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Constraints on the impulsive penetration mechanism for plasma entry into the magnetosphere

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"Impulsive penetration" has been proposed as a mechanism for plasma entry into the magnetosphere. Its basic premise is that a plasma blob with excess momentum can move across the magnetopause onto closed magnetospheric field lines. The physical mechanism by which this is possible, involves setting up a polarization electric field sustained by charge separation layers at the edges of the blob. The plasma blob is shielded from the environment it moves through by current-carrying interfaces.

It has turned out to be extremely difficult to build an accurate kinetic numerical model of impulsive penetration, since it requires a simulation geometry that is at least one-dimensional in space and two-dimensional in velocity space (in terms of parallel and perpendicular velocity). In addition, it really is a multi-scale problem that involves the fluid, the ion, and the electron scales. Not only the spatial resolution has to be very fine, but also the precision of the model has to be high so as to resolve the minute (order 10e-6) charge imbalance on the electron gyroradius scale at the edges of the penetrating blob.

In the present contribution we present results obtained with a fully kinetic slab model. This model is 3-dimensional in velocity space, but only 1-dimensional in coordinate space. It is based on the hypothesis that the blob is elongated along the magnetic field and in its direction of motion. Under these circumstances, the penetrating plasma can be regarded as a slab confined between two tangential discontinuities. This type of model is semi-analytic and can achieve a very high spatial resolution. As a consequence, it is able to model the charge separation effects very well. Given the known limitations on the stability of tangential discontinuities regarding shear flow, we draw some interesting conclusions about the impulsive penetration mechanism.

These theoretical results are then discussed in terms of the possibility to unambiguously identify the impulsive penetration mechanism in the magnetosphere.