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Structure Formation with Primordial Magnetic Fields: enhancing baryon fraction in halos

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Primordial magnetic fields (PMFs) can enhance matter power spectrum on small scales ($lesssim$ Mpc) and still agree with bounds from cosmic microwave background (CMB) and Faraday rotation measurements. As modes on scales smaller than Mpc have already become non-linear today, constraints on PMFs from the impact on small-scale structures require dedicated cosmological simulations. Here, for the first time, we perform a suite of hydrodynamical simulations that take into account the dissimilar impact of PMFs on baryons and dark matter. The form of initial conditions and their role is emphasized. We also highlight the large theoretical uncertainty in the peak enhancement of the matter power spectrum due to PMFs, which was not considered in previous studies. We show that PMFs can generate galaxies with baryon fraction several times larger than the cosmic average at high redshifts. This is simply a consequence of the fact that PMFs enhance baryon perturbations, causing them to be larger than dark matter perturbations. We argue that this scenario could help reconcile the large efficiency of gas conversion suggested by the first JWST observations and deserves further investigation.

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