MAGNETIC FIELD AND AMBIPOLAR DIFFUSION IN MOLECULAR CLOUDS AND PROTOSTARS

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1. Molecular clouds with magnetic field are places of contamporary star formation. Decoupling of magnetuc field from neutral gas is caused by ambipolar diffusion, rising in molecular clouds, when the ionization ratio, $x < 10^{-8}$.The ambipolar and Ohmic diffusion diminish magnetic flux in clouds with densities, $n > 10^5-10^6$ cm^{-3}, if the initial conditions for the contraction of clouds are extremely far from an equlibrium (Mouschovias 1987). For the initial force-free magnetic fields this happens in collapsing clouds with $n > 10^{10}-10^{14}cm^{-3}$(Dudorov 1984,1986; Nakano and Umebayshi 1986)

2. A linearized analysis of gravitational stability of magnetic molecular clouds carried out by two-component approximation has shown, that the ambipolar diffusion decrease the growth rate and critical wavelength λ_{cr} of disturbances, propagating across the magnetic force lines. THe gravitational instability may lead to formation of spherical protostellar clouds with dimensions $\lambda_{cr} \simeq \lambda_J$ (λ_J - Jeans wavelength). The relation of magnetic energy to gravitational one is $\mathcal{E}_m = 10^{-1}-10^{-2}$. If the gas clouds are ionized by XR or UV, diluted at densities, $n>10^4-10^6cm^{-3}$, the masses of protostellar clouds may be as large as several tens of solar masses. Cosmic rays allow the fragmentation, when $n > 10^8-10^{10}cm^{-3}$, so the masses of protostellar clouds are less than $10M_\odot$.

3. Dudorov (1984, 1986, 1988), Dudorov and Sazonov (1987) investigated numerically variations of magnetic flux during star fomation in frame of kinematic MHD-problem. The gravitational radiation MHD-equations were solved by computer code based on Lax-Vendroff method. Ambipolar and Ohmic diffusion terms are included in induction equation. For the magnetic field, $B(r,\Theta,t)=\{B_r(r,t)\cos\Theta,\ B_\Theta(r,t)\sin\Theta,\ 0\}$ and gas velocity $V=\{V_r(r,t),\ 0,\ 0\}$ variables in MHD-equations are separated, allowing to investigate with the one-dimensional numerical code the problems of magnetic flux and

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angular momentum.

4. The basic parameter of magnetic diffusion in molecular clouds and protostars is the ionization ratio, x. Calculations of x take into account collisional ionization and thermal ionization of some elements with low ionization potentials. The ionization rate is determined by cosmic rays, X-rays, ultraviolet radiation and radiactive elements. Recombination agents are the radiative recombination and recombination on the grains, which are evaporated if the temperature exeeds 1500 K.

Calculations show, that in regions of contracting clouds with density, $n \in [10^5 n_0 - 10^9 n_0]$, the magnetic diffusion develops with hydrodynamical velocities, where n_0-initial density. The lower density limit is determined by attenuation of ionizing radiation, the upper limit - by grains evaporation and by thermal ionization of trace elements. The strength of magnetic field on a stage of magnetic decoupling changes as B n^k, with $k > 0$. If the relation of magnetic energy to gravitational one, > 1 the magnetic braking leads to uniform rotation of protostars.

5. The fossil magnetic field of stars on the ZAMS is influenced by a flux of ionizing radiation, by a dust properties and by abundance of trace elements. For normal characteristics the fossil magnetic field is $B \sim n^k / \beta$, where $1/2 < k < 2/3$ and β - the decoupling degree. For stars with masses $M < 0.5\ M_0$ $\lg \beta \simeq 3-5$ and for stars with $M > 0.5\ M_0$ $\lg \beta \simeq 2-3$. The surface fossil magnetic field increases along the ZAMS from B_{fs}=10-20 G (F-stars) to B_{fs}=300-500 G (B-stars). The magnetic energy is $E_m = 10_{-1} - 10_{-2} E_g$ (E_g - gravitational energy).
The mean internal magnetic field is $B_f = 10^5 - 10^8$ G.
The interaction of fossil magnetic field with convection and buoyancy of small scale magnetic flux tubes may lead to the activity of T Tau stars.

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