FORMATION OF A PLASMA ENVELOPE

AROUND ROTATING MAGNETIZED PLANET

A. O. Soldatkin [(1)], Yu. V. Chugunov [(2)]

[(1)] Institute of Applied Physics of the RAS, 46 Ulyanov st., 603950 Nizhny Novgorod, Russia.
E-mail: soldatkin@appl.sci-nnov.ru

[(2)] As (1) above, but E-mail: chugun@appl.sci-nnov.ru

ABSTRACT

Self-consistent axis-symmetric model of a stationary rotating homogeneously conducting plasma envelope around the magnetized planet is analyzed taking into consideration the anisotropy of conductivity. A system of equations describing both effects of planetary gravity force, viscosity and Ampere force is considered in a case of weakly ionized plasma. The approach of strongly anisotropic conductivity is used. Obtained results can serve as a basis for qualitative explanation for a number of actual problems of plasmasphere physics. Under the terrestrial conditions these are superrotation at ionospheric altitudes, generation of the equatorial electrojet and the specific form of the plasma density distribution.

MODEL AND METHOD

System of electrostatics and magnetohydrodynamics equations is considered in case that medium mass velocity has an azimuthal component only. The case of weakly ionized plasma is discussed under assumption, that ionized component does not influence significantly on the neutrals density distribution. Equations describing the structure of the plasmaspheric flow, field, current and plasma density distributions are solved under the definite model of weakly ionized gas conductivity. This strong anisotropic conductivity model assumes, that electrons condition the plasma conductivity being “magnetized”, whereas ions are not “magnetized”.

In the case of strong anisotropy of conductivity the initial very complicated nonlinear system can be simplified, such approach allows to find a first integral of the new system. If the conditions of strong anisotropy and relatively weak viscosity are met it is possible to linearize the simplified system, assuming perturbations of the initial dipole magnetic field are small. The general solution of obtained linear system has been found.

RESULTS AND CONCLUSIONS

Considered solution of linearized system describes perturbations of dipole magnetic field, the profile of the angle velocity $\omega(r,\Theta)$, the distribution of conduction current and densities of neutral and ionized components of the medium. Detailed calculations are performed for partial case of the obtained solution, when angle velocity of plasma envelope is independent on polar angle Θ.

We emphasize the following main results concerning the phenomena of the Earth’s plasmasphere.

1. It has been shown that under considered approach there is the characteristic scale determining the size of a plasma layer, where the rotation is differential and the conduction current and perturbation of magnetic field are concentrated. Under the terrestrial conditions it is much smaller than the planetary radius.
2. The possibility of stationary superrotation of a plasma envelope in the presence of viscosity has been demonstrated in the framework of the self-consistent model.
3. It has been shown that taking into consideration the anisotropy of conductivity, the azimuthal conduction current runs in the planetary envelope. Such an effect can serve as one of the reasons of the equatorial electrojet generation.

The work has been supported by Russian Foundation for Fundamental Researches, grant No 02-02-17111