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ORIGINAL ARTICLE

Anomalous magnetic viscosity in accretion disks with q-distributed plasmas

D.G. Li · S.Q. Liu · X.Q. Li

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Abstract Based on the equations of the self-generated magnetic field in the q-distributed plasmas, the studies show that the magnetic field is modulationally unstable by the perturbation method and the equations have self-similar collapse solution. The anomalous magnetic viscosity of accretion disks generates from highly spatially intermittent flux of the self-generated magnetic field. In addition, the anomalous viscosity coefficient is 8 orders more than the molecular viscosity and is modified by the adjustable index q, which may preferably explain the observations.

Keywords q-Distributed · Self-generated magnetic field · Anomalous viscosity · Accretion disks

1 Introduction

Accretion disks are present and play a central role in a variety of astrophysical objects, such as mass-transfer binaries, young stellar objects (YSOs), and active galactic nuclei (AGN) (Frank et al. 1992), which are generally postulated as the energy source of active galactic nuclei, galactic X-ray sources, and so on. The nature and magnitude of the viscosity are the cause of the main uncertainty about the structure and evolution of accretion disks (Shakura and Sunyaev 1973), the process by which the gas loses angular momentum to accrete onto the massive central object. Bluementhal et al. (1984) think that if molecular viscosity is the only agent responsible for angular momentum transport, the evolution time scale for a typical accretion disk will be much longer than the Hubble time. Later Lovelace et al. (1987) think that normal microscopic viscosity is too small to sustain an astrophysically significant accretion flow and an anomalous viscosity is usually assigned to accretion disks. Lodato (2008) thinks that the magnitude of viscosity must be much larger than the simple collisional one. There is general agreement that molecular viscosity is totally inadequate and that some kind of turbulent viscosity is required.

However, there is far less certainty about how to prescribe such a turbulent viscosity in the absence of a proper physical theory of turbulence. Shakura and Sunyaev (1973) make up α-model and introduce an ad hoc parameter α_t, that $\eta_t = \alpha_t c_s H\rho$, ($\alpha_t = \text{const}$), where H is the disk scale height, c_s the sound speed, and ρ the mass density, to parameterize our ignorance of the anomalous 'turbulent viscosity', and just this ignorance makes stability analysis based on the α_t-formalism most problematic: what comprises the unperturbed state is impossible to define (Balbus and Hawley 1998). Eardley and Lightman (1975) firstly calculate magnetic viscosity from Keplerian fluid shear. Coroniti (1986) and Torkelsson (1993) extend the model by including magnetic buoyancy. These models concentrate on viscosity as a direct result of field line stretching by the Keplerian mean flow. But these investigations are still in the kinematical version and it is not sensible to only dwell on magnetohydrodynamic studies. Investigations of microscopic and non-linear instabilities, especially of magnetic driving, resulting in anomalous viscosity, are also necessary.

D.G. Li (✉) · S.Q. Liu
School of Materials Science and Engineering, Nanchang University, Nanchang 330047, China
e-mail: dgli@ecit.edu.cn

D.G. Li
School of Nuclear Engineering and Technology, East China Institute of Technology, Fuzhou 344000, China

S.Q. Liu · X.Q. Li
Department of Physics, Nanchang University, Nanchang 330047, China