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Magnetorotational instability saturation and transition to anisotropic turbulence

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The magnetorotational instability (MRI) plays a key role in transfer of angular momentum outward in accretion disks. We study the growth of secondary parasite instabilities which trigger the saturation of the MRI. We examine the late linear stage of the MRI and transition to turbulence. We seek to gain a qualitative and quantitive understanding of the nature of the turbulence resulting from the MRI: its anisotropy and time-dependent evolution in a self-sustaining process. We carried out a set of magnetohydrodynamic local shearing box simulations in 2D and 3D to investigate the nonlinear saturation the magnetorotational instability due secondary instabilities. Both in the compressible and incompressible regimes the exact MRI solution was the first to mode appear, in agreement with linear theory. The exact MRI modes are rapidly broken down in less than one orbit by the fast growing Kelvin-Helmholtz parasite instability. We find that the chains of alternating vortices grow and cause the MRI flow to become disrupted, leading to saturation. We isolated the effects of the instability and identified signatures in 3D and 2D axisymmetric flows. We compared the evolution of the parasite Kelvin-Helmholtz mode with theory and found confirmation of its growth rate with theory. We studied the 3d time evolution in Fourier space and quantified the anisotropy of turbulence driven by the magnetorotational instability.

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