3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Turbulent dynamo in a weakly ionized medium

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The small-scale turbulent dynamo is an important process contributing to the cosmic magnetization. In partially ionized astrophysical plasmas, the dynamo growth of magnetic energy strongly depends on the coupling state between ions and neutrals and the ion-neutral collisional damping effect. A new damping stage of turbulent dynamo in a weakly ionized medium was theoretically predicted by Xu & Lazarian (2016). By carrying out a 3D two-fluid dynamo simulation, we for the first time numerically confirmed the physical conditions and the linear-in-time growth of magnetic field strength of the damping stage of dynamo. The dynamo-amplified magnetic field has a characteristic length as the damping scale, which increases with time and can reach the injection scale of turbulence after around eight largest eddy-turnover times given sufficiently low ionization fraction and weak initial magnetic field. Due to the weak coupling between ions and neutrals, most turbulent energy carried by neutrals cannot be converted to the magnetic energy, resulting in a relatively weak magnetic field at the end of dynamo. This result has important implications for the growth of magnetic fields in the partially ionized interstellar medium and shock acceleration of Galactic cosmic rays.

References

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