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The generation of strong magnetic fields during the formation of the first stars

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Over the course of the last decade, a great deal of progress has been made in understanding the physical processes governing the birth of the first stars and their influence on later epochs of structure formation. These studies have ignored the possible role of magnetic fields primarily because the initial field strengths obtained from either cosmological processes like inflation and phase transition or astrophysical processes like the Biermann battery or the Weibel instability are highly uncertain. However, cosmological hydrodynamical simulations of primordial star formation suggest that the gas within the first star-forming halos is turbulent. This has strong implications on the subsequent evolution, in particular on the generation of magnetic fields via the small-scale dynamo. Using high-resolution numerical simulations, we show that in the presence of turbulence, weak seed magnetic fields are exponentially amplified by the small-scale dynamo during the formation of the first stars. The presence of the small-scale dynamo can only be identified in numerical simulations in which the turbulent motions in the central collapsing core are resolved by at least 32 grid cells. We conclude that strong magnetic fields are generated during the birth of the first stars in the universe, potentially modifying the mass distribution of these stars and influencing the subsequent cosmic evolution.

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