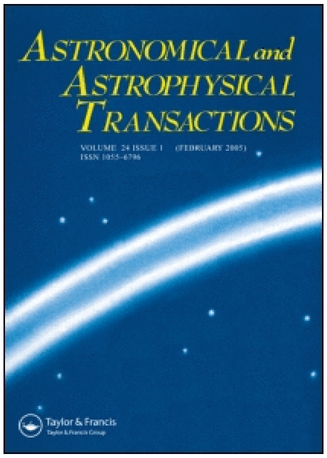

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SHEAR-LAYER INSTABILITIES IN ACCRETION DISKS AROUND MAGNETIZED COMPACT OBJECTS

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In the case of disk accretion onto magnetized compact objects (neutron stars and white dwarfs) the following situation may occur: the accretion disk material is rotating at the velocity of $|\mathbf{v}| = r\Omega \gg c_{s_{in}}$ (here $c_{s_{in}}$ stands for the sound velocity in the disk material), the disk being over-pressed by the rotating magnetic field having force lines parallel to the disk plane and transverse to velocity $\mathbf{v}$ direction (see Kundt & Rubnik 1980, Anzer, Borner & Meyer–Hofmeister 1987, Lipunov 1980). If the material penetrates into the magnetosphere, it becomes frozen into the magnetic field and rotates together with it at the velocity of $r\Omega_B$. Therefore the relative velocity of the material in the disk and magnetosphere may be supersonic ($|\mathbf{v}_o| = r(\Omega - \Omega_B) \gg c_{s_{in}}$) for a broad region of the disk and the thickness of transition layer from the disk to the magnetosphere is small compared to the disk thickness.

In the model being considered at least two types of instabilities may arise depending on the presence (or absence) of material in the magnetosphere, respectively: either magnetohydrodynamic instability of acoustic resonance type (Ferrari, Massaglia & Trussoni 1982, Hardee & Norman 1988), or the development of unstable surface modes of the interfaces between the disk material and the magnetic field in vacuum—the Kelvin–Helmholtz instability (Northrop 1956, Wang & Welter 1982, Lipunov 1978). For the first, contrary to the second, the development of a large number of higher (reflection) harmonics (the unstable modes of a waveguide) besides the fundamental pinching and bending modes is typical.

The following considerations seem to be important:

1. The growth rate of acoustic resonance type instability exceeds that of Kelvin–Helmholtz instability even if the density of the material in the magnetosphere is much less than the disk material density.

2. For both the instabilities in the model considered ($\mathbf{v}_o \perp \mathbf{B}_{ex}$) the external magnetic fields $\mathbf{B}_{ex}$ of arbitrary magnitude do not stabilize the most "dangerous" perturbations with wave vector $\mathbf{k} \parallel \mathbf{v}_o$.

3. A good qualitative agreement of the results obtained in the considered and the hydrodynamic ($B_{ex} \equiv 0$) cases allows us to use the results obtained by Hoperskov & Mustsevoj (1990) and to state that the presence of material only in a thin layer of the magnetosphere near the disk is essential for the instability of acoustic resonance type development, its growth rate being insensitive to the presence of material elsewhere in the magnetosphere besides this transition layer.

4. In the case of an accretion disk the non-linear growth of the fundamental bending mode perturbations must not lead to the initial flow disruption (unlike the jets—see Norman & Hardee 1988), since the material is in the potential well, hence the fluid particle motion in the transverse direction is finite.

One of the problems of the accretion into magnetized objects is the mechanism of the plasma penetration onto the magnetic field surrounding the accreting object. It seems the following scenario may be proposed. In the initial stage, when there is no material in the magnetosphere, the Kelvin–Helmholtz instability (as well as others—see Lipunov, 1987) may be the starting mechanism. As a result of its development, the material density in the magnetosphere regions close to the disk becomes finite, and the fundamental bending mode of the acoustic resonance type instability predominates, its growth rate being greater. If then the material density in the regions mentioned grows to values of the order of $\rho_{ex} \sim 2p_{in}/v_0^2$($p_{in}$ is the pressure in the disk), then short wavelength reflection harmonics of pinching and bending modes may arise, which, in turn, may cause the effective turbulization of the disk material due to appearance of the hierarchy of spatial scales and frequencies of perturbations.

References

1. Anzer, U., Borner, G., Meyer-Hofmeister, E. (1987) *Astron. Astrophys.*, **188,** 85.
2. Ferrari, A., Massaglia, S., Trussoni, E. (1982) *Mon. Not. R. Astr. Soc.*, **198,** 1065.
3. Hardee, P. E., Norman, M. L. (1988) *Astrophys. J.*, **334,** 70.
4. Hoperskov, A. V., Mustsevoj, V. V. (1990) Preprint Vol SU 5–90.
5. Kundt, W., Rubnik, M. (1980) *Astron. Astrophys.*, **91,** 305.
6. Lipunov, V. M. (1978) *Astron. Tsirk.*, **993,** 1 (in Russian).
7. Lipunov, V. M. (1980) *Astron. Jurn.*, **57,** 338 (in Russian).
8. Lipunov, V. M. (1987) Astrofizika nejtronnyh zwiozd.-M.: Nauka, 256 p. (in Russian).
9. Norman, M. L., Hardee, P. E. (1988) *Astrophys. J.*, **334,** 80.
10. Northrop, T. (1956) *Phys. Rev.*, **103,** 85.
11. Wang, Y. H., Welter, G. L. (1982) *Astron. Astrophys.*, **113,** 113.