Dynamics of protoplanetary disks with rheological viscosity

Alexander Tevzadze and Luka Poniatowski

e-mail: alexander.tevzadze@tsu.ge

Department of Physics, Faculty of Exact and Natural Sciences, Tbilisi State University, Chavchavadze avenue 3, Tbilisi 0179, Georgia

We study the linear dynamics of circumstellar disks taking into account rheological properties of the flow that contains gas, dust and debris orbiting central gravitating object. Interaction of solid particles is studied within the granular flow model, when local constitutive equation can be used. In this model we derive 2D equilibrium flow with Keplerian velocity profile and radially stratified pressure, surface density and kinematic viscosity parameter. Kinematic viscosity of the flow depends on the pressure, as well as the velocity shear of the flow.

We use local shearing sheet model and neglect flow curvature to study the linear dynamics of vortex and spiral-density waves under the influence of granular rheology. Using radial rescaling of linear perturbations (see [1]) we derive linear spectrum of the problem and show dissipative properties of individual wave modes. Using isentropic flow model we reduce to barotropic configuration where potential vorticity is conserved apart from viscous dissipation. In this limit we show potential vorticity generation mechanism due to the interplay of background differential rotation and rheological properties of the flow. Process found in granular Keplerian flows can contribute to the generation of large amplitude anticyclonic vortices and promote planet formation at early stages in protoplanetary disks.

References

[1] A. G. Tevzadze, G. D. Chagelishvili, G. Bodo, P. Rossi, MNRAS **401**, 901 (2010). doi:10.1111/j.1365-2966.2009.15723.x