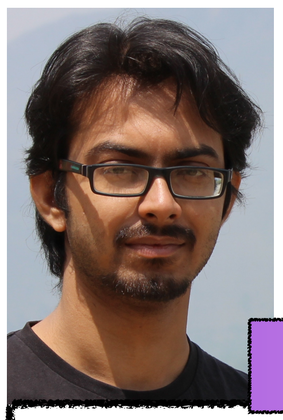
Hunting misaligned black hole accretion disks



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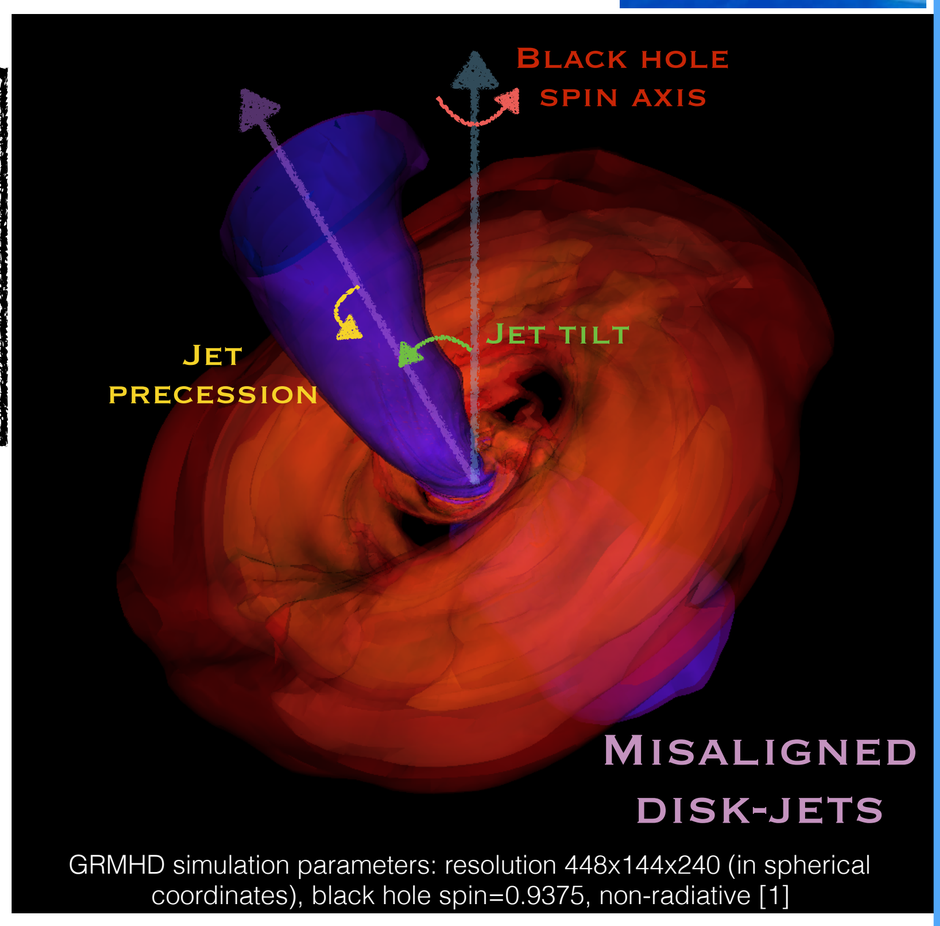
Black holes and their surroundings

Black holes are perhaps the most diverse laboratories of physics due to the interplay between the strong gravity, matter and electromagnetic fields. Since the in-falling gas remains blissfully unaware of the black hole spin axis till very small distances, misalignment between the accretion disk and the black hole spin axis is thought to be common. However, is it possible to tell observationally if a black hole disk is tilted?



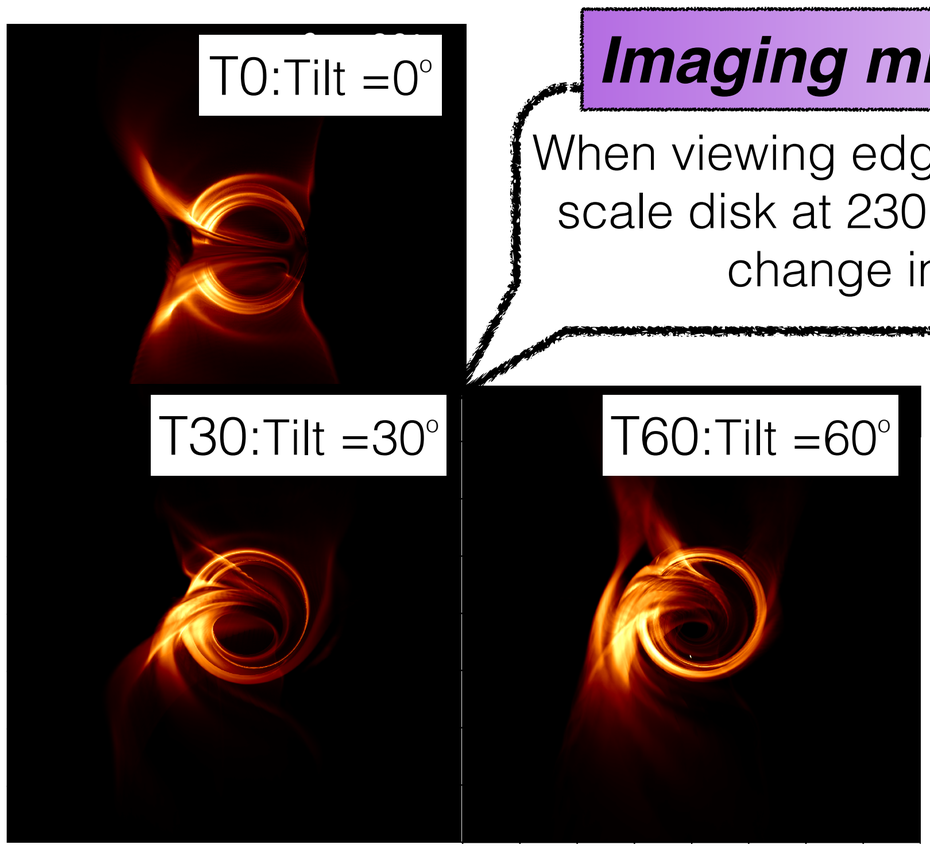
GRMHD simulation parameters: resolution 448x144x240 (in spherical coordinates), black hole spin=0.9375, non-radiative [1]

H-AMR: the world's first GPU accelerated GRMHD code: some prominent results

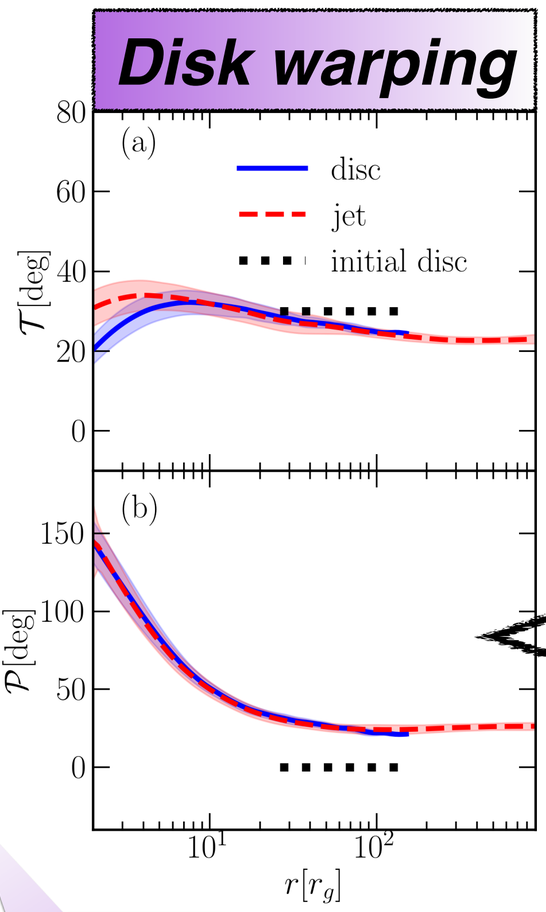
- First simulation to show precessing jets from misaligned disks [1].
- Largest 2D simulation to date explains spine-sheath jet structure [2].

Imaging misaligned disks

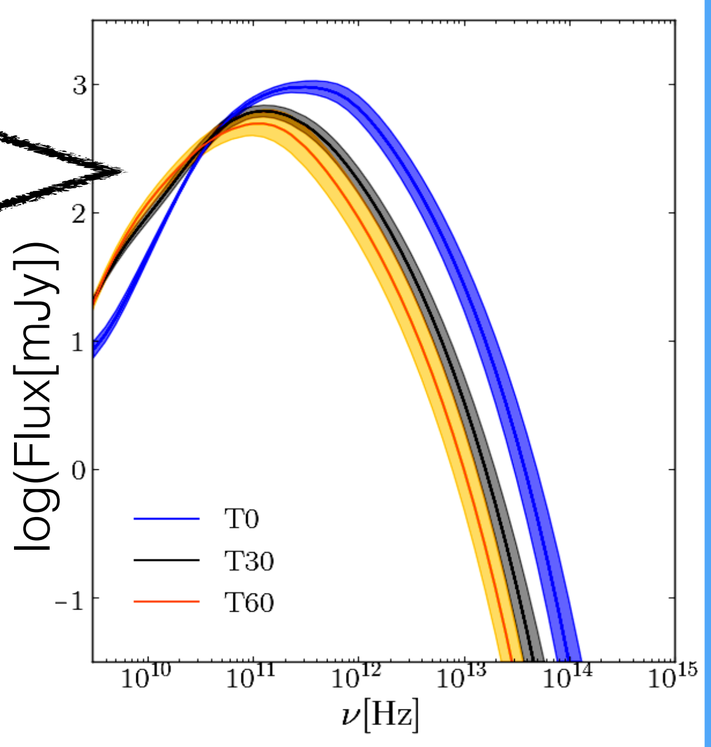
When viewing edge-on towards the large-scale disk at 230 GHz, we clearly see a change in the image [3]



Disk warping

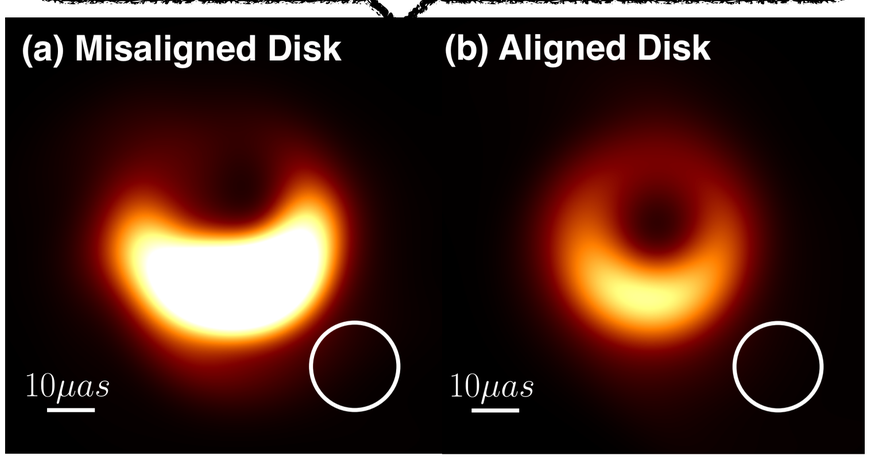


Thermal synchrotron spectrum increases in the radio band: jet emission boosted towards observer



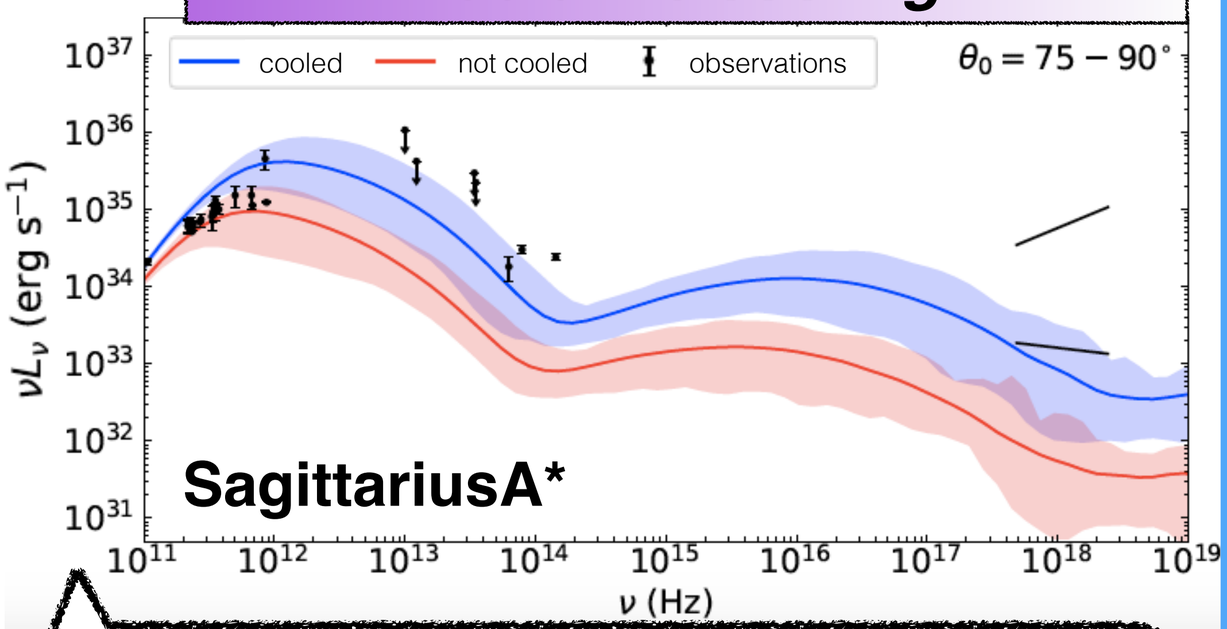
Tilt angle (T) has a radial dependence: alignment near the black hole; Inner disk region warps (P) more strongly

First BH horizon-scale images of tilted accretion disks and jets applied to M87 for a (a) tilted inner disk compared to the (b) aligned case [3]



Misalignment: Exciting new parameter space to explore for X-ray variabilty

In the works: beyond GRMHD - radiative cooling



Cooling of the hot accretion flow leads to a thinner optically-thick disk & boosts X-ray emission [4]

Results: Observing tilts

- Disk warping may cause shocks/magnetic reconnection in the plunging streams -> possible origin of X-ray flaring detectable by Chandra
- Polarised radiation is an indicator of magnetic field orientation: explore presence of tilt in jets.

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See a youtube playlist of our simulations and images by scanning this QR code!

References:
1. Liska et al., 2018, MNRAS Letters, 474, L81
2. Chatterjee et al., 2019, MNRAS, 490, 2200
3. Chatterjee et al., 2020, in prep
4. Yoon, Chatterjee,..Markoff,..et al. 2020 in prep

20 years of Chandra, 2019, Boston