Abstract Submitted
for the DPP19 Meeting of
The American Physical Society

Magnetic Eddy Viscosity of Mean Shear Flows in 2D Magnetohydrodynamics: Possible Application to Gas Giants' Interiors[1] NAVID CONSTANTINOU, Australian Natl Univ, JEFFREY PARKER, Lawrence Livermore National Laboratory — Magnetic induction in magnetohydrodynamic (MHD) fluids at magnetic Reynolds number (Rm) less than 1 has long been known to cause magnetic drag. Here, we show that when Rm $\gg$ 1, and additionally in a hydrodynamic-dominated regime in which the magnetic energy is much less than kinetic energy, induction due to a mean shear flow leads to a magnetic eddy viscosity. We derive magnetic viscosity from simple physical arguments, where a coherent response due to shear flow builds up in the magnetic field until decorrelated by turbulence. The dynamic viscosity coefficient is approximately $B_p^2/(2\mu_0)\tau_{\mathrm{cor}}$, the poloidal magnetic energy density multiplied by the correlation time. We confirm the magnetic eddy viscosity through numerical simulations of 2D incompressible MHD. We also consider the 3D case, and in cylindrical or spherical geometry we find a nonzero viscosity whenever there is differential rotation. Hence, these results serve as a dynamical generalization of Ferraro's law of isorotation. The magnetic eddy viscosity leads to transport of angular momentum and may be of importance to zonal flows in astrophysical domains. For example, it may explain recent discoveries by Juno and Cassini regarding the depth that zonal flows reach inside Jupiter and Saturn.

[1]U.S. Dep. of Energy, contract No. DE-AC52-07NA27344

Navid Constantinou
Australian Natl Univ

Date submitted: 29 Jun 2019 Electronic form version 1.4