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Diffusion of magnetic field via turbulent reconnection

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The diffusion of astrophysical magnetic fields in conducting fluids in the presence of turbulence depends on whether magnetic fields can change their topology via reconnection in highly conducting media. Recent progress in understanding fast magnetic reconnection in the presence of turbulence is reassuring that the magnetic field behavior in computer simulations and turbulent astrophysical environments is similar, as far as magnetic reconnection is concerned. This makes it meaningful to perform MHD simulations of turbulent flows in order to understand the diffusion of magnetic field in astrophysical environments. Our studies of magnetic field diffusion in turbulent medium reveal interesting new phenomena. First of all, our 3D MHD simulations initiated with anti-correlating magnetic field and gaseous density exhibit at later times a de-correlation of the magnetic field and density, which corresponds well to the observations of the interstellar media. While earlier studies stressed the role of either ambipolar diffusion or time-dependent turbulent fluctuations for de-correlating magnetic field and density, we get the effect of permanent de-correlation with one fluid code, i.e. without invoking ambipolar diffusion. In addition, in the presence of gravity and turbulence, our 3D simulations show the decrease of the magnetic flux-to-mass ratio as the gaseous density at the center of the gravitational potential increases. We observe this effect both in the situations when we start with equilibrium distributions of gas and magnetic field and when we follow the evolution of collapsing dynamically unstable configurations. Thus the process of turbulent magnetic field removal should be applicable both to quasi-static subcritical molecular clouds and cores and violently collapsing supercritical entities. The increase of the gravitational potential as well as the magnetization of the gas increases the segregation of the mass and magnetic flux in the saturated final state of the simulations, supporting the notion that the reconnection-enabled diffusivity relaxes the magnetic field + gas system in the gravitational field to its minimal energy state. This effect is expected to play an important role in star formation, from its initial stages of concentrating interstellar gas to the final stages of the accretion to the forming protostar.