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Cosmology at low frequencies: The 21 cm transition and the high-redshift Universe

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Abstract

Observations of the high-redshift Universe with the 21 cm hyperfine line of neutral hydrogen promise to open an entirely new window onto the early phases of cosmic structure formation. Here we review the physics of the 21 cm transition, focusing on processes relevant at high redshifts, and describe the insights to be gained from such observations. These include measuring the matter power spectrum at $z \sim 50$, observing the formation of the cosmic web and the first luminous sources, and mapping the reionization of the intergalactic medium. The epoch of reionization is of particular interest, because large HII regions will seed substantial fluctuations in the 21 cm background. We also discuss the experimental challenges involved in detecting this signal, with an emphasis on the Galactic and extragalactic foregrounds. These increase rapidly toward low frequencies and are especially severe for the highest redshift applications. Assuming that these difficulties can be overcome, the redshifted 21 cm line will offer unique insight into the high-redshift Universe, complementing other probes but providing the only direct, three-dimensional view of structure formation from $z \sim 200$ to 6.

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Contents

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