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Flow, current, and electric field in omnigenous stellarators[1]

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An omnigenous magnetic field is one in which all collisionless drift orbits are confined. Omnigenity is a less restrictive condition than quasisymmetry, for a magnetic field can be omnigenous without being quasisymmetric [1], whereas all quasisymmetric fields are omnigenous [2]. Even though an omnigenous stellarator is generally fully three-dimensional, we have derived concise, explicit expressions for the bootstrap current, ion flow, and radial electric field in these devices in the long-mean-free-path regime [3], as well as expressions for the collisionality-independent Pfirsch-Schlüter current and flow in these devices. The radial electric field is determined in a manner that is consistent with intrinsic ambipolarity in the quasisymmetric limit. This electric field turns out to be independent of the details of the magnetic field geometry. The flow and current expressions involve only one more term than known expressions for quasisymmetric plasmas [2], but our results apply to a much larger class of stellarators. If the B contours of an omnigenous field close poloidally, the bootstrap current vanishes [3, 4]. As a result, the drive for MHD instability is reduced, and the magnetic field optimization is less sensitive to the pressure profile. Stellarators that are optimized for maximal alpha-particle confinement will be approximately omnigenous, so our analytic results may give new insight into the physics of advanced stellarators.

[1] J. R. Cary & S. G. Shasharina, Phys. Plasmas 4, 3323 (1997).
[2] A. Boozer, Phys. Fluids 26, 496 (1983).
[3] M. Landreman & P. J. Catto, Plasma Phys. Control. Fusion 53, 015044 (2011).
[4] P. Helander & J. Nuhrenberg, Plasma Phys. Control. Fusion 51, 055004 (2009).

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