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Velocity Acoustic Oscillations on Cosmic Dawn 21 cm Power Spectrum as a Probe of Axion Dark Matter

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We investigate the feasibility of using the velocity acoustic oscillations (VAO) features on the Cosmic Dawn 21 cm power spectrum to probe small-scale density fluctuations. In the standard cold dark matter (CDM) model, Population III stars(The first generation stars) form in minihalos and affect the 21 cm signal through Ly-alpha and X-ray radiation. Such a process is modulated by the relative motion between dark matter and baryons, generating the VAO wiggles on the 21 cm power spectrum. In the axion dark matter models for which the number of minihalos is reduced, the VAO wiggles are weaker or even fully invisible. We investigate the wiggle features in the CDM with different astrophysical models and in different dark matter models. We find that (1) in the CDM model the relative streaming velocities can generate the VAO wiggles for broad ranges of there important parameters: the star formation efficiency, X-ray production efficiency, and the intensity of Lyman–Werner (LW) radiation, though for different parameters the wiggles would appear at different redshifts and have different amplitudes. (2) For the axion model with different mass, the amplitude of the VAO wiggles are also different. In the mixed model, the VAO signal is sensitive to the axion fraction. Therefore, the VAO signal can be an effective indicator for small-scale density fluctuations and a useful probe of the nature of dark matter. The Square Kilometre Array-low with ~2000 hr observation time has the ability to detect the VAO signal and constrain dark matter models.

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