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Structure of magnetized transonic accretion disks

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Using general relativistic analytical treatment in Kerr metric and numerical simulations with the public HARM2D code, we consider the vertical structure and velocity field in the inner parts of a black hole accretion disk, both outside and inside the last stable orbit.

Chaotic magnetic fields frozen into the accreting matter easily become the dominant pressure source inside the sonic point that allows to predict the equilibrium thickness of the flow. Numerical simulations, however, reveal instabilities in the magnetic fields leading to formation of current sheets in the super-sonic part of the flow and ultimately to accretion through thin layers (or wisps, in 3D) with the vertical spatial scale much smaller.

If disk thickness is large, any consideration of its vertical structure should use some assumptions about the rotation velocity field inside the disk. The latter seems to be strongly dependent upon the presence of a regular magnetic field component near the black hole. If the magnetic flux through the black hole horizon is small, rotation close to the sonic surface conforms very well to Keplerian, and isorotational surfaces have practically cylindrical shapes ($r\sin\theta = const$). We use the assumption of Keplerian cylindrical rotation $\Omega(r,\theta) = \left((r\sin\theta)^{3/2} + a\right)^{-1}$ to estimate the effects of disk thickness upon the Eddington limit and accretion efficiency in black hole accretion disks.

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