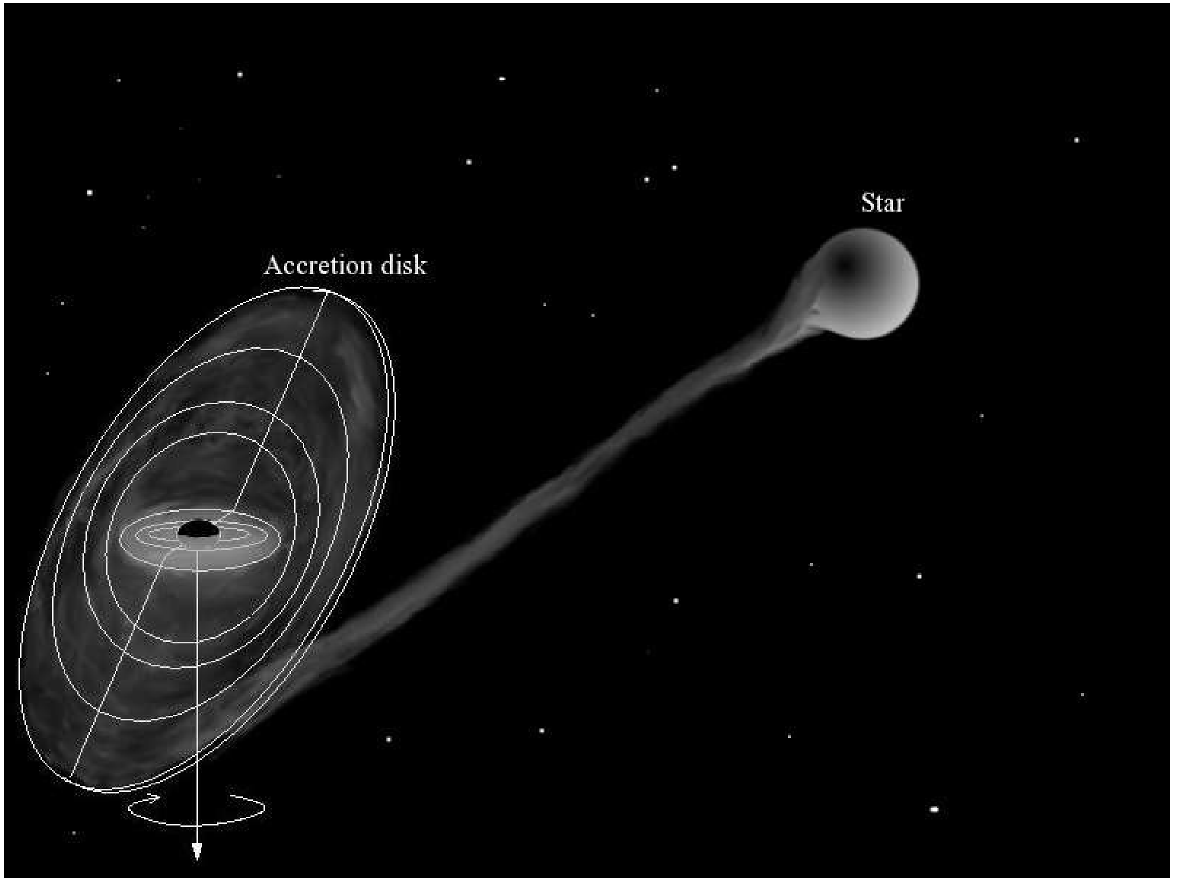
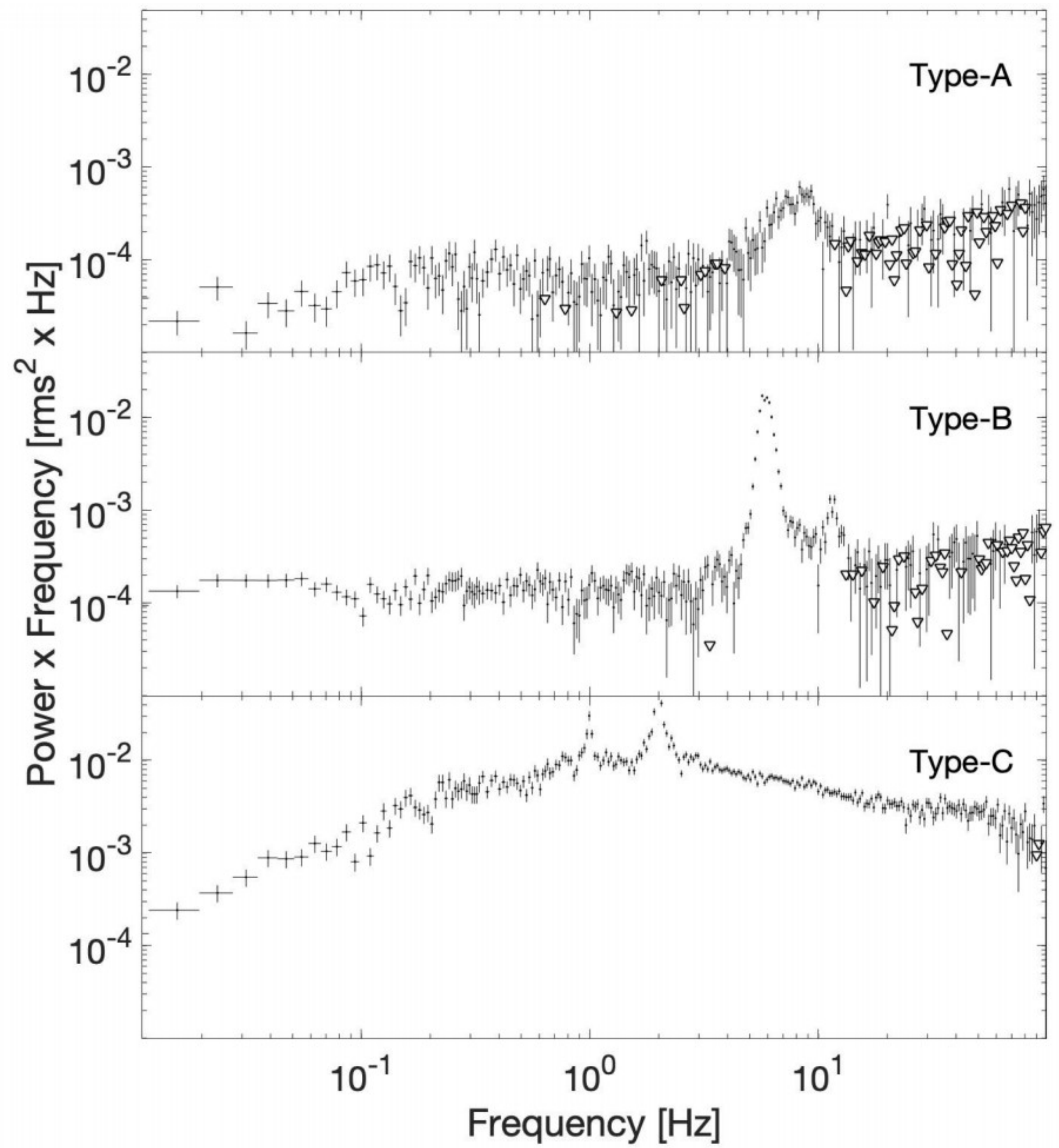
Tilted Accretion Disks around Black Holes

By C. Fragile & M. Liska



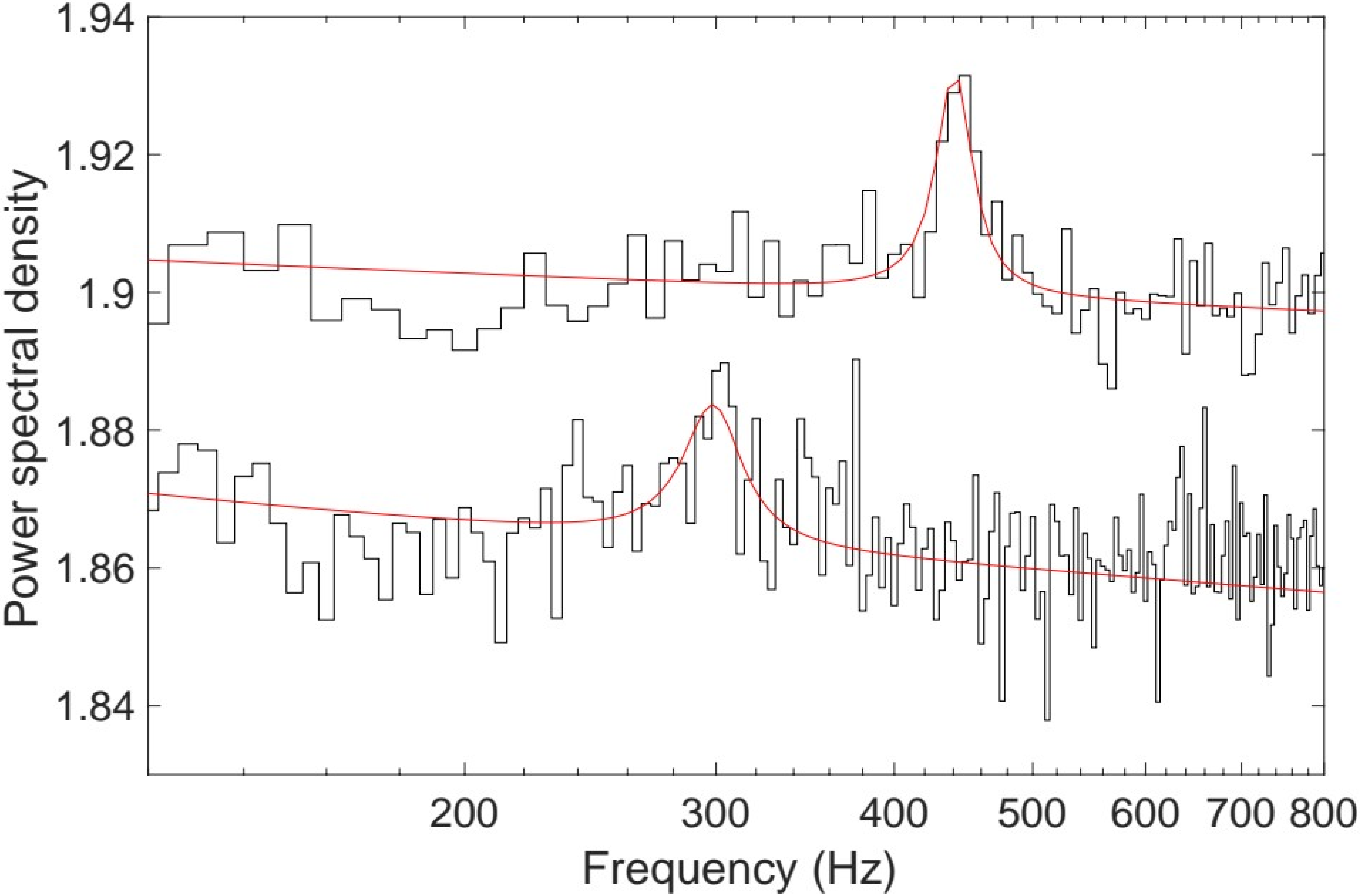
Oct 23, 2024

Low Frequency QPOs from BH XRBs



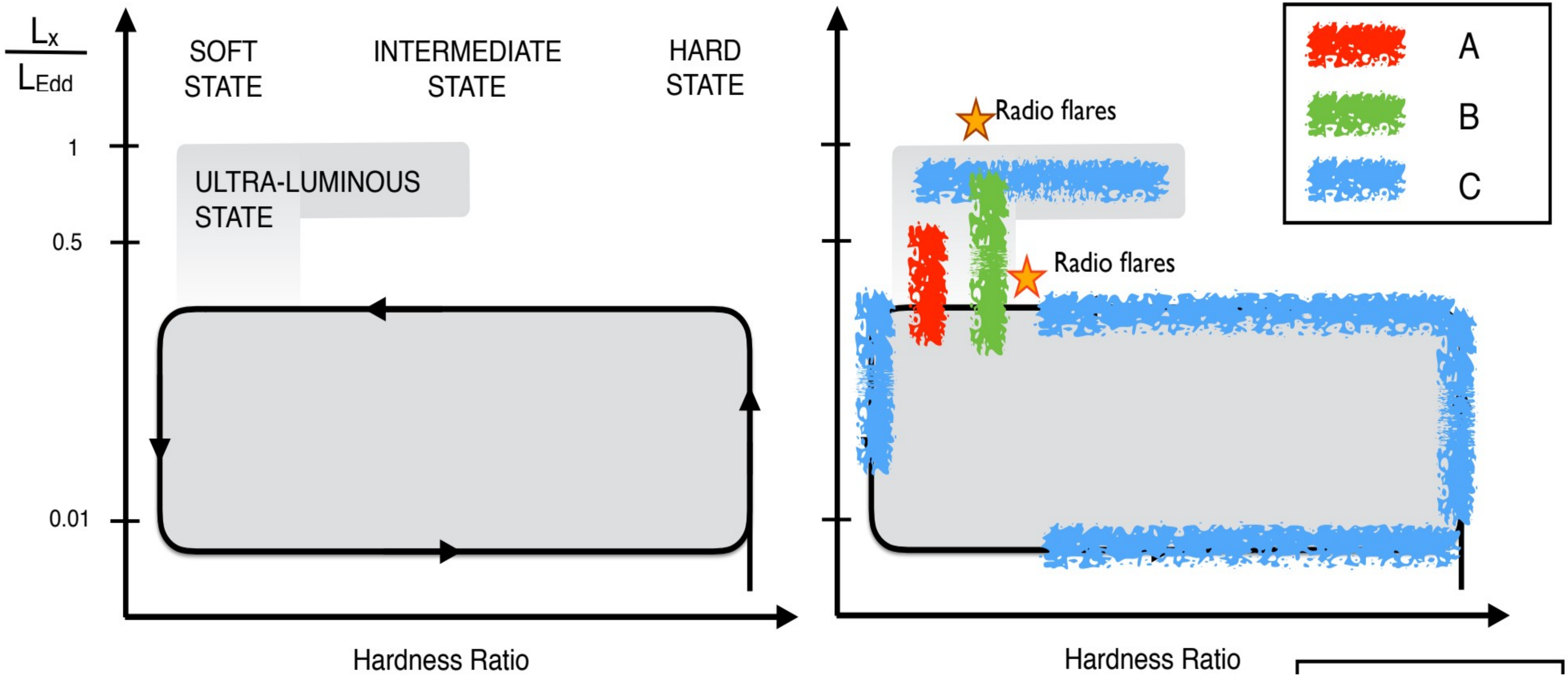
(Ingram & Motta 2019)

High Frequency QPOs from BH XRB GROJ1655-40



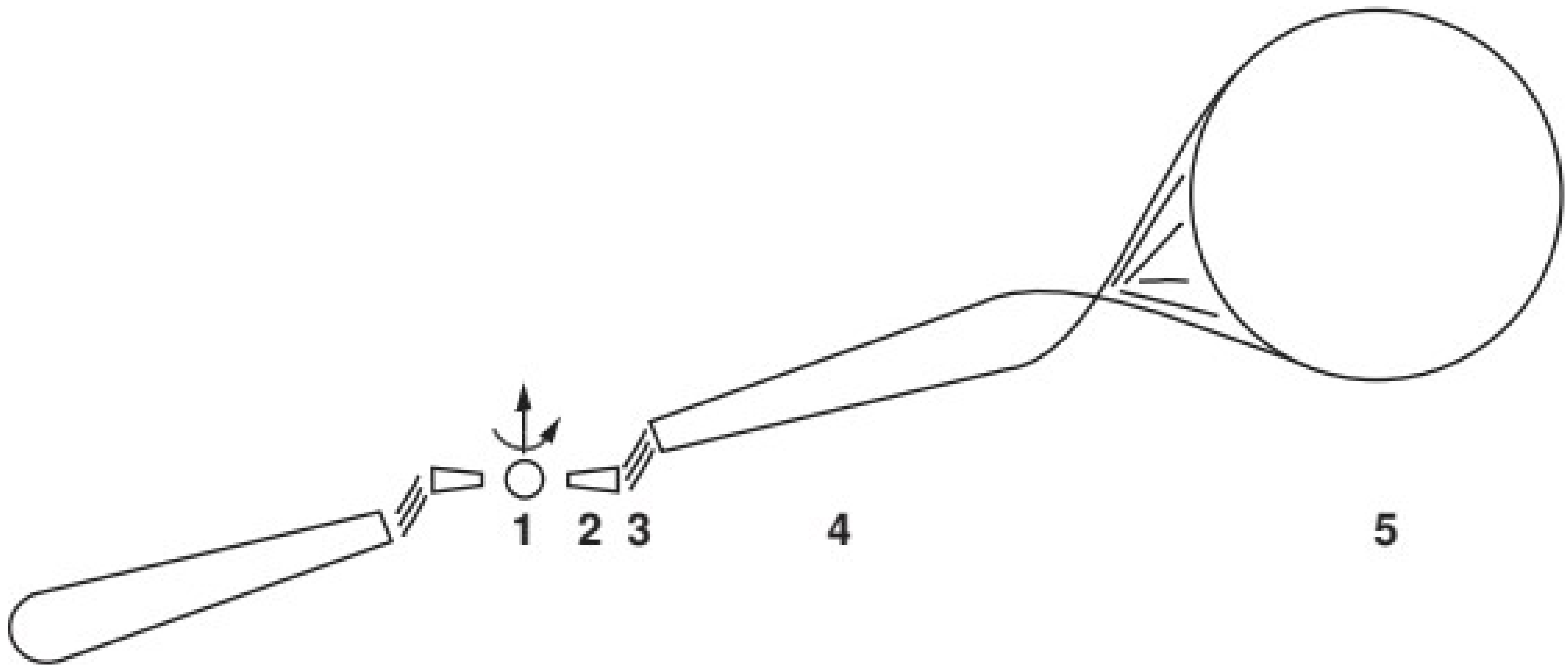
(Motta et al., 2014)

Behaviour of BH in a Hardness-Intensity diagram



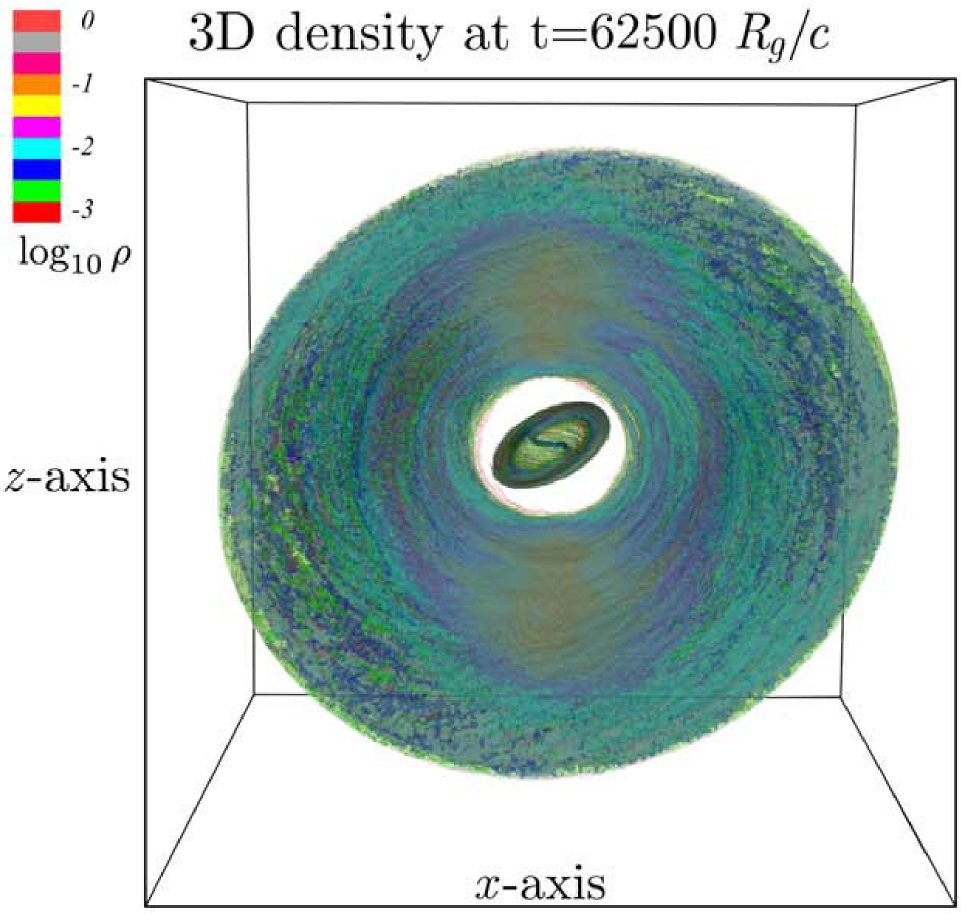
(Munoz-Darias et al. 2014)

Schematic diagram of the Bardeen-Petterson effect in a black hole X-ray binary showing (1) the central rotating black hole, (2) the inner, aligned accretion disk, (3) the transition region, (4) the outer, tilted accretion disk, and (5) the companion star.

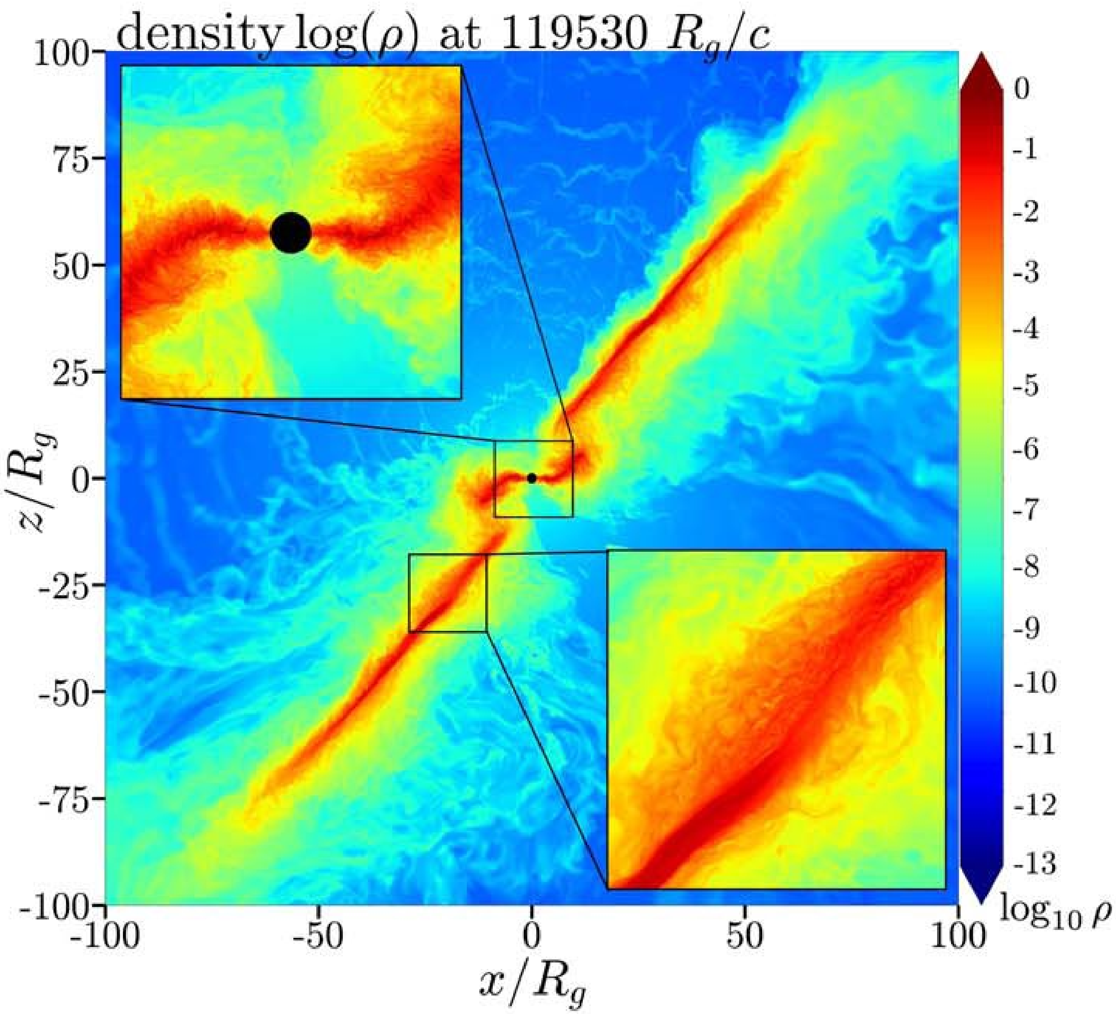


(Fragile, Mathews & Wilson 2001)

GRMHD simulation of a thin accretion disk which tears apart into an outer, non-precessing disk and inner, precessing one.

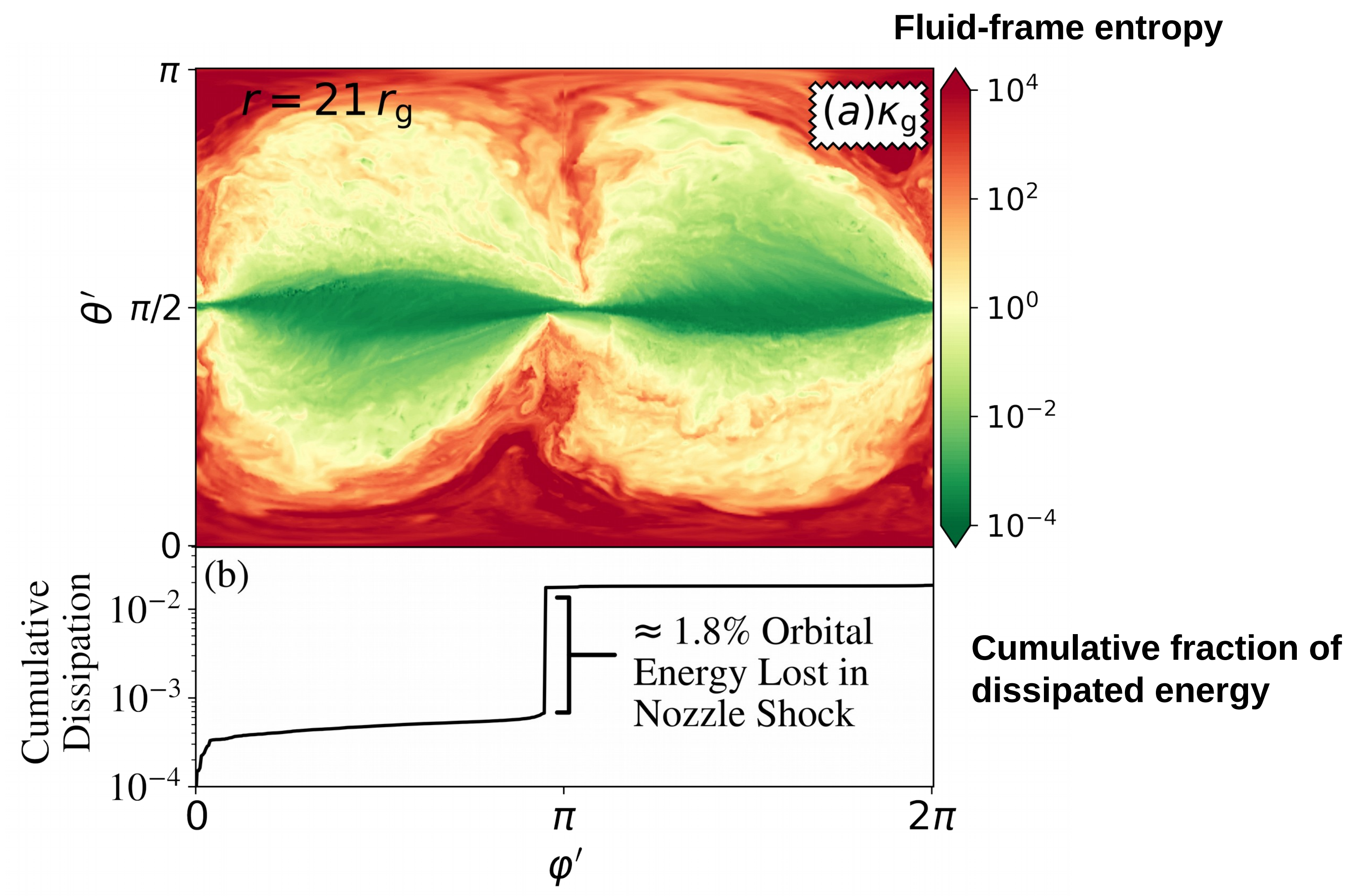


Vertical slice through the density with the black hole spin pointing vertically



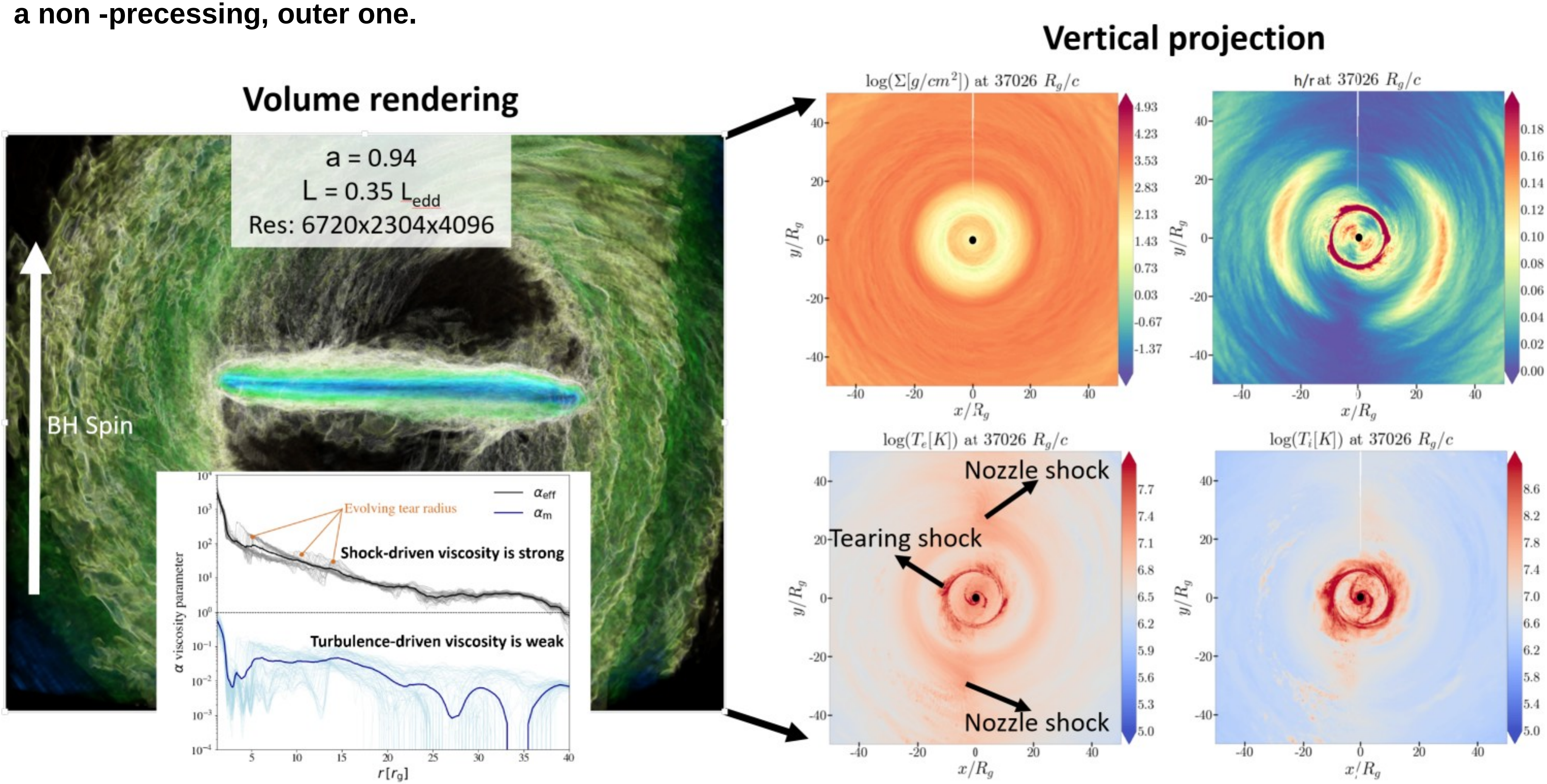
(Liska et al. 2022)

Vertical compression in simulations of warped, thin disks



(Kaaz et al. 2023)

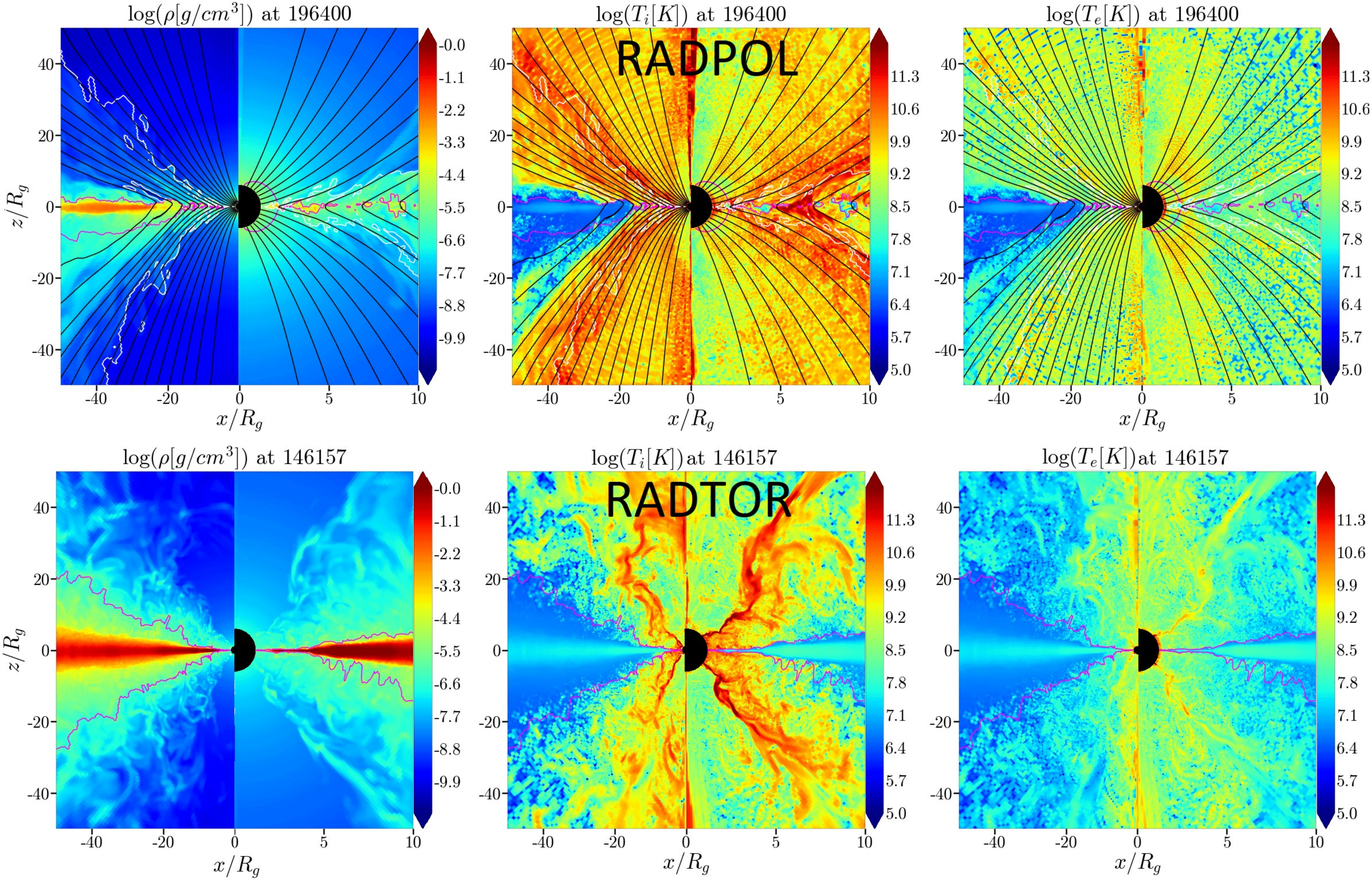
Warping of ST causes the disk to tear apart:
a precessing, inner disk and
a non -precessing, outer one.



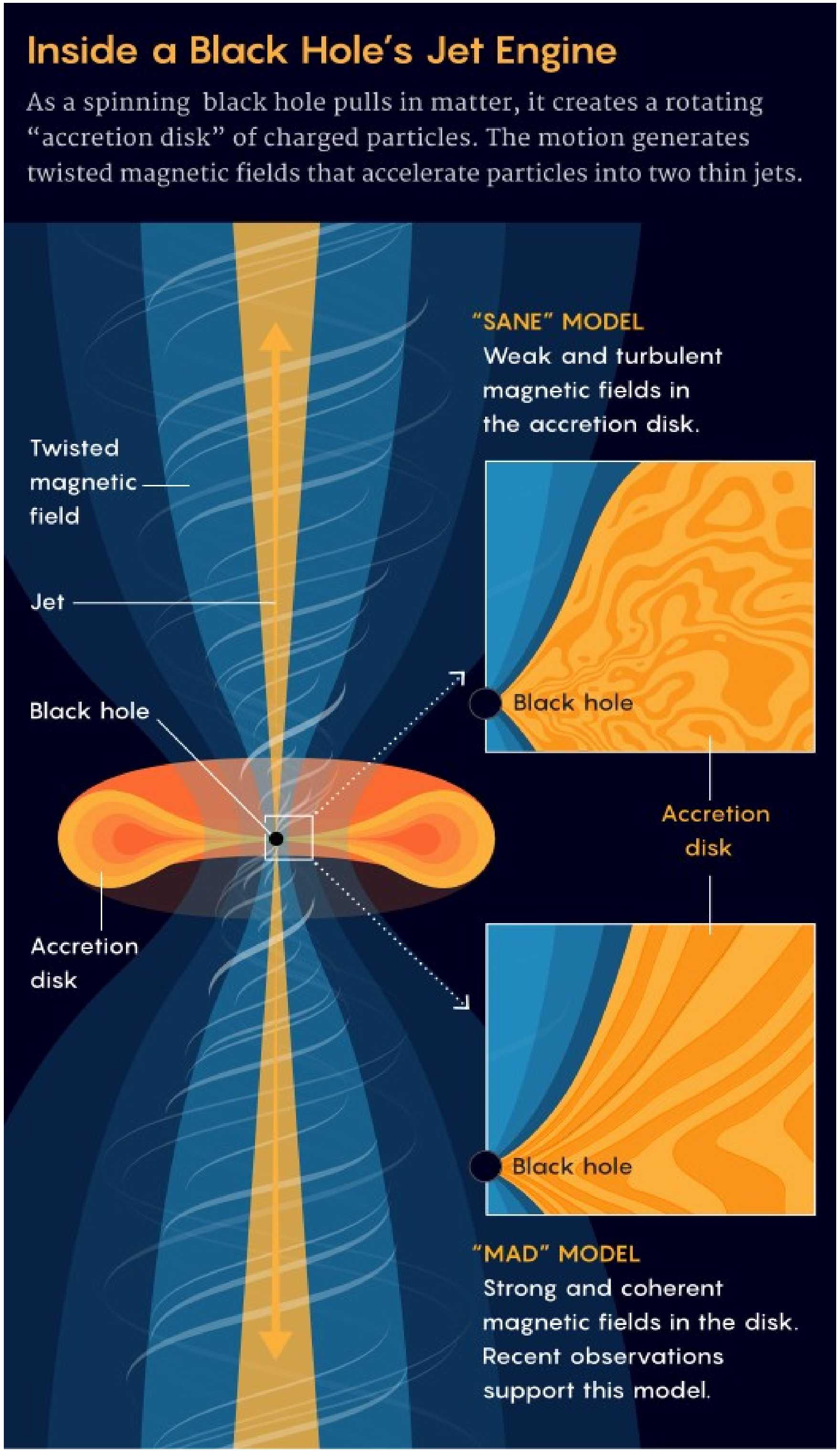
Shock-induced effective viscosity (α_{eff}) orders of magnitude larger than the turbulent viscosity seeded by MRI turbulence (α_m)

(Kaaz et al. 2023; Liska et al. 2023)

Presence of large-scale poloidal magnetic flux leads to the development of a two-phase medium



(Liska et al. 2022)

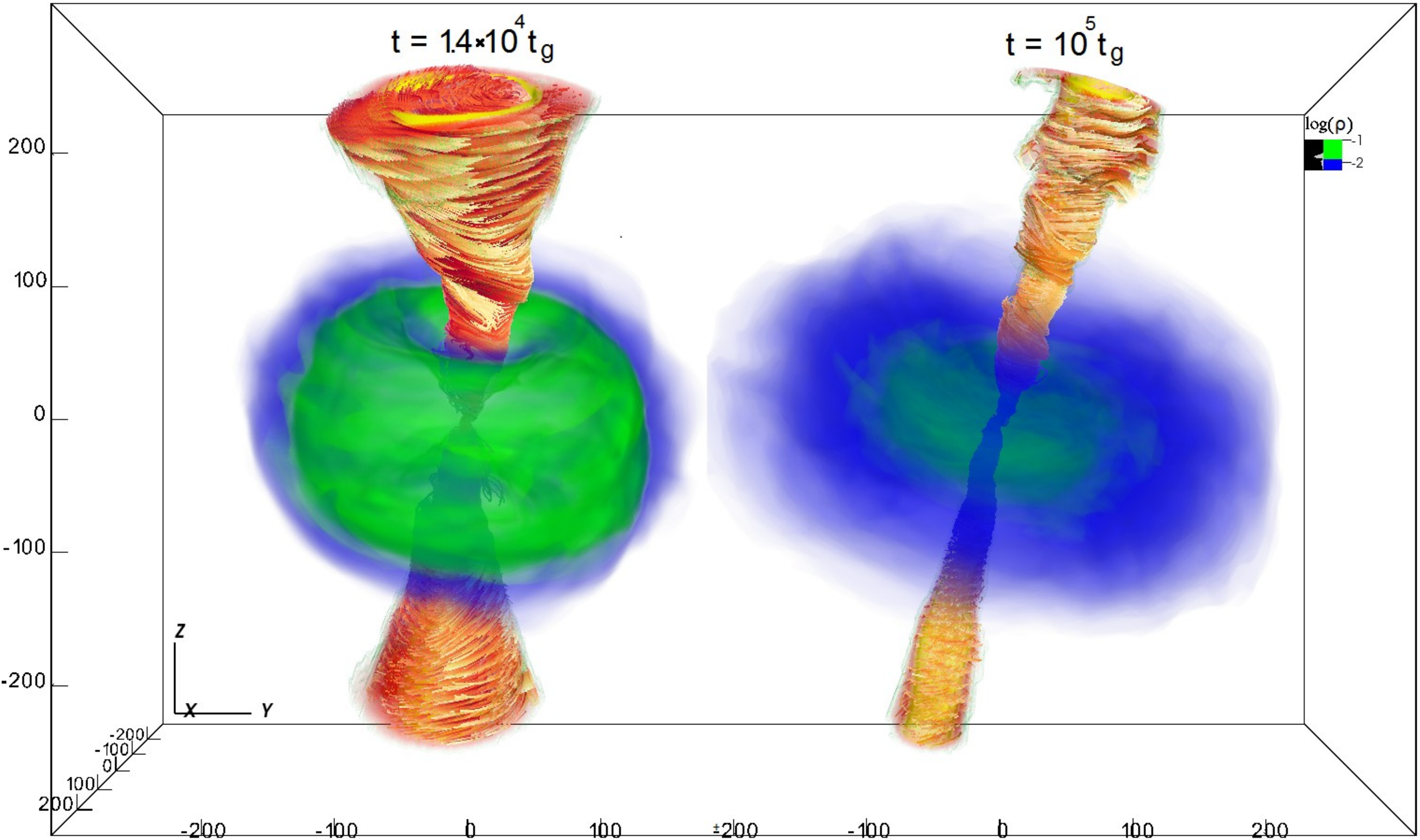


Standard And Normal Evolution (SANE)

Magnetically Arrested Disk (MAD)

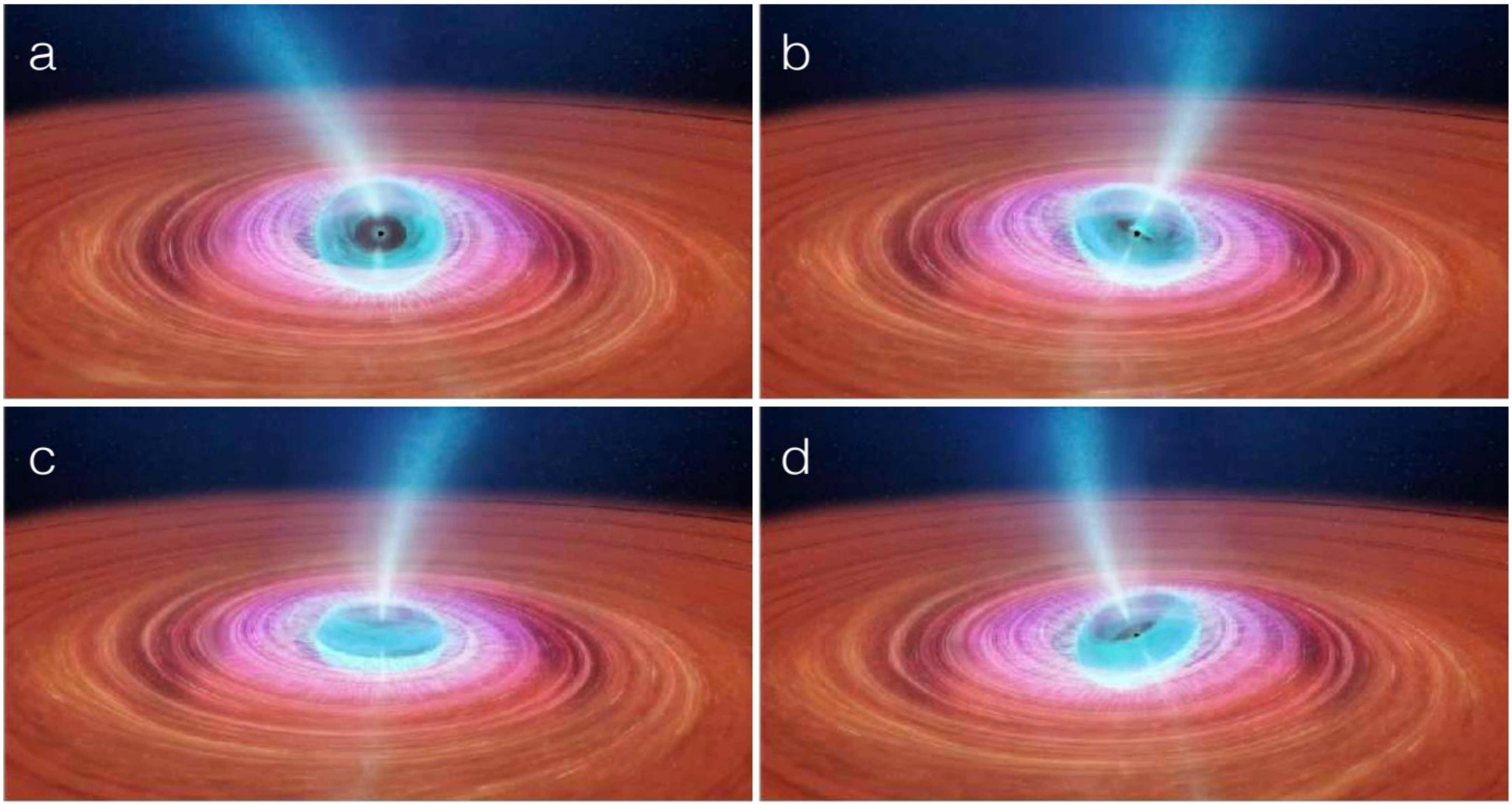
(Image credit: Quanta Magazine)

Standard And Normal Evolution (SANE) in thick disks: Jets precess in phase with the disk



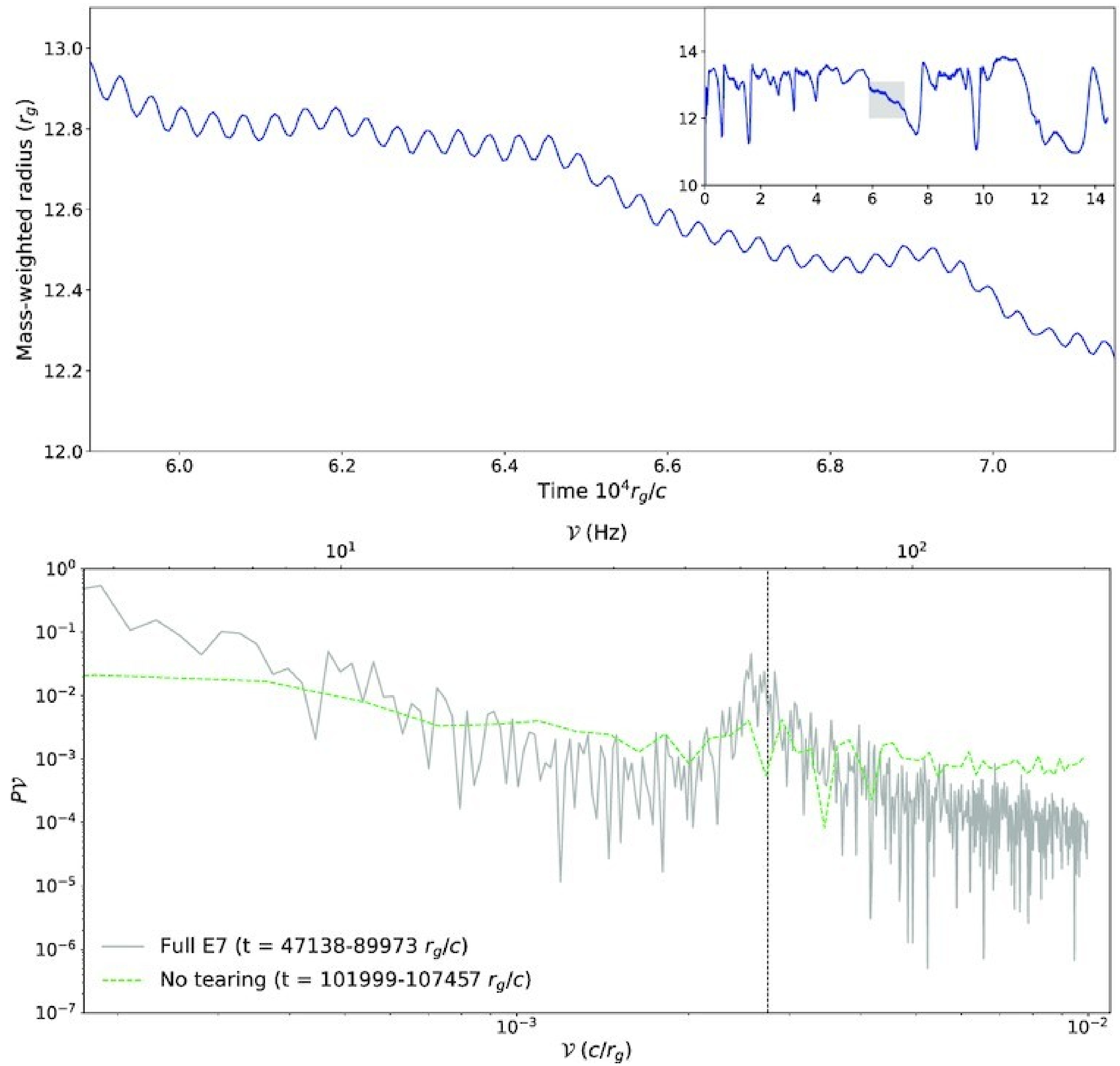
(Liska et al. 2018)

Precessing inner flow model: The disc (orange) remains stationary, whilst the inner flow (blue torus) and the jet precess around the BH spin axis (which is pointing upwards and slightly towards the observer in this example). Here, precession and disc rotation are both anticlockwise.



(Miller-Jones et al. 2019)

Radial oscillations of the inner sub-disk in a tearing-disk simulation



(Musoke et al. 2023)

Current/Future simulations

Broader range of tilts

Broader range of spins

Wider variety of starting conditions

SANE & MAD

(Adapted from last slide of C. Fragile at the Simon Foundations in January 2024)

The trouble with people is not that they know so little, but that what they know is largely not true. ~ Mark Twain

Thank you.