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Dayside magnetosheath properties related to the magnetic reconnection

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The ideal MHD model turned out to be a rather successful tool for reproducing the detached bow shock wave, as well as the behavior of plasma parameters in the magnetosheath region. But an ideal MHD model without any dissipation cannot explain the penetration of the magnetic field and plasma through the magnetopause, which is considered a tangential discontinuity. The goal of our work is to reconcile the MHD model of solar wind flow around the magnetosphere with the model of magnetic reconnection occurring at the daytime magnetopause. In particular, we discovered the dependence of the electric field at the magnetopause on solar wind parameters. For the magnetic reconnection region, we use the Hall MHD model with the Bohm-type resistivity in the diffusion region. In this case, the spatial change in resistivity is modeled by a Gaussian function. It is assumed that the reconnection line is directed along the electric current at the magnetopause. The steady-state structure of magnetic reconnection and the reconnection rate were determined as a result of the time relaxation of the numerical solution of the resistive Hall MHD equations. A series of calculations were carried out for various plasma betas in the inflow region just above the diffusion region. The reconnection rate was found to be a decreasing function of the plasma beta parameter. In the case of antiparallel magnetic fields, the reconnection rate has a maximum value of about 0.22 for very small betas and decreases monotonically to 0.13 when beta increases to 2. In the case of non-antiparallel magnetic fields, the reconnection rate smaller in a factor of sin(Θ/2), where Θ is the angle between the reconnecting magnetic field lines. The resulting reconnection rate as a function of the plasma beta parameter was used to match the reconnection region with the parameters of the dayside magnetosheath determined from the numerical MHD model of the solar wind flow around the magnetopause, which dayside shape was approximated by a hemisphere. A numerical MHD code based on the Godunov-type scheme was run for several Alfvén Mach numbers (5, 6, 8, 10). Finally, the resulting magnetosheath solution gives radial profiles of the ratio of the normal velocity to the local Afven velocity, plotted as a function of the local plasma beta parameter. This ratio should be equal to the reconnection rate calculated in the diffusion region for the same plasma beta. Using this condition, we find the magnetic field strength and electric field in the diffusion region depending on the solar wind parameters. In particular, for the southward IMF we find a maximum electric potential difference along the equatorial magnetopause about Φ_m=0.6 $E_{sw} R_m$ for a wide range of solar wind Alfven Mach numbers from 5 to 10. Here E_{sw} is the solar wind electric field ahead of the bow shock, R_m is the radius of curvature of the subsolar magnetopause. When the subsolar reconnecting magnetic fields are not antiparallel, but have an angle Θ, then the electric field is smaller by a factor of $\sin(\Theta/2)^2$ compared to the purely antiparallel case.

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