EPSC Abstracts,
Vol. 4, EPSC2009-114-1, 2009
European Planetary Science Congress,


# Anomalous Turbulent Diffusion in Rotationally Supported Protoplanetary Disks

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## Abstract

Redistribution of the matter in an astrophysical disk configuration under the influence of rotating potentials of gravitationally (Jeans-) unstable ring and spiral perturbations (e.g., those produced by a spontaneous disturbance) are crucial to the understanding of the dynamics of highly flattened spiral galaxies, protostellar and protoplanetary clouds, and planetary rings. This may be also crucial to the understanding of the feeding mechanism of active galactic nuclei and supermassive black holes. (The significance of gravitational instability for the properties of compact nuclear disks in the centers of galaxies has been recognized. It is widely accepted that quasars and other active galactic nuclei are powered by accretion of matter onto a central black hole. The energy set free in the disk accretion process would be adequate to support the high luminosity of supermassive black holes located in quasars and in the nuclei of galaxies.) While numerical simulations have demonstrated the importance of magnetic fields in generating the turbulence believed necessary for accretion in protostellar and protoplanetary clouds, so far they have not produced the high mass accretion rates required to explain the most interesting cases. In the framework of our model, the anomalous turbulent viscosity in accretion disks might be caused by Jeans' gravitational instability. This work purports to provide new insight into turbulent diffusion induced by instabilities in astrophysical systems through application of an approximate linear hydro-dynamical analysis. The analysis is the hydrodynamic limit of work from a much more detailed earlier papers of the author and his co-workers. It is shown that in self-gravitating, rotationally flattened configurations, such as protoplanetary disks the anomalous turbulent diffusion arising by Jeans' gravitational instability may exceed the ordinary microscopic (collision) diffusion substantially. Redistribution of the matter under the influence of rotating potentials of Jeans-unstable perturbations is therefore crucial to the understanding of the dynamics of these systems. The advocated idea is tested with numerical simulations. The observational test of the theory is suggested as well.

This work was supported in part by the Israel Science Foundation and the Binational US–Israel Science Foundation.