CONSTRAINING WDM AND POP III STARS WITH THE GLOBAL 21 CM SIGNAL FROM THE LUNAR FARSIDE. J.J. Hibbard¹, J. Mirocha², D. Rapetti¹,2, N. Bassett, J.O. Burns¹, K. Tauscher¹
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Introduction: After the Epoch of Recombination, the early universe was filled with neutral hydrogen gas which cooled adiabatically as the universe expanded during the Dark Ages. The initial perturbations in the Dark Matter (DM) overdensities started to collapse into halos, forming deep gravitational potential wells. The neutral hydrogen gas then fell into these wells and began to collapse into the first stars and galaxies during what is known as the Cosmic Dawn. DM thus plays a central role in the timing and physics of these collapsing objects. One way to measure the global properties of DM is to measure the highly redshifted sky-averaged (global) 21-cm emission signal of the collapsing neutral hydrogen gas during these Epochs. Given the sensitivity of the global signal on the DM model, however, it is necessary for these experiments to be essentially free from systematics induced by the observational conditions. Thus, a radio telescope on the lunar farside, such as the NASA-funded CLPS experiment Lunar Surface Electromagnetics Experiment (LuSEE), will be able to place the first constraints upon these largely unmeasured epochs and probe the nature of DM [1].

Warm Dark Matter: 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 (nearly metal-free) with unknown properties.

We study these various cases and their degeneracies with the WDM mass parameter m_X using a Fisher matrix analysis. We study the m_X = 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 (low metallicity), m_X is constrained to an uncertainty of ~ 0.4 keV for all models and noise levels at 68% confidence.

![Figure 1: Graph showing the number of DM halos versus the halo mass for the three major cosmological epochs. The dashed and dotted lines are for WDM masses and exhibit a cutoff in the low-mass halo end, leading to a dampening of structure formation relative to CDM (solid lines) From [2].](image)

When the likelihood includes weak Pop III stars, m_X ~ 0.3 keV, and if Pop III star formation is relatively efficient, m_X ~ 0.1 keV uncertainty, with tight Pop III star-formation parameter constraints. Our results show that the global 21-cm signal is a promising testbed for WDM models, even in the presence of strong degeneracies with astrophysical parameters [2].

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References: