Angular momentum transport by turbulence in Keplerian flows

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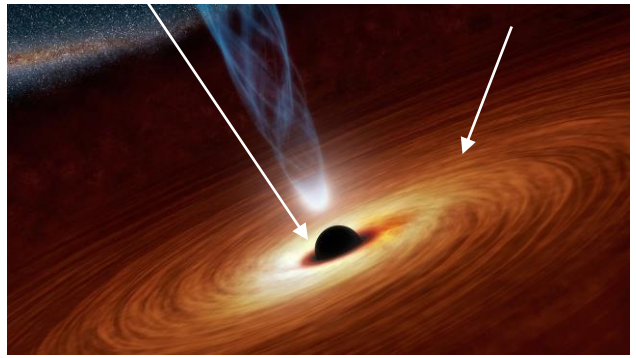
Black hole Accretion disk

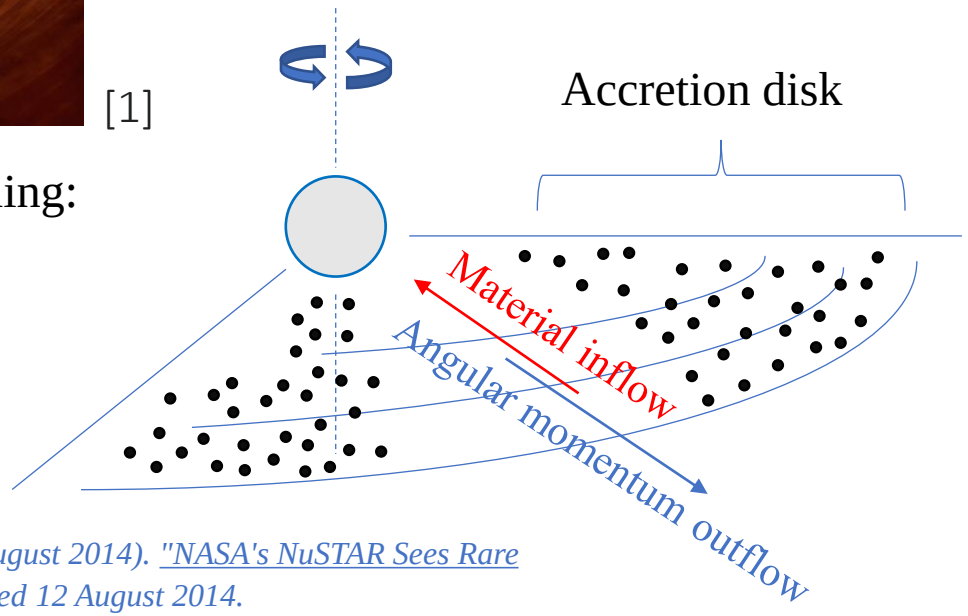


[1]

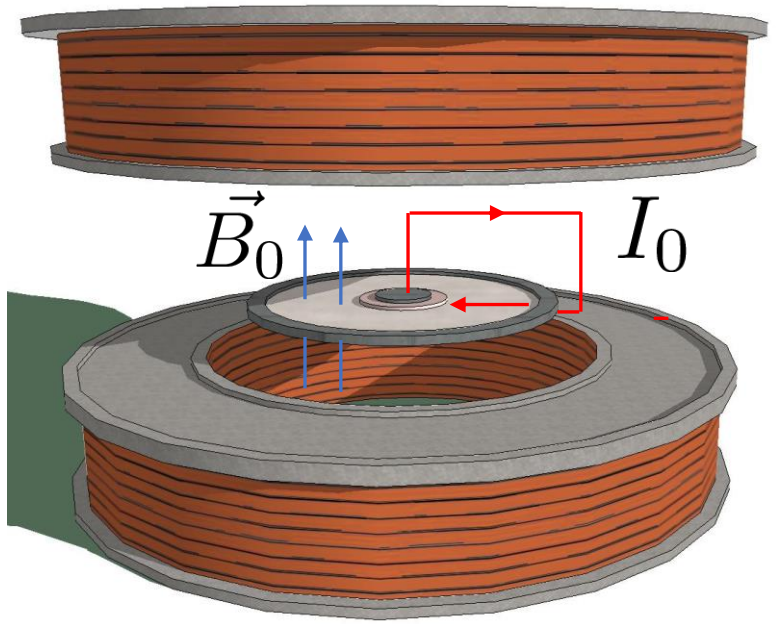
Keplerian rotation rate scaling:

$$\Omega \propto \frac{1}{r^{3/2}}$$

Massive central body

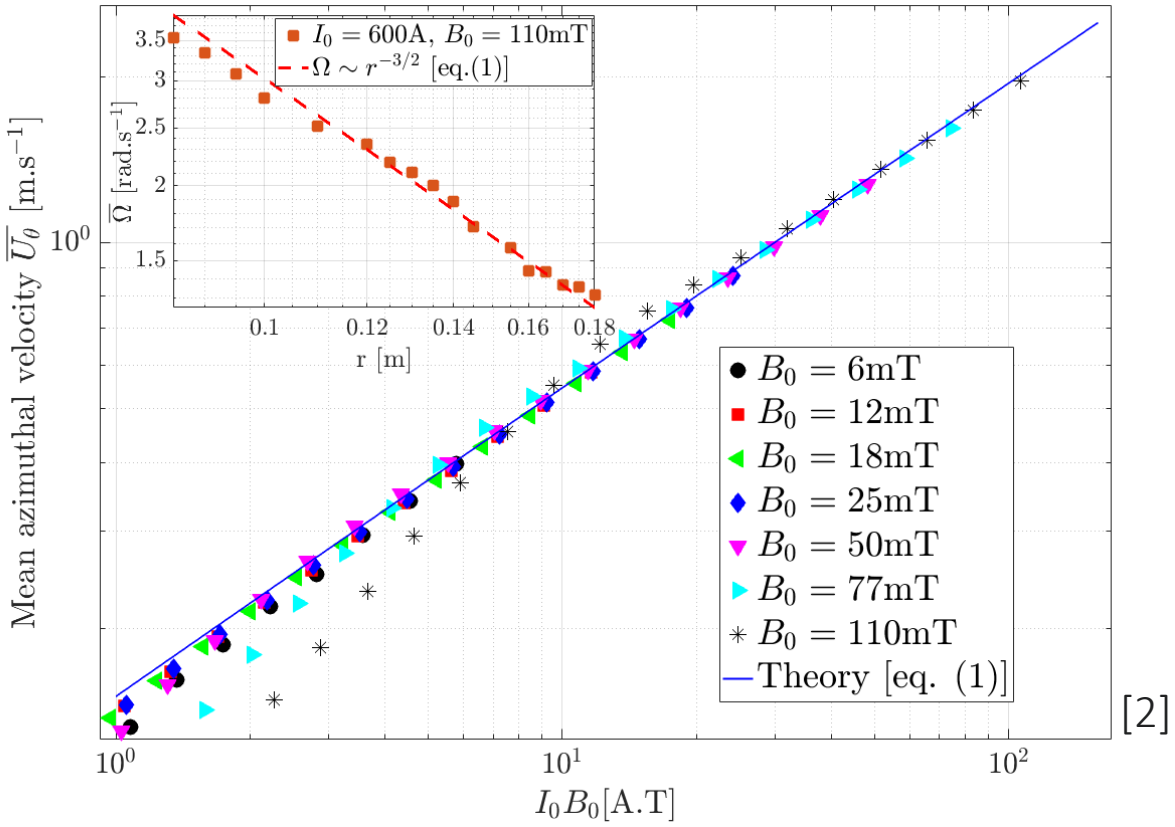


Kepler experiment :



[1] *Clavin, Whitney; Harrington, J.D. (12 August 2014). "NASA's NuSTAR Sees Rare Blurring of Black Hole Light". NASA. Retrieved 12 August 2014.*

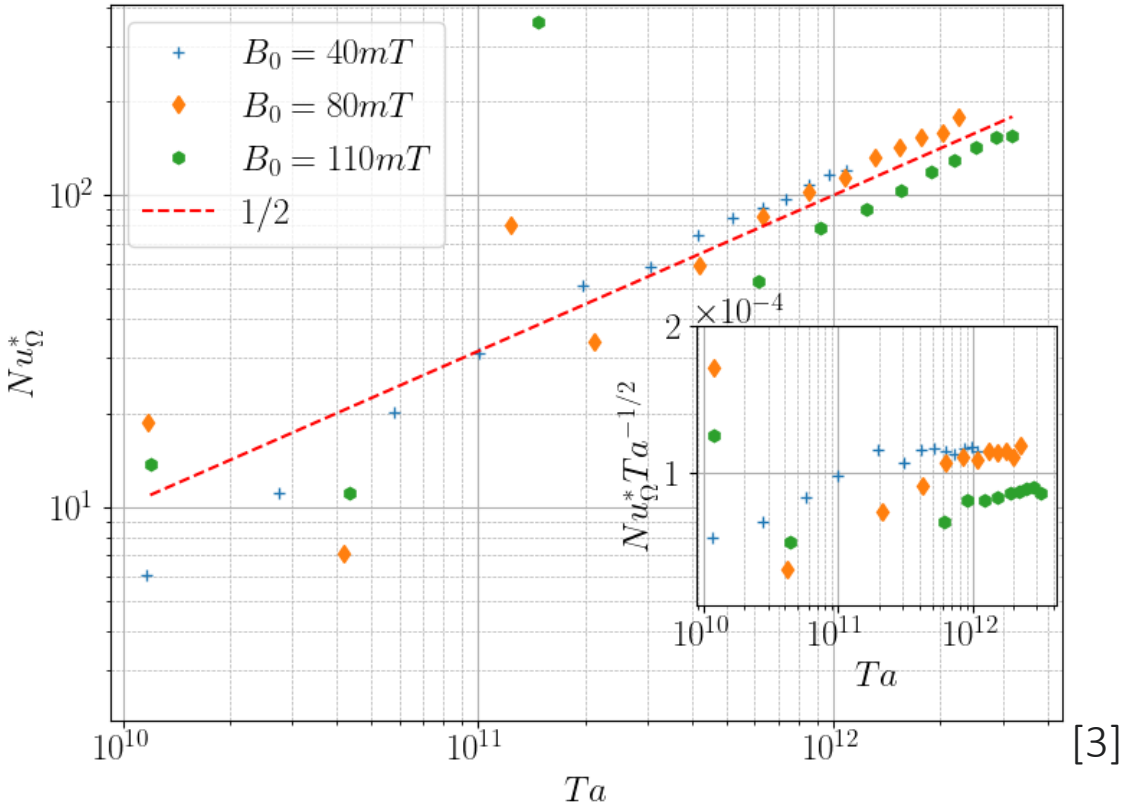
Kraichnan's ultimate regime :



[2]

- Fully turbulent state
- Keplerian rotation flow

$$\overline{u_\theta} = \frac{\log Re}{\kappa}\sqrt{\frac{I_0 B_0}{4\pi\rho r}}$$



[3]

Flux of angular velocity :

$$\overline{J_\Omega}^* = r^3(\overline{u_r^* \Omega^*} - \nu\partial_r(\overline{\Omega}))$$

$$J_{lam} = 2\nu r \overline{u_\theta}$$

Nusselt number : $Nu^*_\Omega = \dfrac{\overline{J_\Omega}^*}{J_{\text{lam}}}$

Kraichnan's regime :

$$Nu^*_\Omega \propto \sqrt{Ta}$$

➢ Kepler experiment therefore gives predictions for accretion rates, which enables direct comparisons with astrophysical objects.

[2] Vernet, M., Pereira, M., Fauve, S., & Gissinger, C. (2021). Turbulence in electromagnetically driven Keplerian flows. *Journal of Fluid Mechanics*, *924*, A29.
[3] Vernet *et al*. Submitted PRL.