Radio Recombination Lines at Decametre Wavelengths: Prospects for the Future

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This paper considers the suitability of a number of emerging and future instruments for the study of radio recombination lines (RRLs) at frequencies below 200 MHz. These lines arise only in low-density regions of the ionized interstellar medium, and they may represent a frequency-dependent foreground for next-generation experiments trying to detect H I signals from the Epoch of Reionization and Dark Ages ("21-cm cosmology"). We summarize existing decametre-wavelength observations of RRLs, which have detected only carbon RRLs. We then show that, for an interferometric array, the primary instrumental factor limiting detection and study of the RRLs is the areal filling factor of the array. We consider the Long Wavelength Array (LWA-1), the LOw Frequency ARray (LOFAR), the low-frequency component of the Square Kilometre Array (SKA-lo), and a future Lunar Radio Array (LRA), all of which will operate at decametre wavelengths. These arrays offer digital signal processing, which should produce more stable and better defined spectral bandpasses; larger frequency tuning ranges; and better angular resolution than that of the previous generation of instruments that have been used in the past for RRL observations. Detecting Galactic carbon RRLs, with optical depths at the level of 10^-3, appears feasible for all of these arrays, with integration times of no more than 100 hr. The SKA-lo and LRA, and the LWA-1 and LOFAR at the lowest frequencies, should have a high enough filling factor to detect lines with much lower optical depths, of order 10^-4 in a few hundred hours. The amount of RRL-hosting gas present in the Galaxy at the high Galactic latitudes likely to be targeted in 21-cm cosmology studies is currently unknown. If present, however, the spectral fluctuations from RRLs could be comparable to or exceed the anticipated H I signals.

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