Magnetic Fields in Galaxies

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The large-scale magnetic field in the Milky Way galaxy has been estimated to have a mean strength of 6 μG, using measurements of synchrotron emission assuming equipartition between cosmic rays and magnetic fields [2]. One theory for the origin of these fields is the galactic dynamo, a mechanism in which a weak primordial field is amplified over time by converting kinetic energy into magnetic energy [1]. Simulations of dwarf and Milky Way–like galaxies support this theory, showing that initial seed magnetic fields can be amplified through dynamo action to the strengths observed in galaxies [3]. However, these models rely on the accuracy of the MHD codes themselves. This project aimed to investigate simulation results obtained using three magnetohydrodynamical (MHD) simulation codes—ART, RAMSES, and AREPO. Each code uses different numerical schemes to solve the ideal MHD equations. We simulated Milky Way–like isolated gas disks without stellar feedback using all three codes with the same initial conditions. Data from the simulations were analyzed and compared using Python packages such as `yt`. We observed a faster amplification of the average magnetic field strength in AREPO compared to the other two codes. Additionally, the magnetic field strength and gas density show a positive correlation with the divergence errors in AREPO. Building on these results, future work will focus on incorporating stellar feedback processes to assess their impact on magnetic field amplification and structure. We also plan to perform higher-resolution simulations to better quantify the effect of numerical divergence on field evolution.

References

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