FM19L_12979

XXI International Congress of Theoretical and Applied Mechanics
Warsaw, Poland, August 15–21, 2004

Dynamo Action in Steady Helical Pipe Flow

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This paper considers laminar flow of an electrically conducting fluid through a helical symmetric pipe driven by a steady pressure gradient. The possibility of spontaneous magnetic field generation is investigated. Two features of the helical geometry are favourable for dynamo action. Firstly, the helical symmetry automatically gives rise to a geometrical linkage akin to the alpha-effect, and secondly the steady pipe flow has a stagnation point structure in the secondary, cross-pipe component at moderate hydrodynamic Reynolds number. It is shown that growing modes, with the same helical symmetry as the underlying flow, can occur for moderate values of the magnetic Reynolds number, $R_m \simeq 100$. The structure of these modes is analysed asymptotically as $R_m \to \infty$, and found numerically. The calculations are continued into the nonlinear saturation regime. This is believed to be the first example of a steady, pressure-driven fluid dynamo. The work has relevance to contemporary experiments to construct a laboratory dynamo.

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