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INTERSTELLAR MEDIUM INTERACTION WITH ACCRETING AND EJECTING STARS

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Global numerical modeling is performed of the stellar wind accretion onto stellar magnetospheres and the local interstellar medium (LISM) interaction with the solar wind.

The influence of radiative effects on the accretion onto stellar magnetospheres is investigated by performing global 2- and 2.5-dimensional simulations on the basis of high-resolution numerical schemes with the application of irregular grids adapted to the shape of the magnetopause. The latter is represented by an impermeable, contracted dipole magnetic field surface with polar holes. The physical model is based on the scenario suggested by Arons & Lea (1976, 1980). Accreting matter is assumed to be optically thin. The physical mechanisms which are taken into account include cooling due to free-free and free-bound transitions, the Compton heating via X-ray scattering on electrons, and the inverse Compton cooling in regions where the temperature of the matter becomes sufficiently large to be able to transfer part of its internal energy to photons. Depending on the determining parameters, both steady-state solutions with a system of discontinuities and unsteady flows with expanding shock waves can be obtained. It is shown that efficient cooling of the matter can substantially facilitate the penetration of the matter through the polar holes. The detailed consideration of the realistic radiative effects proved to be of great importance in our understanding of the accretion phenomenon, since they can substantially affect it both qualitatively and quantitatively. The influence is analyzed of the choice of different cooling functions on the accretion pattern.

In Figure 1 numerical results are shown for the star mass $M = 1.4\,M_\odot$, the accretion rate $\dot{M} = 10^{-9}\,M_\odot\,\mathrm{yr}^{-1}$, and the accretion efficiency $E = 0.1$. The characteristic size of the magnetosphere is $R_* = 3.52 \times 10^8$ cm. At $R_0 = 100\,R_*$, $GM/R_*U_0^2 = 200$ and $T_0 = 10^4$ K, where U_0 and T_0 are the velocity of the radial inflow and temperature. One can see a sharp temperature increase in the region where heavy elements become fully ionized. The flow behind the magnetospheric shock is readily Comptonized and accretes nearly isothermally. It is shown that the polytropic approximation used by Kryukov et al. (2000) gives only qualitative description of the phenomenon.

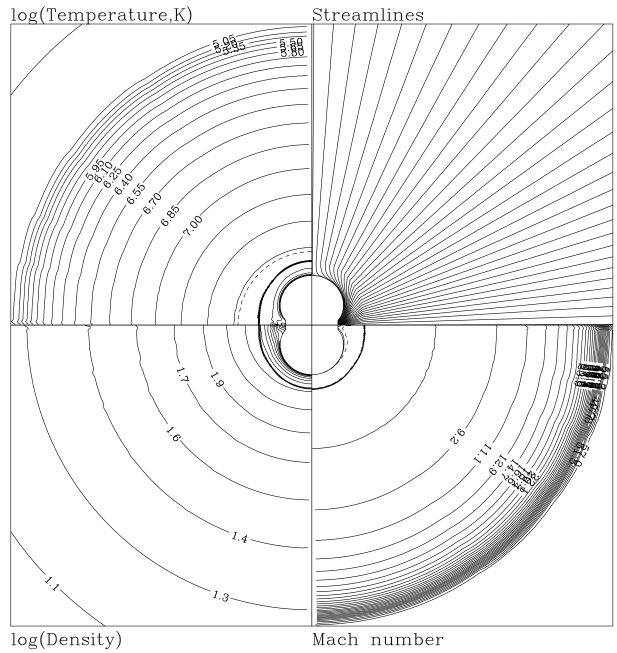

Fig. 1. Accretion pattern stipulated by the radiative cooling and Compton effects.

Analysis of the solar wind interaction with the nonuniform interstellar medium shows that the heliopause, dividing these two flows, is the subject of violent instability (Pogorelov 2000). As a result, clumps of hot rarefied solar plasma regularly penetrate outside, into cold and dense LISM.

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