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THEORETICAL MODELLING OF ACCRETION DISCS IN CYG X-1 AND SGR A*’

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ТЕОРЕТИЧНО МОДЕЛИРАНЕ НА АКРЕЦИОННИ ДИСКОВЕ В CYG X-1 И SGR A*’

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Abstract: *The paper considers the magneto-hydrodynamics of a hot advection accretion disk. The interaction between plasma and magnetic field is examined. The appearance and activity of the instabilities in the flow is discussed. The results describing the 2D radial structure of the disk are shown. The development of the flow in the equatorial plane on disk is analyzed. The problem in the cases of binary system and AGN is discussed.*

Introduction

In this paper we use the results from theoretical 2D-model treatment in [3], [4], [6] for description of the processes in concrete real objects. We got the dimensionless functions of physical parameters of the magnetic disk and coefficients of periodicity k_φ and ω respectively, for the relations on development of characteristics with φ and t, from the dimensionless variable off the center x. The local wave numbers obtained in [2] is qualitative different from coefficients [7]. We will choose two well-known objects:

Cyg X-1 – invisible component of binary system (BS) in constellation Cygnet – candidate low massive black hole (BH).

SgrA*– probable representative of super-massive BH. Nucleus of our galaxy is not selected accidentally. This is most near to us object of that type.

The choice of this BS is not accidental, too. Cyg X-1 and more AGN have many mutual ait. In theirs spectra we find low and high state in X-ray range, reflection from inner regions of disk, K_α of iron, and γ-ray, too.

General intelligence for objects:

Cyg X-1 is in constellation Cygnet be away ~2,5kpc from the Earth. It is CBS – spectroscopic binary. Supergiant M ~20M_o and 9^m, class O9,7Iab and compact object M ~10M_o, who orbited with P ~ 5^d,6. We can observe lighting variation with selfsame period from stream gas HeII – mass transfer in the system. BH occupy substance stellar wind from the other component, who’s extreme near its Roche volume and through the orbital moment is formed Accretion Disk. Observations show and variable circular polarization, which also varies with the period of binary. It requires a magnetic source. Characteristic size of the field of BH coincides with Dyadosphere.

Cyg X-1 is highly variable X-ray and optical range of the spectrum, her periods ranging from milliseconds to years. Its X-ray luminosity is of the order of ~2-8.10^{27}erg s^{-1}. 80 per cent of time is in quiet the state (soft X-ray ~ 2-20keV) and the rest in high (hard X-ray ~ 40-450keV). In the spectrum registered K_α line of iron from the outer part of the disc. There has been a reflection from inner radii in the outer regions of the disc. Received γ-ray with E> 100 κeV and short gamma bursts ~1MeV in the inner region is associated with the behavior of a hot e^--p^+ plasma (κT~400 κeV).

SgrA*: Milky Way is slightly active galaxy; type Sb or Sc on the Hubble. She contains about 400 billion stars. Her mass is ~$2.10^{11}M_o$, luminosity ~10^{44}erg s^{-1}, diameter ~ 30kpc, r_{balch}~700pc, height of the galactic disk ~300-500pc, distance between spirals 1,4kpc and the magnetic field ~$3,5.10^{-6}$G. Its center is located in the constellation Sagittarius. At the core are located two objects: SgrA West (thermal source) and SgrA East (nebula - a remnant of SN with non-thermal radiation). Emission in the region has a varied nature. Main contribution to the nearest IR, Opt and UV-radiation has rings of stars, a high energy cosmic ray's γ-ray coming from interactions in interstellar space, and soft γ-ray and X-ray (soft and hard) come from non-thermal Synchrotron radio-source SgrA*, which is associated with the compact object in the region HII of SgrA West and coincides with an accuracy of **±0,1''** a dynamic center of the **G**alaxy. In the spectrum of we registered Br γ-emission, which is associated with mini-spirals (spirally of? Accretion disk), K_α of diverse highly ionized elements from the outer edge and the line annihilation 511eV inside and 10keV emission from the shell (? corona) covering the region.

Results for the concrete sources and interpretation

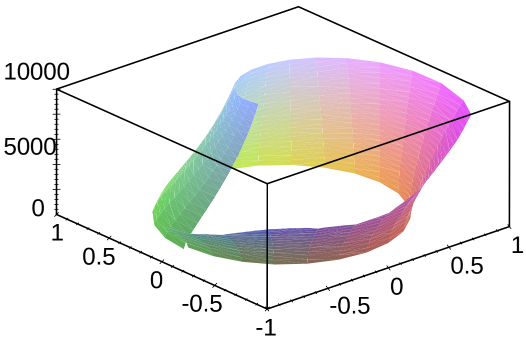
Here we will use the potentialities on the developed model at two concrete objects, representatives of low massive and super-massive BH.
We concur from observation, numerical results and simulations, initial values for the physical parameters of the accretion disks in our objects and we obtain their developments.

Rift in surface distribution of the density shows beginning of the spiral at x ~ 0.8 (Fig.1). Moreover, the increasing density manifested Non symmetric nature of the flow. (Fig.1a) shown how in the binary, the orbit rings obtained ellipticity and their center deviates from that of the disk (shifting). We observe similar behavior and in other object, but part of material this disc return back into the outer tor (or semi-tor).

Velocity of the flow is formed in two branches (Fig.2). Retarder inflowing and outflow. This only shows the presence of circulatory structures of micro-level, but unfortunately gives no information on their size. Feature is that in binary inflow and outflow in the disk becomes more intense than in galactic nucleus.

Figure 3: the sound speed also have two main branches across the disk. Judging by the upper branch for Cyg X-1 (3a) each ring has a full range of densely arranged gaskets. They could consider random disturbances (within error) if was not spinning in the sprigs surfaces, which connects them with the fast sound waves in the flow and respectively the various levels of local compaction.

In SgrA * (3b) we have two well-formed individual branches, which extend to the outer radius of Keplerian disk. Rings are formed without complementary gaskets.



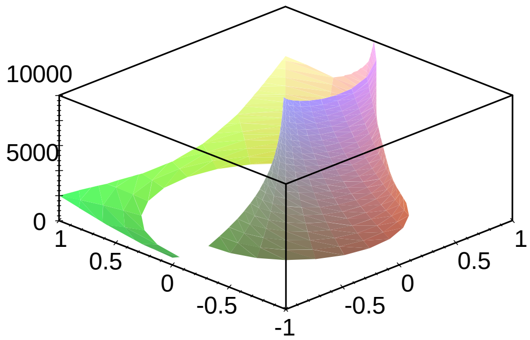


Fig. 1: f_1(X, Y) – dimensionless function of density distribution in non-axe-symmetric MHD model for Cyg X-1 (left) and for Sgr A* (right).

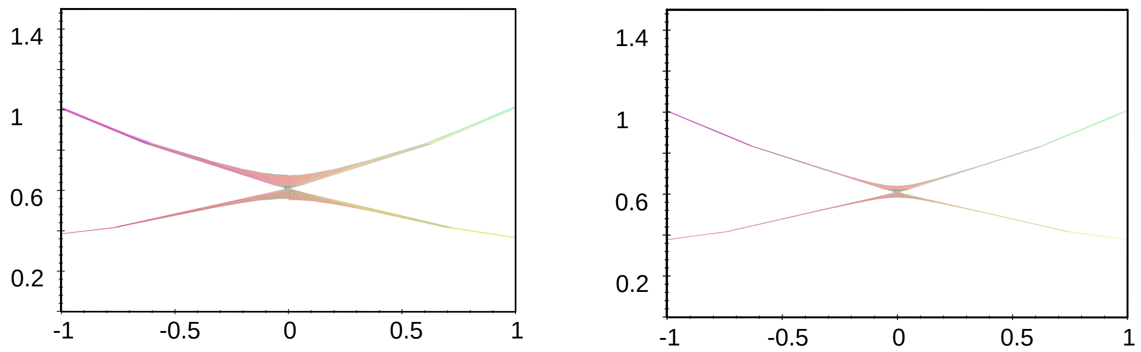


Fig. 2: That is a dimensionless function of radial velocity $f_2(X, Y)$ for Cyg X-1 (left) and for Sgr A* (right).

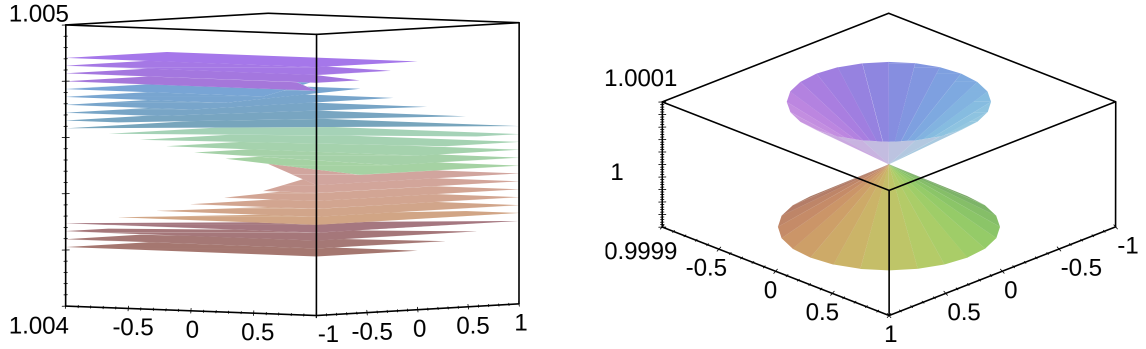


Fig. 3: That is a dimensionless function of sonic velocity distribution $f_3(X, Y)$ in the disc for Cyg X-1 (left) and for Sgr A* (right).

Fig. 4: B_r increases both inwards and outwards in both halves of the disc. Since preserves the same sign, such conduct shall be consistent with displacement of the center given density (1a, 4a). Function (4b) suggests the existence of groups MRN with different size (in levels 1~1.04, 9~11, 10^3~$4*10^3$…) and exchange of energy between low and high harmonicas in the spectrum sizes. In other words: fragmentation and consolidation with absorption of energy from the environment.

Fig. 5: for Cyg X-1 projection shows that the disk has many different sized loops - positive and negative (against the tide). Function did not show any clustering around discrete values dimensions, as we saw (4b). Unlike Sgr A *, where increasing by leaps (5b) support the idea inspired by the distribution of radial component.

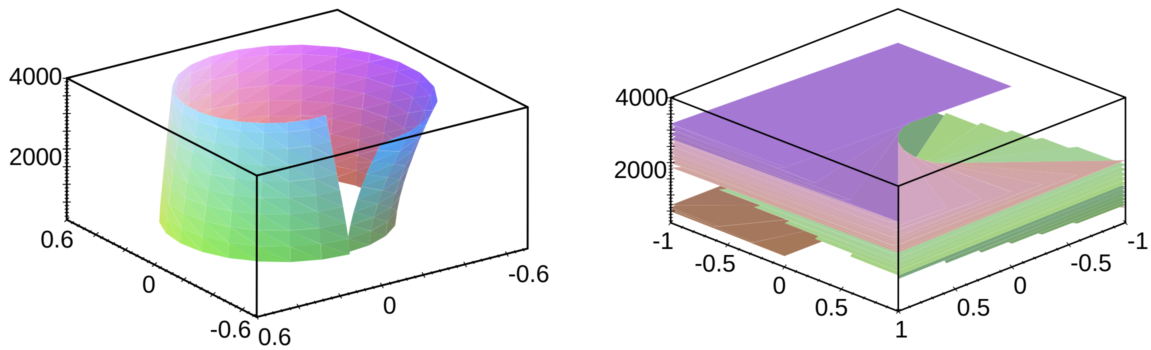


Fig. 4: That is a dimensionless function of radial component of the magnetic field distribution $f_5(X, Y)$ for Cyg X-1 (left) and for Sgr A* (right).

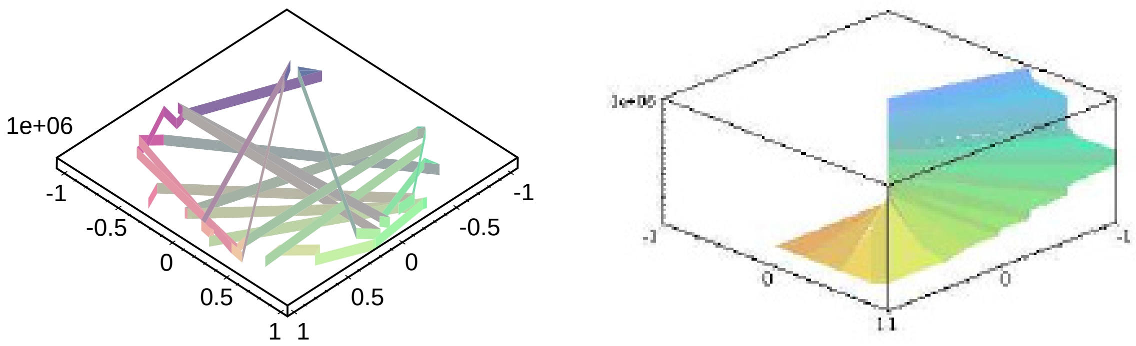


Fig. 5: That is a dimensionless function of azimuth component of the magnetic field distribution $f_6(X, Y)$ for Cyg X-1 (left) and for Sgr A* (right).

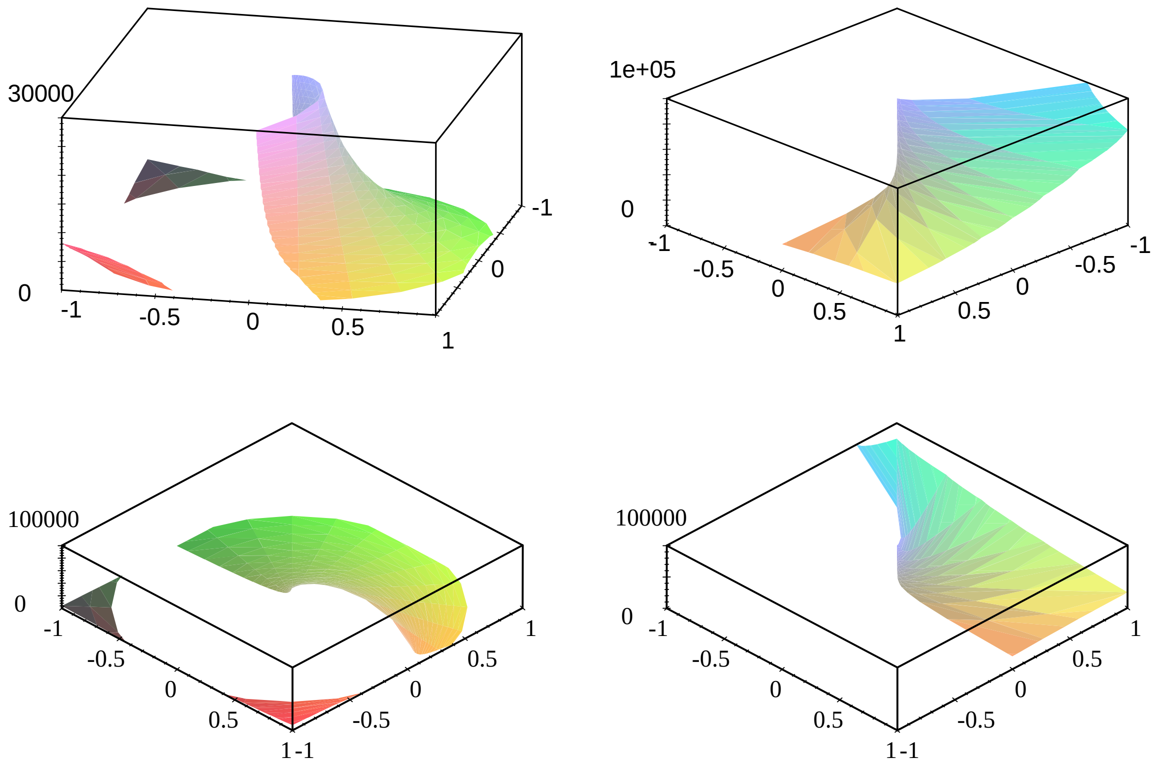


Fig. 6: That is a dimensionless function of the magneto-sound velocity distribution f(X, Y) for Cyg X-1 (left) and for Sgr A* (right).

Magneto-acoustic speed resembles the behavior of the radial field, but with an increasing asymmetry in the disk. FIG.6 (a)

Magneto-acoustic speed resembles the behavior of the azimuthally field, but increased smoothly. FIG.6 (b)

Conclusions

Main conclusions for the two sites, what we may make of these results are:

o The model enables to obtain a description of a specific subject without ignoring its individual characteristics, even in the event of similar processes can to see the differences. In Figure 1 in both the object appears spiral, but the overall behavior of the density is different in the two cases. In Fig. 2 is seen different intensity of accretion in two sources.

o Different densities in the layers of a ring in Cyg X-1 may lead to the formation of fluid lightguides and to ensure an advection and in a colder environment (not related to the natural processes of absorption and scattering in the disc, but with refraction of already formed radiation in the layers). While in SgrA * rings are formed without complementary congestion –

no lightguides. However there are formed accretion channels [see 5] – Feature of this disc is the fact that at different levels simultaneously realize and violates the condition for the existence of magneto-rotational instability. This helps a lot of substance to penetrate through equatorial window, because disc flow itself has a relatively colder component.

- Instabilities not only increase its linear dimensions, but they are consolidated and eating each other. Sign that are implement 2D turbulence [1]. View of sound and alfenova velocities and components of the field of SgrA * gives reason to believe that in part of the disk covered by the corona, if it is satisfied $\alpha_m\rho^{1/2} < v_a/v_s$ there are other preconditions for the emergence of magnetic Turing instability. So generate two-dimensional vortices whose dimensions could be grouped according to discrete values. Their consolidation leads to increased with leaps B_φ and v_a in 2D. Appear of magnetic-Turing instability in SgrA * shows that in this disc developed simultaneously as three-dimensional magneto-rotational instability associated with the instability of Parker and two-dimensional magneto-rotational instability associated with Turing-instability. Mechanism substantially is assured of enabling environment in which there are processes of accelerating particles.

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