Grad-Shafranov reconstruction of the in-plane magnetic field potential in the X-point vicinity: boundary-layer approximation

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The problem of steady symmetrical two-dimensional magnetic reconnection is addressed in terms of the EMHD approximation. In the immediate vicinity of the X-point, this approach has been proven to be an appropriate frame for the reconstruction problem, expressed, particularly, by the Poisson equation for the magnetic potential $\mathbf{A}$, where the right-hand side contains the out-of-plane electron current density with reversed sign. With boundary conditions fixed at some curve (the satellite trajectory), and assuming the right-hand side to be a function of $\mathbf{A}$, one arrives at an ill-posed problem for the Grad-Shafranov equation. The further simplification of the problem may be achieved by using the boundary layer approximation, since magnetic configuration in reconnection region is highly stretched. The benchmark reconstruction of PIC-simulation data, using four numerical techniques, has shown that the main contribution for inaccuracy arises from replacing the Poisson equation by the Grad-Shafranov one. A boundary layer approximation, in turn, does not affect the accuracy significantly; in some cases this approach can appear even the most appropriate.