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ORIGINAL ARTICLE

Self-similar solutions of viscous and resistive ADAFs with thermal conduction

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Abstract We have studied the effects of thermal conduction on the structure of viscous and resistive advection-dominated accretion flows (ADAFs). The importance of thermal conduction on hot accretion flow is confirmed by observations of hot gas that surrounds Sgr A* and a few other nearby galactic nuclei. In this research, thermal conduction is studied by a saturated form of it, as is appropriated for weakly-collisional systems. It is assumed the viscosity and the magnetic diffusivity are due to turbulence and dissipation in the flow. The viscosity also is due to angular momentum transport. Here, the magnetic diffusivity and the kinematic viscosity are not constant and vary by position and α-prescription is used for them. The govern equations on system have been solved by the steady self-similar method. The solutions show the radial velocity is highly subsonic and the rotational velocity behaves sub-Keplerian. The rotational velocity for a specific value of the thermal conduction coefficient becomes zero. This amount of conductivity strongly depends on magnetic pressure fraction, magnetic Prandtl number, and viscosity parameter. Comparison of energy transport by thermal conduction with the other energy mechanisms implies that thermal conduction can be a significant energy mechanism in resistive and magnetized ADAFs. This property is confirmed by non-ideal magnetohydrodynamics (MHD) simulations.

Keywords Accretion, accretion discs · Conduction · Magnetohydrodynamics: MHD

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1 Introduction

The observational features in active galactic nuclei (AGN) and X-ray binaries can be successfully explained by the standard geometrically thin, optically thick accretion disc model (Shakura and Sunyaev 1973). The motion of the matter in the standard thin model of the accretion disc is approximately Keplerian, and the gravitational energy released in the disc is radiated away locally. In the past two decades, another type of accretion flow has been considered in which it is assumed that the energy released through heating processes in the disc may be trapped within accreting gas. As, only the small fraction of the energy released in the accretion flow is radiated away due to inefficient cooling, and most of the energy is stored in the accretion flow and advected to the central object. This kind of accretion flow is called as advection- dominated accretion flow (ADAF). The basis ideas of ADAF models have been developed by a number of researchers (e.g. Ichimaru 1977; Rees et al. 1982; Narayan and Yi 1994; Abramowicz et al. 1995; Blandford and Begelman 1999; Ogilvie 1999).

The observations of black holes confirm existence of hot accretion flow, which contrasted with classical cold and thin accretion disc scenario (Shakura and Sunyaev 1973). Hot accretion flows can be seen in the population of supermassive black holes in galactic nuclei and during quiescent of accretion onto stellar-mass black holes in X-ray transients (e.g., Lasota et al. 1996; Esin et al. 1997, 2001; Narayan et al. 1998a; Menou et al. 1999; Di Matteo et al. 2000; see Narayan et al. 1998b; Melia and Falcke 2001; Narayan 2002; Narayan and Quataert 2005 for reviews). *Chandra* observations provide tight constraints on the density and temperature of gas at or near the Bondi capture radius in Sgr A* and several other nearby galactic nuclei. Tanaka and Menou (2006) exploited these constraints (Loewenstein et al. 2001;