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How ions really flow to objects in magnetized plasmas

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A new exact, 3-D, analytic solution has been obtained of the drift equations for the plasma perturbation around an ion-collecting object of essentially arbitrary shape in a flowing strongly-magnetized plasma [1]. It provides a direct rigorous theory of magnetized Langmuir probes, especially Mach probes, and of other diverse plasma-object interactions. The cross-field flow is a combination of external drifts and self-consistent perturbation by the object. This convective calculation is valid for objects smaller than the characteristic size of turbulent plasma flow structures: the usual situation. The Mach probe calibration obtained agrees with prior diffusive theory, but now accounts for cross-field diamagnetic drifts, which are not ignorable. Their contribution is non-intuitive, in that the *electron* diamagnetic velocity is dominant. Consequently, transverse Mach probes measure a combination of ExB and diamagnetic drifts. The analytic fluid solution compares very favorably with numerical kinetic-parallel-distribution calculations [2]. And 3-D PIC calculations for a spherical object, accounting for finite gyro-radius, also verify its regime of applicability.

[1] I.H. Hutchinson, Phys Plasmas, 15, 123503 (2008)
[2] L. Patacchini and I.H. Hutchinson submitted to Phys Rev E.