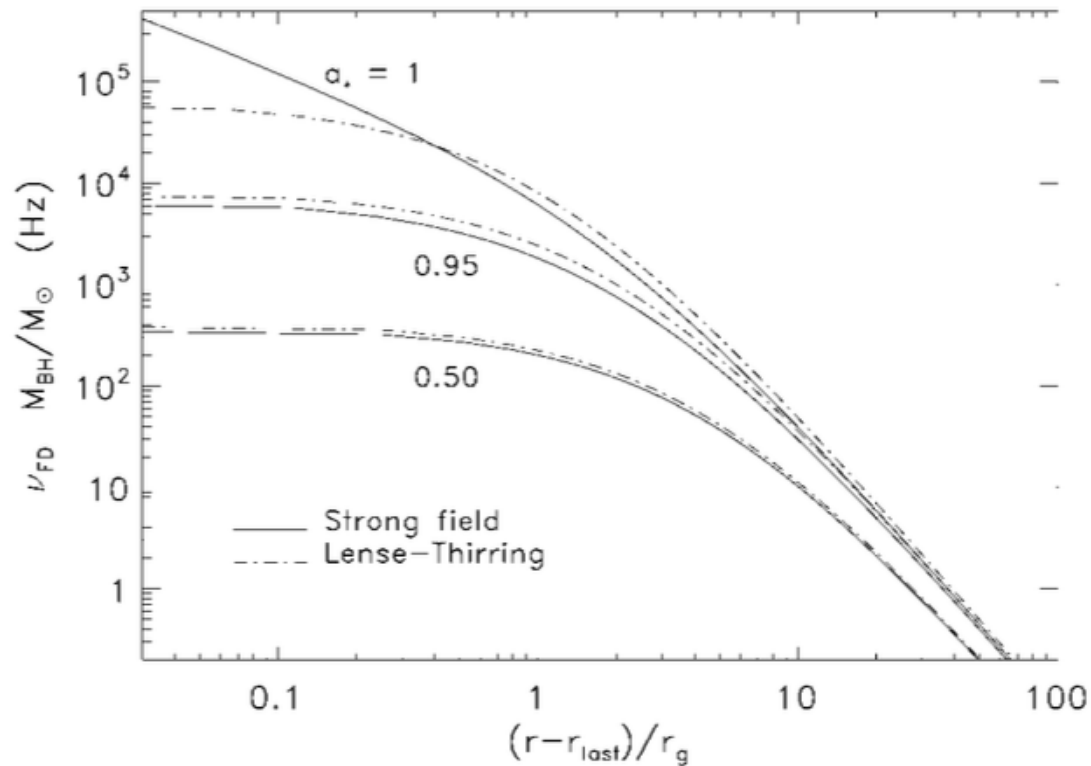
Fibian + 2000

Also see Alessandra De Rosa's talk

Measuring Black Hole Spin



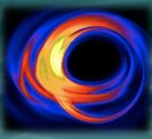
High-frequency QPOs Method



Cui, Zhang, Chen 1997; Wagoner + 2001; Schnittman 2005

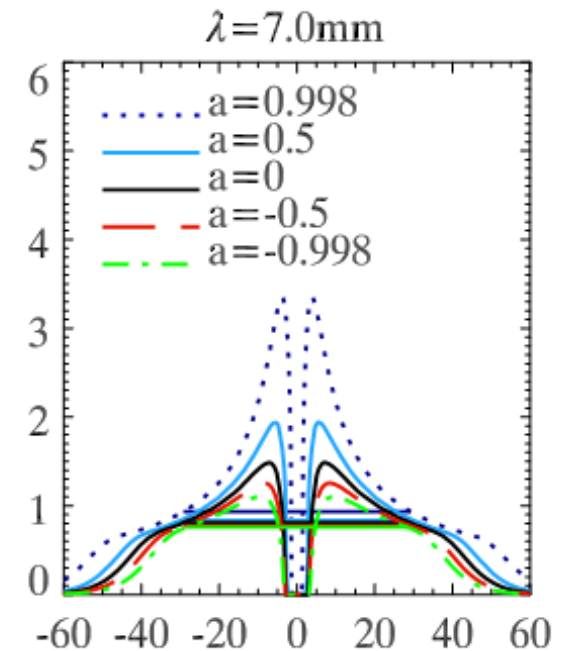
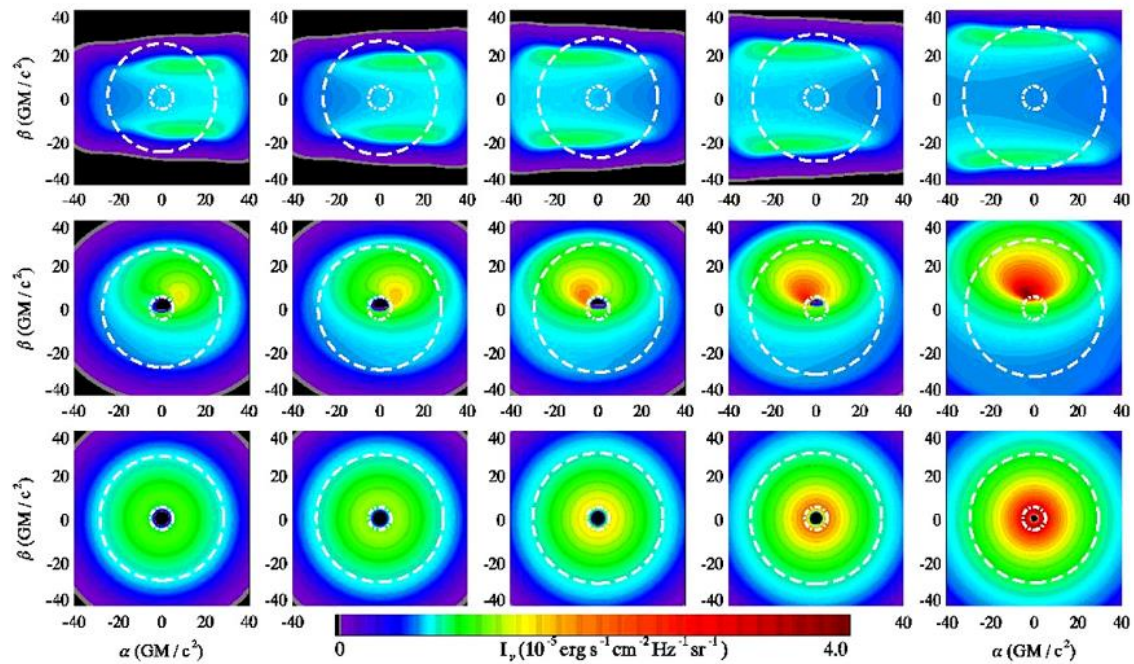
Also see talks of Marieke van Doesburgh, Andrea Maselli and Adam Ingram

Measuring Black Hole Spin



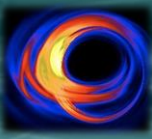
Imaging of BH Shadow Method

Only works in submm & IR band for Sgr A* /M87



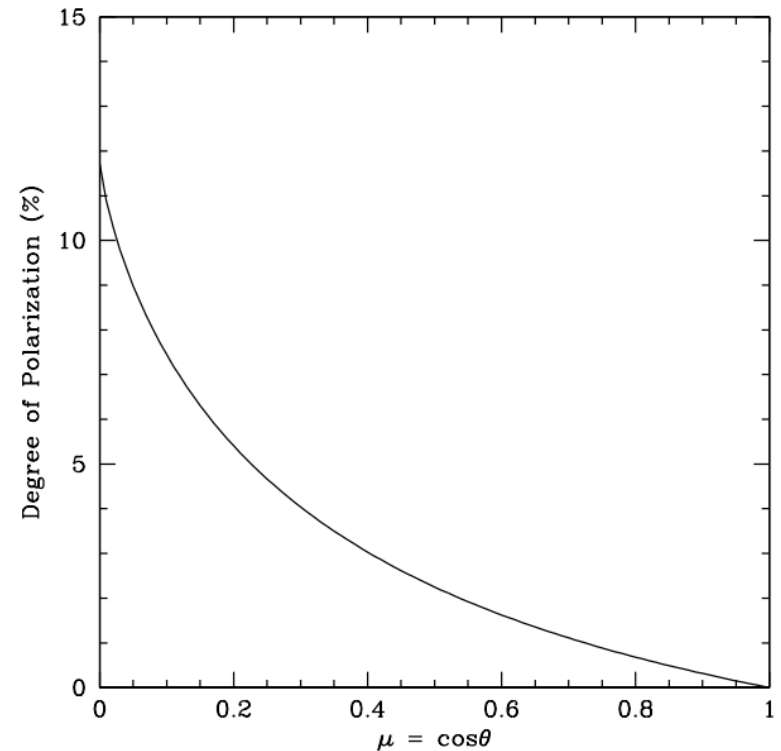
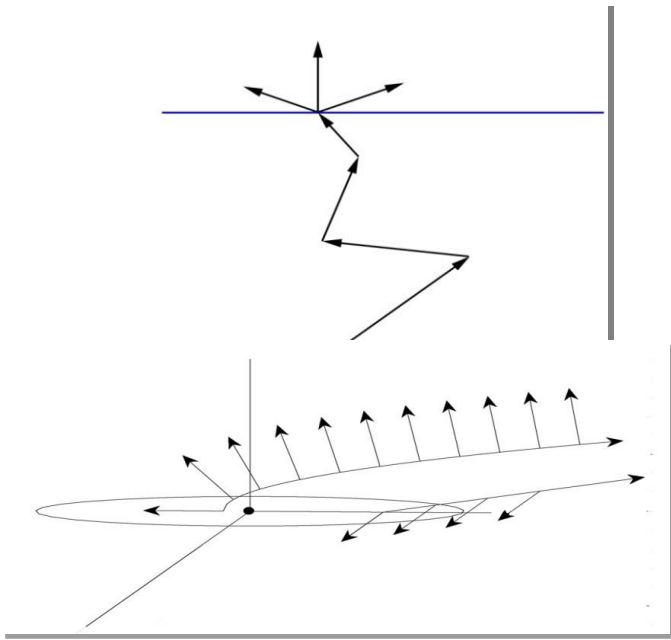
e.g. Yuan +2010

X-ray Polarization of disk emission



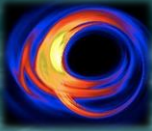
semi-infinite plane-parallel atmosphere

In an optically thick accretion disk, the atmosphere is dominated by Compton scattering

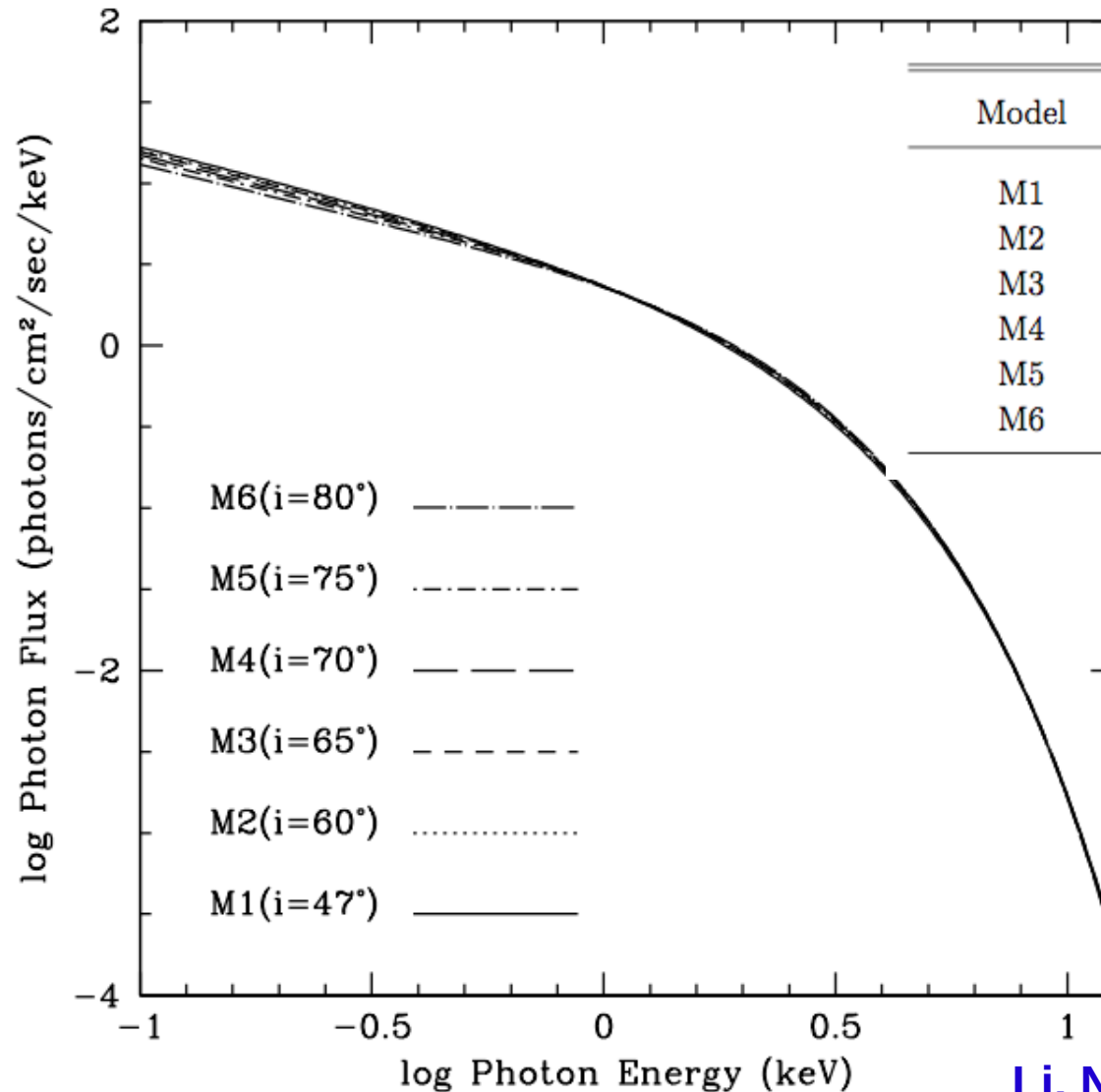


- ◆ The polarized fraction is 0-12%, depending on inclination (Chandrasekhar 1960)
- ◆ The polarization direction is parallel to the disk surface

X-ray Polarization of disk emission



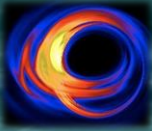
Degeneracy of inclination and spin in CF method



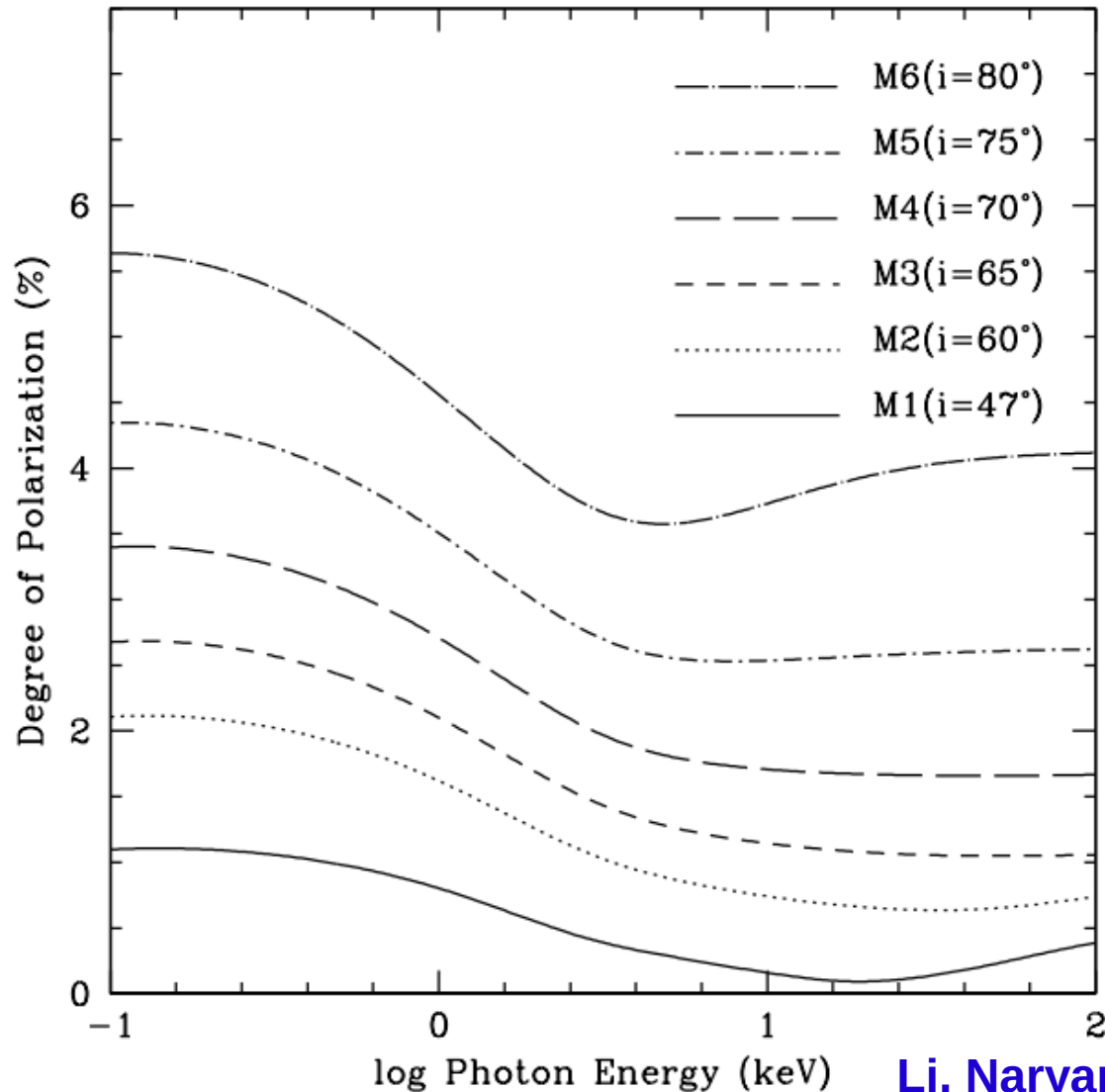
Model	a_*	i_{disk}	$\dot{M}$
M1	0.998	47.0	0.48
M2	0.900	60.0	1.00
M3	0.830	65.0	1.40
M4	0.750	70.0	2.00
M5	0.630	75.0	3.20
M6	0.450	80.0	5.80

Li, Naryan & McClintock 2009

X-ray Polarization of disk emission

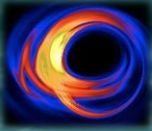


Degeneracy decoupling of inclination and spin

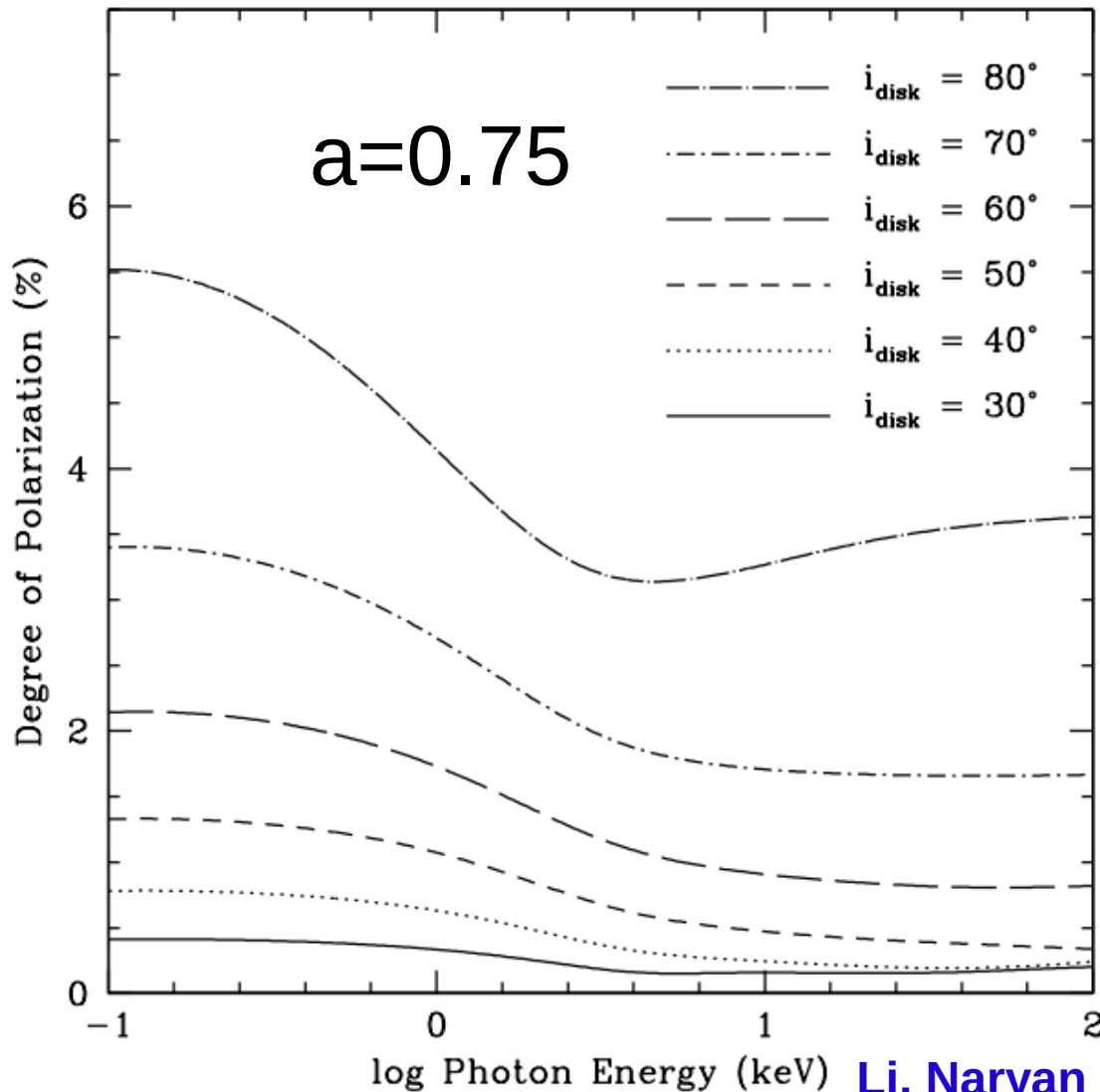


Li, Naryan & McClintock 2009

X-ray Polarization of disk emission

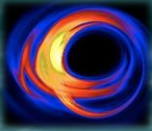


Degeneracy decoupling of inclination and spin

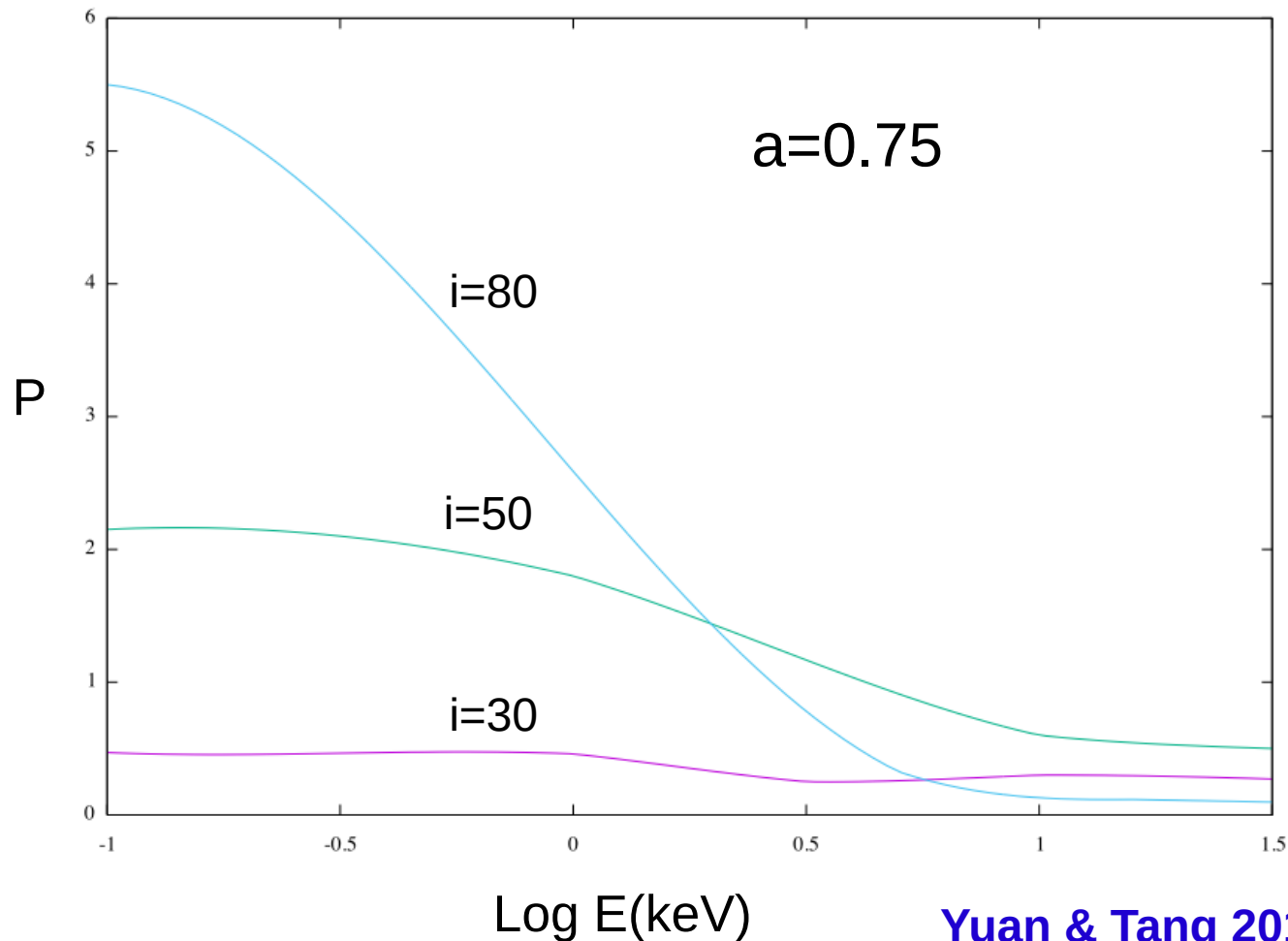


Li, Naryan & McClintock 2009

X-ray Polarization of disk emission

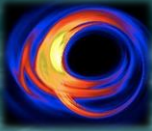


Self-shadowing of the slim disk



Yuan & Tang 2017 in preparation

Conclusions and Discussions

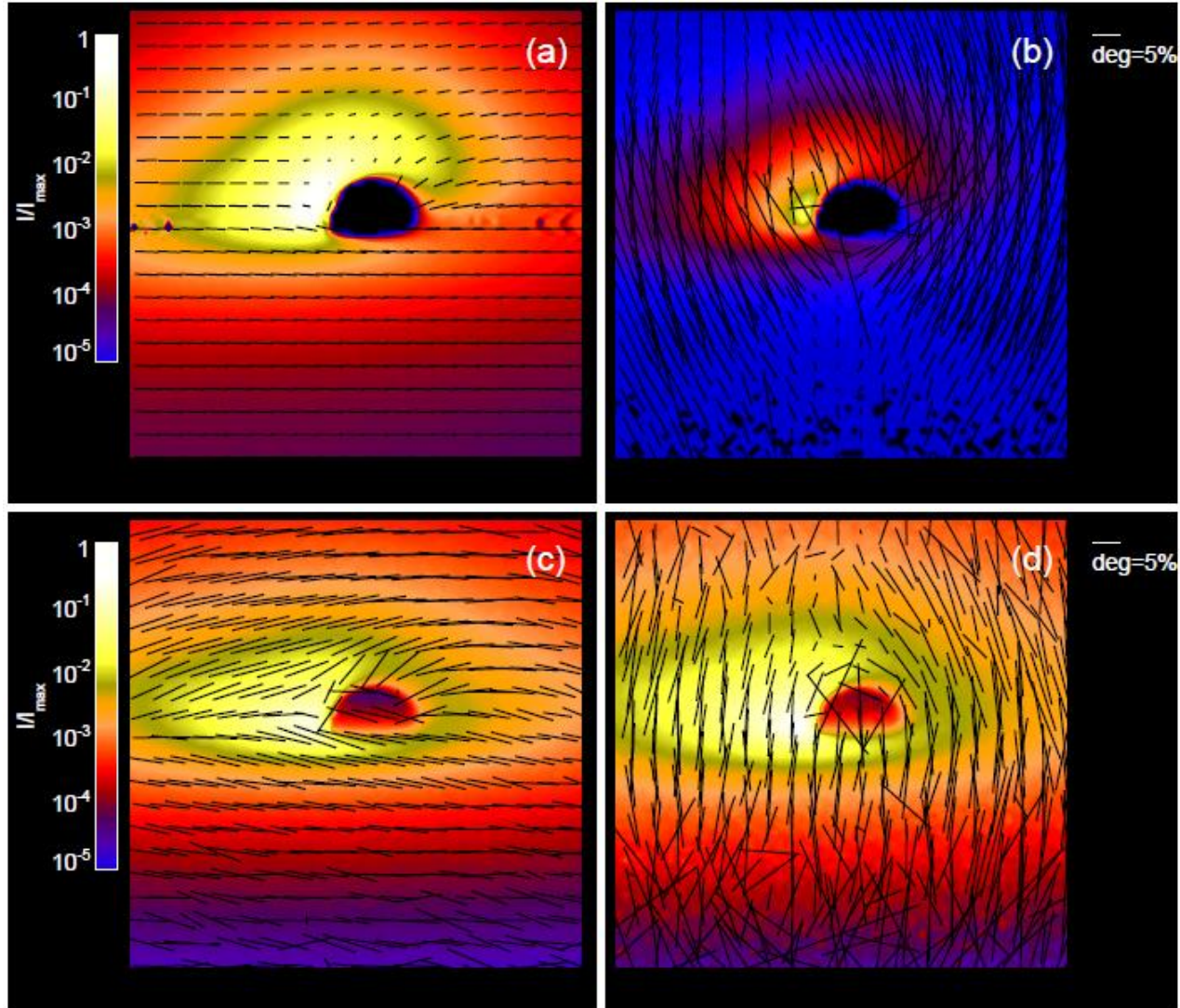
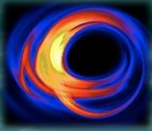


- ◇ X-ray polarization can measure a and i
- ◇ Degeneracy decoupling of a and i in CF fitting
- ◇ X-ray polarization can measure $\dot{m}$?

The background of the slide is a dark teal color with a complex pattern of thin, white, curved lines that create a sense of depth and movement, resembling a stylized globe or a network of connections.

MANY THANKS

Polarization in disk-corona model



Schnittman and Krolik 2010