§25. General Relativistic Jet Formation from Black Hole Magnetized Accretion Disks

Koide, S. (Toyama Univ. Eng.)
Shibata, K., Kudoh, T. (NAO)
Amano, T.

The radio observations have revealed the compelling evidence of existence of relativistic jets not only from active galactic nuclei (AGNs) but also from "microquasars" in our Galaxy [1]. It is believed that in the cores of these objects a black hole exists and magnetic phenomena occur near the black hole to form the relativistic jets [2, 3, 4, 5]. To simulate the jet formation in the magnetosphere, we have newly developed the general relativistic magnetohydrodynamic (GRMHD) code [6]. We report here the numerical result of the jet formation.

Our study is based on the general relativistic equations of conservation laws about mass, momentum, and energy of conductive fluids and Maxwell equations. We use the Schwarzschild metric, which provides the space-time around the black hole at rest. We employ *simplified total variation diminishing* (TVD) method. As the initial condition, we assume a transonic free fall corona and a relativistic Keplerian disk in the stable-orbit region with a uniform magnetic field.

Figure 1 shows the early stage of the jet formation when the disk rotates almost one cycle. The black region shows the black hole (inside event horizon, $r \leq r_S$). The disk loses its angular momentum due to the magnetic dragging and falls into the black hole. However the centrifugal barrier stops the advection-dominated flow between $2r_S$ and $3r_S$ (Fig. 1 (a), vector in Fig. 1 (b)). The high pressure region is produced in front of the barrier and pushes the plasma of the disk upward. The plasma is accelerated upward by both the gas pressure and the magnetic force of the oblique magnetic field (Fig. 1 (b)). In the nonrelativistic calculation, such structure of the jet formation is not found. It is remarkable even in the free fall corona of the non-rotating black hole a jet is formed from the disk very near the event horizon.

We thank M. Koide for her important comments for this study and also thank NIFS for the use of supercomputers.

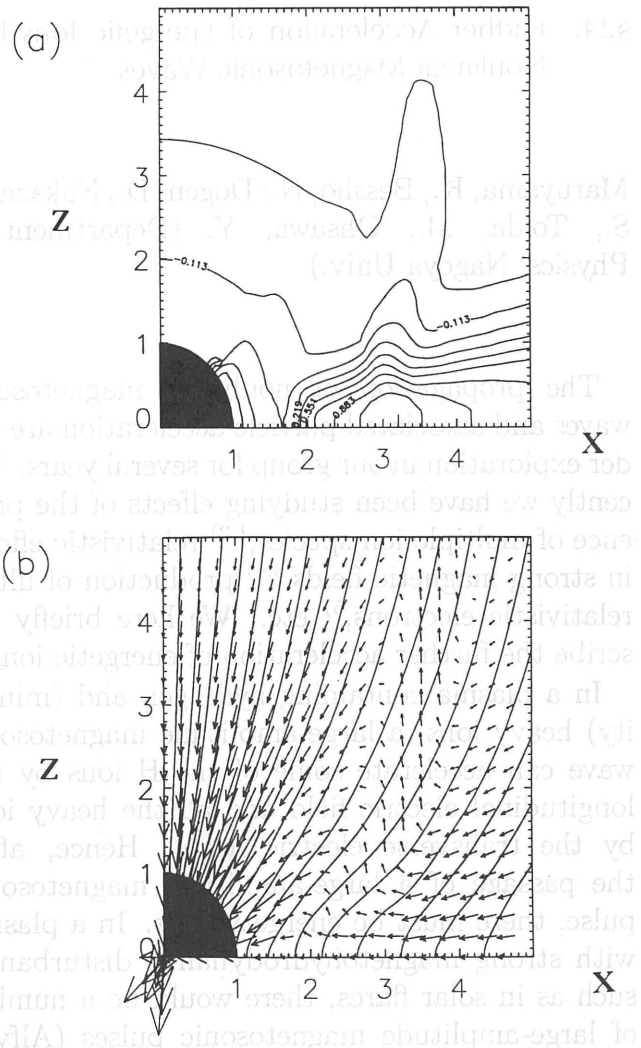

Fig. 1. A snapshot of (a) proper mass density in the logarithmic scale, (b) velocity (vector) and magnetic field lines (solid lines) in the early stage of the jet formation.

Reference

[1] Mirabel, I. F. and Rodriguez, L. F., Nature, **371**, (1994) 46.

[2] Blandford, R. D. and Payne, D. G., MNRAS, **199**, (1982) 883.

[3] Uchida, Y. and Shibata, K., PASJ, **37**, (1985) 515.

[4] Shibata, K. and Uchida, Y., PASJ, **38**, (1986) 631.

[5] Kudoh, T. and Shibata, K., ApJ, **476**, (1997) 632.

[6] Koide, S., Shibata, K., and Kudoh, T., ApJ, **495**, (1998) L63.