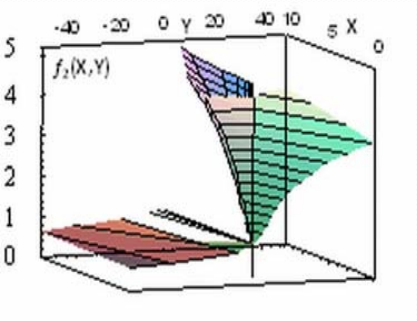
Theoretical modeling on the advective nature of magnetized accretion disk

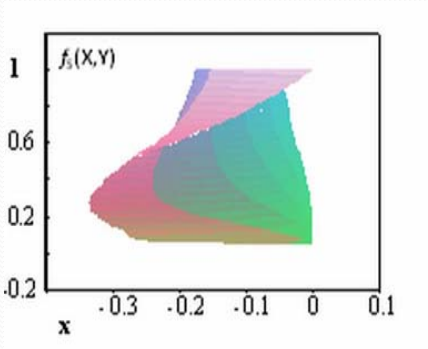
Krasimira Yankova
Space Research and Technology Institute - BAS
Acad G. Bonchev Str., Bl. 1, 1113 Sofia, Bulgaria
E-mail: f7@space.bas.bg

ABSTRACT

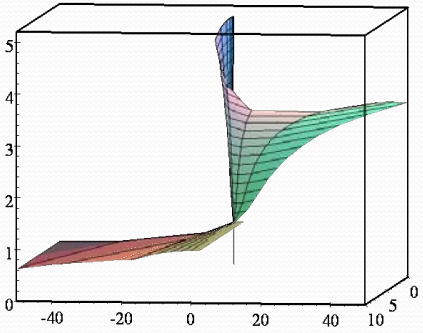
In this paper we are researching the structuring of the flow in the system disk-corona. We will analyze the interaction between stream and magnetic field. How does the new advective hypothesis and why this type of advection manifests itself only in the magnetic environment. Will discuss the importance of the factor dynamo for self-induction on advection in the disk.

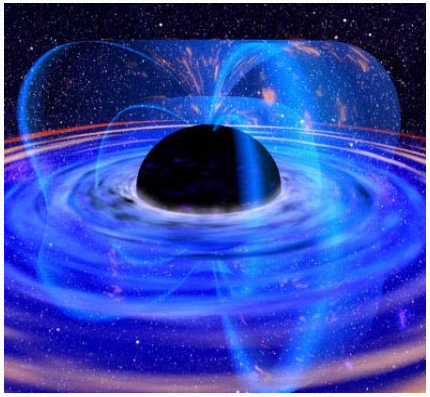
- *We have developed a new model of the accretion disc's magnetohydrodynamics, based on some specific advective hypothesis, presented in (Yankova, 2013). We constructed geometrically thin, optically thick, one-temperature Keplerian disc in a normal magnetic field, around a black hole. The results of the model, given in detail in (Iankova, 2007; Iankova, 2009; Iankova & Filipov, 2010), allow us to: observe the evolution of the disc; investigate the emergence of the disc's instability; study the generation of its corona (Figs).*



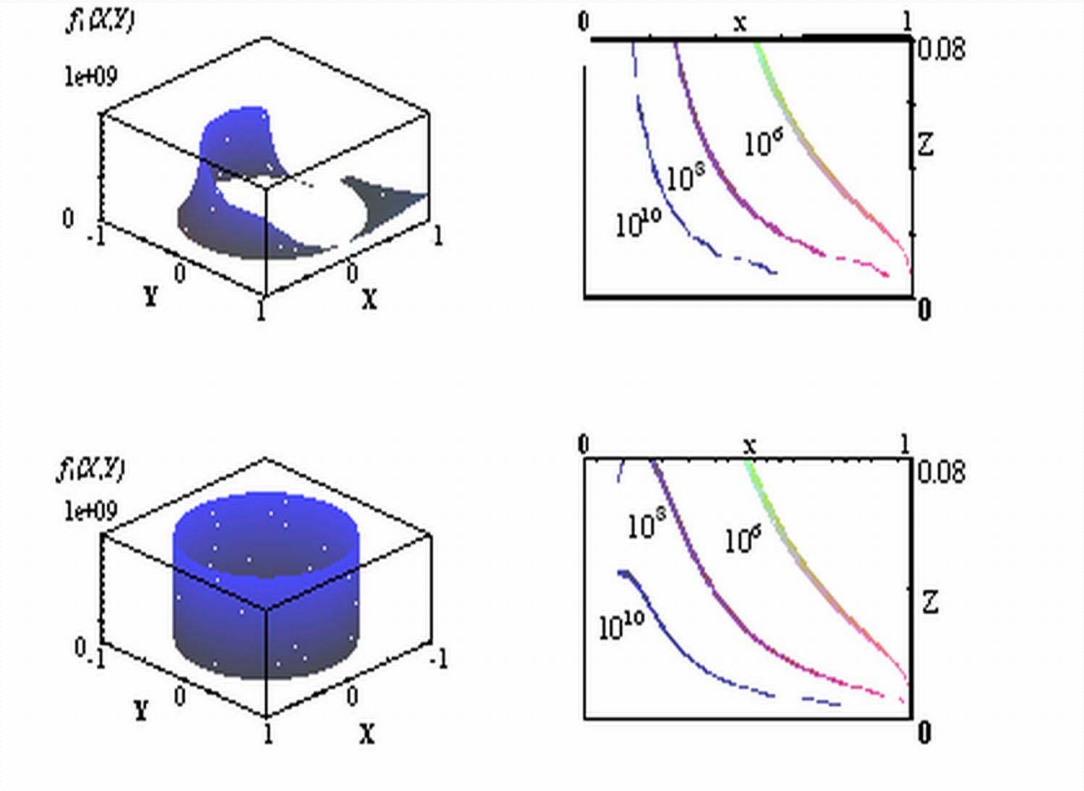


- *Many authors, have considered advective-dominated sub-and super-Eddington flows. The more popular models suggest a flow deformation, such as: 1) A rotation of the velocity vector - in the form of a sharp increase in the radial velocity and a significant decrease of the orbital velocity to sub-Keplerian values; 2) An orbital advection for low- magnetic discs, where the maximum speed of sound is dominated by the Keplerian rotation (Fabian et al. 2012).*
- *In our research, in contrast to these models, we provide the advection in the form of the complete advective term (1), which is naturally produced in the equations describing the flow dynamics:*





$$\frac{\partial(\rho v_i)}{\partial t} + \frac{\partial}{\partial x_j}(\rho v_i v_j) = \rho\left(\frac{\partial v_i}{\partial t} + v_j \frac{\partial v_i}{\partial x_j}\right) = \rho \frac{Dv_i}{Dt} \quad (1)$$



These advection shows there is no any increase of the radial velocity. The form of the complete advective term, doesn't indicate the individual modification of one or other of the velocity components. This means it arises a shifting of the average flow with velocity v_i in any direction.

In a case, when the advection is non-dominant mechanism, there isn't a condition of flow deformations. The full advective term transfers the solution as a whole. In contrast to the other models, no rotation or lengthening of the velocity vector appears here.

The physical meaning of the vector's rotation in models with radial advection, see (Beloborodov, 1999; Bisnovatyi-Kogan, 1998; Bisnovatyi-Kogan, 1999; Chen et al., 1997; Narayan et al., 1997; Narayan &Yi, 1995), is that the action of $\partial v_i / \partial t$ is ignored.

An orbital advection, by (Fabian et al. 2012), is a superposition of an orbital speed vector that is added to the Keplerian velocity. At this type of advection, the nature of the process requires the linearization in the model equations.

- *Magnetic reconnection - feedback (Papaloizou et al. 1997) one of the fundamental mechanisms associated with the structuring of space plasmas.*
- *MP the object can be its own central or external (galactic, from the donor). If its own field is located vertically to the plane of the disc, then moment in it grows inward toward the center. This effect can be compensated from powerful jets that lead the moment (Kuncic et al. 2004). But before reaching the central funnel, redistribution moment shall give an impact: Accelerated rotation releases higher amounts of energy, so by gradient of the entropy directly contributing to advection, and thus influence on the restructuring of the disk as an open system.*

- *In the powerful gravitational field of the black holes, the "complete term" type of advection (see the equation above) has the highest rate of probability to arise. During the disc's development in a normal dipole field, the term BrBφ of the equation of motion creates the conditions for the radial advection (Campbell et al.1998) in the flow. Thereby, we can unambiguously determine the direction of the disc's middle flow displacement. A radial pulling into a black hole with complete advection can lead the inflow speed to about the half of the free fall rate, without any weakening of the orbital rotation. In fact, exactly the opposite is true, when the redistribution of the momentum in a dipole field is accelerating the rotation. Then, the viscose and dynamic time-scales are comparable and they are shorter than the thermal scale. This way, the cooling process becomes inefficient. The above described conditions give rise to the self induces advection activity.*

- *The advection in similar conditions can work for relatively lower temperatures in the outer regions of the disc. The earlier advection appearances guarantee that the flow will remain optically thick at the temperatures of orders (1,2) which is higher than the normally accepted one.*

  The sign of the entropy determined the basic criterion for development, equilibrium and stability of the disc. If he does not cooling efficiently in time, energy is kept in disk in form of heat and reduces the radial gradient of entropy to the center. This is a prerequisite the disc to reach a new thermodynamic state, to remain globally stable and not be destroyed. This transition is irreversible. Instabilities in the disk is feeding by heating, absorb the excess free energy, thus is stimulate feedbacks in reshuffling the disk and instabilities become structures (vortices, spirals, corona). The effect is reinforced by the partial detention (slowdown) of the accretion, with due to such a distribution of angular momentum. Then advection helps for smooth transformation of the instabilities in the structures.
- *In the internal regions of the disc where the flow most difficult emits, advection carries the stored heat from the outer zones.*

- *The presence of a magnetic field contributes to efficient energy transfer from the ions to the cooler component. However, these disks are also difficult to cool because the field includes an additional mechanism of the OHM dissipation. This increases the efficiency of radial accretion by 1,5.*

- *Most of the accretors show that they have a magnetic field. This is evident in the polarization of light and the annihilation line in the spectrum. For rotating stars with magnetic fields the electro-dynamic force is a stream-collimator (Kaburaki 1999). Even, if initially the flow is spherically symmetric, very soon it concentrates to the equatorial plane forming an accretion disk.*

- *Gas motion in accretion disks is sufficiently spiral-like, so that a Zeldovich dynamo necessarily occurs. In the case of differential rotation and an oscillating field, the dynamo will self-regulate by means of MRI.*
- *3D-simulations indicate that MRI could support the central field even in a global model (Brandenburg & Subramanian 2004). The difference is that in such a regime the main field does not alter significantly, only losses are compensated for.*

- http://chandra.harvard.edu/photo/2003/bhspin/bhspin_comp.jpg
- http://chandra.harvard.edu/press/05_releases/press_101305.html

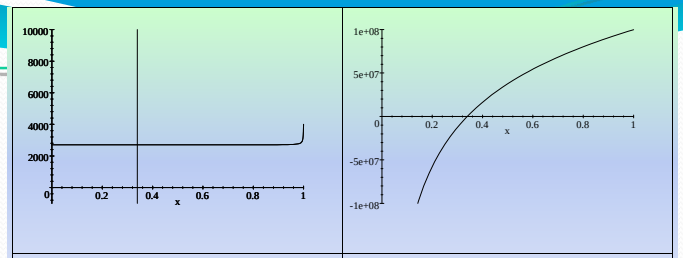
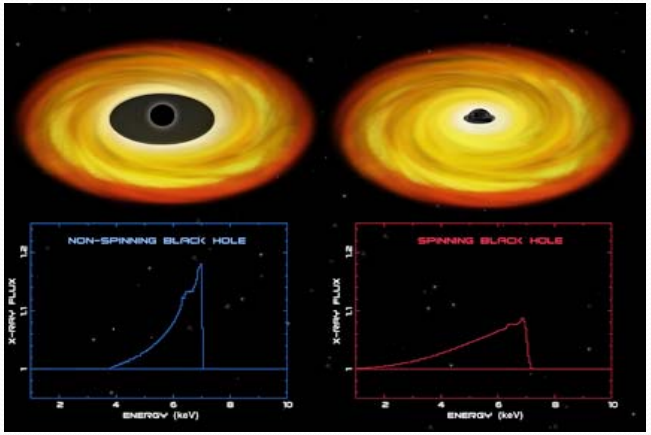


Figure 4: This is distribution of $v_s(r)$ over distribution $v_a(r)$. | This is distribution of $v_s(r)$.



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