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A shallow-water theory of thin annular sections of cold astrophysical disks

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Astrophysical disks are characterized by order unity Rossby numbers. This makes the analysis of their vortical disturbances difficult to perform in terms of classical geostrophic flow approximations. In this study a scaling analysis is motivated and an asymptotic reduction of the equations of motion are presented which addresses this issue. The resulting equations describe motion which is geostrophic in the radial and hydrostatic in the vertical. An analysis of a series of simple problems is presented. In one problem an incarnation of the stratorotational instability is recovered. In another, the nonlinear evolution of an unstable Rossby wave is studied using weakly nonlinear techniques (single-wave theory). A discussion is presented discussing both the limitations of the theory and future directions.