

THE 21-CM SPIN-FLIP TRANSITION AS A PROBE OF THE COSMIC DAWN

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The “spin-flip” hyperfine line of neutral hydrogen, with a rest wavelength of 21 centimeters, has a long and illustrious history in astronomical observations. Now, a new generation of low-frequency radio telescopes, operating at 50-200 MHz thanks to the cosmological redshift, is attempting to detect it during some of the earliest phases in our universe’s history, during the first generations of galaxies and black holes (now known as the *Cosmic Dawn*).

In this tutorial I will review some of the fundamental physics of the spin-flip transition during the Cosmic Dawn. I will discuss the physics of the intergalactic medium and the mechanisms that illuminate it in the spin-flip transition, especially its excitation temperature and the Wouthuysen-Field effect. I will then discuss some of the crucial properties of the luminous sources that determine the amplitude of the signal, as expected in state-of-the-art theoretical models, including the first stars, the first black holes, and high-redshift galaxies. Finally, I will briefly describe some of the tools available for predicting the properties of this signal.