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Constraining Warm Dark Matter and Pop III stars with the Global 21-cm Signal

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Upcoming ground and space-based experiments may have sufficient accuracy to place significant constraints upon high-redshift star formation, Reionization, and dark matter (DM) using the global 21-cm signal of the intergalactic medium. In the early universe, when the relative abundance of low-mass DM halos is important, measuring the global signal would place constraints on the damping of structure formation caused by DM having a higher relic velocity (warm dark matter, or WDM) than in cold dark matter (CDM). Such damping, however, can be mimicked by altering the star formation efficiency (SFE) and difficult to detect because of the presence of Pop III stars with unknown properties. We study these various cases and their degeneracies with the WDM mass parameter mX using a Fisher matrix analysis. We study the mX=7 keV case and a star-formation model that parametrizes the SFE as a strong function of halo mass and include several variations of this model along with three different input noise levels for the likelihood; we also use a minimum halo virial temperature for collapse near the molecular cooling threshold. We find that when the likelihood includes only Pop II stars, mX is constrained to an uncertainty of ~0.4 keV for all models and noise levels at 68% CI. When the likelihood includes weak Pop III stars, mX~0.3 keV, and if Pop III star formation is relatively efficient, mX~0.1 keV uncertainty, with tight Pop III star-formation parameter constraints. Our results show that the global 21-cm signal is a promising test-bed for WDM models, even in the presence of strong degeneracies with astrophysical parameters.

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