Abstract Submitted
for the APR12 Meeting of
The American Physical Society

Transonic Flow in a Tokamak[1] ELIEZER HAMEIRI, Courant Institute-NYU, LUCA GUAZZOTTO, University of Rochester — Observed poloidal flow in tokamaks is of the order of the sound speed, multiplied by the ratio of poloidal/total magnetic field (the poloidal sound speed). At this range, the governing Grad-Shafranov (GS) equation changes its type twice: From elliptic near the center (low velocity) to hyperbolic in the region where the velocity is near the poloidal sound speed, then again to elliptic when the velocity is higher still. Previous work established the existence of a contact discontinuity across which the plasma density falls and the Mach Number increases. One problem with this is that the computation solves the GS equation as if it is elliptic. Moreover, a hyperbolic region never shows up, presumably because it is extremely narrow. These facts cast some doubt on the previous results. Here we consider this matter analytically. First, we construct a model problem having similar transitions of type as the transonic plasma equation. The model problem is solved analytically and indeed shows a hyperbolic region, as expected. Second, we treat the exact GS equation asymptotically, the small parameter being the ratio of sound to Alfven speed, which corresponds to the width of the hyperbolic region. We show that as this becomes very small, the hyperbolic region shrinks to naught, leaving no trace left over, so that solving the GS equation as an elliptic problem with a contact discontinuity yields the correct asymptotic approximation to the solution, thus validating the work of Ref. 1.

[1] L. Guazzotto, R. Betti, J. Manickam and S. Kaye, Phys. Plasmas 11, 604 (2004)

[1]Work supported by USDOE.

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Date submitted: 10 Jan 2012 Electronic form version 1.4