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21 cm radiation: A new probe of fundamental physics

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Abstract. New low frequency radio telescopes currently being built open up the possibility of observing the 21 cm radiation from redshifts $200 > z > 30$, also known as the dark ages, see Furlanetto, Oh, & Briggs(2006) for a review. At these high redshifts, Cosmic Microwave Background (CMB) radiation is absorbed by neutral hydrogen at its 21 cm hyperfine transition. This redshifted 21 cm signal thus carries information about the state of the early Universe and can be used to test fundamental physics. The 21 cm radiation probes a volume of the early Universe on kpc scales in contrast with CMB which probes a surface (of some finite thickness) on Mpc scales. Thus there is many orders of more information available, in principle, from the 21 cm observations of dark ages. We have studied the constraints these observations can put on the variation of fundamental constants (Khatri & Wandelt(2007)). Since the 21 cm signal depends on atomic physics it is very sensitive to the variations in the fine structure constant and can place constraints comparable to or better than the other astrophysical experiments ($\Delta\alpha/\alpha =< 10^{-5}$) as shown in Figure 1. Making such observations will require radio telescopes of collecting area $10 - 10^6$ km^2 compared to ~ 1 km^2 of current telescopes, for example LOFAR. We should also

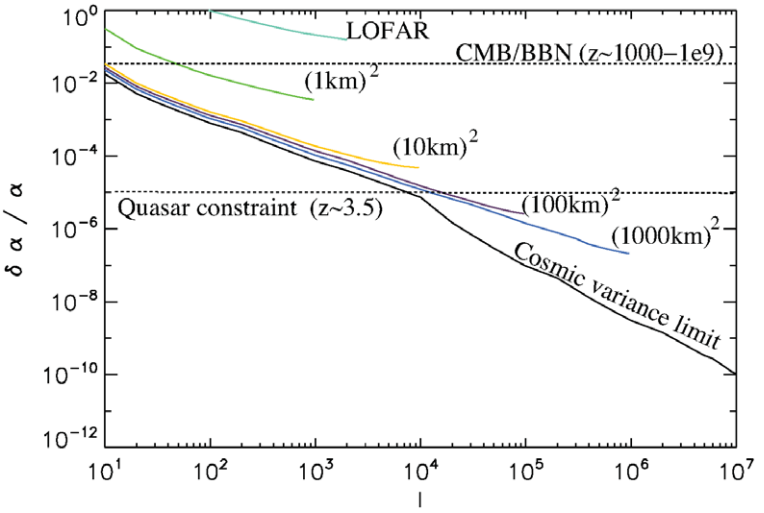

Figure 1. 21 cm constraints on α.

expect similar sensitivity to the electron to proton mass ratio. One of the challenges in observing this 21 cm cosmological signal is the presence of the synchrotron foregrounds which is many orders of magnitude larger than the cosmological signal but the two can be separated because of their different statistical nature (Zaldarriaga, Furlanetto, & Hernquist(2004)). Terrestrial EM interference from radio/TV etc. and Earth's ionosphere poses problems for telescopes on ground which may be solved by going to the Moon and there are proposals for doing so, one of which is the Dark Ages Lunar Interferometer (DALI). In conclusion 21 cm cosmology promises a large

wealth of data and provides the only way to observe the redshift range between recombination and reionization.

Keywords. Cosmology: early Universe, Radio lines: general, Cosmology:diffuse radiation

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