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Penetration of the interplanetary magnetic field into the planetary magnetospheres due to disruption of the near-magnetopause enhanced pressure layer

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It follows from the frozen-in condition that the IMF does not penetrate into the magnetospheres of planets, which possess their own magnetic fields (e.g., Mercury, Earth, Jupiter, Saturn, etc.). When the IMF is anti-parallel to the magnetospheric field, a thin layer of enhanced plasma pressure that forms near the magnetopause plays the role of a shield that prevents its penetration. The enhanced pressure layer (EPL) is interchange unstable due to magnetic field curvature and favorable pressure gradient. The instability growth time is about 1 minute [Alexeev and Maltsev, 1990; Rezhenov and Maltsev, 1994; Arshukova and Erkaev, 2000; Arshukova et al., 2002]. The EPL destabilizing leads to a violation of the frozen-in condition and penetration of the anti-parallel IMF into the magnetosphere. We have studied the non-linear stage of this process and estimated the rate of the penetration. At the stage under consideration, some filaments detach from the EPL and move away from the magnetosphere. The plasma flow continuity suggests counter-streams of colder plasma of the magnetosheath toward the magnetosphere. This colder plasma is heated near the magnetopause due to non-adiabatic processes, and the EPL restores. Again, it undergoes disruption and the whole process repeats. As a result, counter-streaming filaments permanently exist in the magnetosheath. The transverse size of the structures is expected to be several proton gyroradii. The plasma pressure in the hot filaments exceeds that in colder features by about $B^2/2\mu_0$, where B is the magnetic field in the magnetosheath. We estimate

the velocity of the hot filaments in the framework of colder plasma as $v_h = \pi v_A/8$, v_A being the Alfvén velocity in the magnetosheath. The colder plasma, when reaching the magnetosphere, has velocity $v_c \approx v_h/2 = \pi V v_A/16$. Therefore, a tangential electric field equal to $E_t = v_c B \approx \pi v_A B/16$ arises on the magnetopause. This value is quantitatively consistent with the observed penetration rate of the duskward interplanetary electric field into the Earth's magnetosphere.