MHD Taylor-Couette flow theory for small magnetic Prandtl number and with Hall effect

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ABSTRACT

So far the magnetorotational instability (MRI) only exists in the supercomputer. In order to verify its existence in the laboratory a theory has been established for the marginal instability in MHD Taylor-Couette (TC) experiments. While the magnetic diffusivity of liquid sodium is of the same order of magnitude as that astrophysical plasma, its viscosity is much smaller. The resulting critical Reynolds number for the MRI is of order 10^6. At such values the hydrodynamic TC-flow may already be (nonlinearly) unstable so that the MRI may meet a medium with a turbulent magnetic Prandtl number. The consequences for MRI in protoplanetary accretion disks and in the laboratory are presented with particular interest to nonaxisymmetric and overstable solutions.

Also the consequences of the Hall effect for the magnetic TC experiment have been determined. Depending on the rotation law only one orientation of the external magnetic field in relation to the rotation axis provides instability. It is the first time that the sign of the magnetic field plays an important role in the theory of such MHD instabilities.