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MODEL OF ACCRETION FLUX IN THE PRESENCE OF MAGNETIC FIELD

K.Iankova, L.Filipov

Space Research Institute-Bulgarian Academy of Sciences

Abstract
We consider a geometrically thin disk. The material accretes on a star with magnetic field. We study the MHD behaviour of the disk-magnetosphere system and their interaction. Are these conditions related to corona generation?

1. Introduction

Quite often, accretion on a magnetic star is accompanied by a corona. The observations reveal hard X-ray of the corona and soft X-ray of the cold disk incorporated in it. The presence of a corona and the magneto-hydrodynamic (MHD) processes in such a system is considered by a number of authors, such as [1,2,10]. Other authors study a disk-magnetosphere system (DMS) without a corona [4,5,9]. Our objective is to reveal the possible continual transition between these models.

2. Formulation of the problem

Let us consider the second case, i.e. a thin disk (H<<r) in the presence of magnetic field (MF), where H and r are corresponding half-thickness of disk and the distance from the rotation axis z (DRA). We shall choose dipoler MF, which is normal to the plane of disk and we shall use cylindrical coordinates (r, φ, z).

$$(1)\qquad r\frac{\partial\Sigma}{\partial t}+\frac{\partial}{\partial r}(r\Sigma v_r)=0,$$

$$(2)\qquad \frac{\partial v_r}{\partial t}+v_r\frac{\partial v_r}{\partial r}-\frac{v_\varphi^2}{r}=-\frac{1}{\Sigma}\frac{\partial P}{\partial r}-\frac{\partial\Phi}{\partial r}\quad ,$$

(3) $$r\frac{\partial}{\partial t}(\Sigma\omega r^2)+\frac{\partial}{\partial r}(r\Sigma v_r\omega r^2)=\frac{\partial}{\partial r}(r\Sigma\vartheta r^2\frac{\partial\omega}{\partial r})+r^2B_zB_\varphi\ ,$$

(4) $$Q^+ + Q_{mag} = Q^-\ ,$$

(5) $$P = P_r + P_g + P_m\ ,$$

where v_r - radial velocity; $v_\varphi = r\omega$ is linear velocity on φ; Φ - gravitational potential; $\Sigma = 2H\rho$ is surface density; $\vartheta = \alpha v_s H$ - kinematic viscosity; $v_s^2 = P/\rho$ - sound velocity ; P - pressure (5); $B_r << B_z, B_\varphi$ are the field components; Q^+ - viscosity dissipation; Q_{mag} - magnetic dissipation; Q^- - radiative cooling.

This is a basic MHD equation of the model. In such a disk, as a result of the physical conditions, four layers with different accretion regimes are formed. The can be seen best in profile $v_r(r)$.

3. Profile of $v_r(r)$

1. $R > r > R_{co}$, where $\omega(R_{co}) = \omega_s$ [6]. In this layer, when we ignored the MF, because it is far enough we shall have time-dependent disk accretion (6).

(6) $v_r \sim t^{-1}r^{-0.25}$ or $v_r \sim t^{-1}r^{-0.4}$,

depending on opacity law $\chi(\rho, T)$.

2. $R_{co} > r > R_m$, where $\omega(R_m) = \omega_a$. Here, it is necessary to solve the full equations, taking into account the instabilities' influence on the parameters in layer [8,11].

There are alphenic waves in the layer, because the values of the velocity on the flow and the alphenic velocity are very close. These waves along with differential rotation are the reasons for the appearance on magneto-rotary instabilities of Balbus-Houly (BHI) and supersonic accretion – for thermal instability (TI).

3. $R_m > r > R_d$ where disk destruction starts when $Q_{mag}/Q^+ \sim 1$ [7]. The layer is viscously unstable. There, the MF (or ML) lines are closed, they press firmly the disk, forcing plasma to rotate like a solid, i.e. the equation do not dependent explicitly on time, but only through the changes

in MF. Therefore, the derivatives in (1)-(5) disappear and the parameters are expressed by r and α (7) only, where $\alpha = \alpha(B)$ [3].

$$(7) \qquad v_r \sim \frac{\alpha(B)r}{\alpha^2(B)+r^2}$$

4. The quick decrease of v_r corresponds to plasma motion along the ML.

4. Comments

Here, the basic laws and assumptions for the system's evolution are presented. The birth of the corona is directly related with the disk-magnetosphere interaction in layers 2 and 3. BHI creates MF in the disk and TI assists ML to emerge outwards until the field envelops the entire disk.

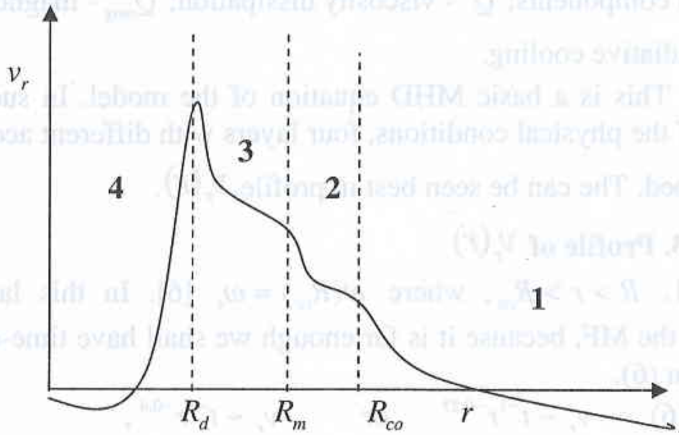

Fig. 1 Profile of $v_r(r)$.

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МОДЕЛ НА АКРЕЦИОНЕН ПОТОК В ПРИСЪСТВИЕ НА МАГНИТНО ПОЛЕ

К.Д.Янкова, Л.Г.Филипов

Резюме

Разглеждаме геометрично тънък диск. Веществото акрецира върху звезда с магнитно поле. Изследваме магнито-хидродинамичното поведение на системата диск-магнитосфера и тяхното взаимодеиствие. Свързани ли са тези условия с появата на корона?