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# APSERa - an upcoming S-band cosmology experiment

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There are inevitable distortions in the CMB spectrum, including from the epoch of recombination (ERA) when the first atoms formed. These cosmological recombination lines are predicted to appear as broad, weak spectral distortions and are quasi-periodic ripples spanning a wide frequency range from 100 MHz to 3 THz. They have an amplitude of ~ 10 nK in the 2-6 GHz band, which is estimated to have the highest signal-to-noise ratio for ground-based detection [1]. A detection will help with understanding the thermal and ionization history of the early universe, verifying our models of recombination physics in early epochs during the formation of the first stable atoms. Fig. 1 shows the expected signal, which are cosmic recombination radiation (CRR) lines spanning a large range in frequency as predicted by CosmoSpec [2]. These appear as an additive distortion to the CMB blackbody spectrum, which is 9 orders of magnitude brighter.

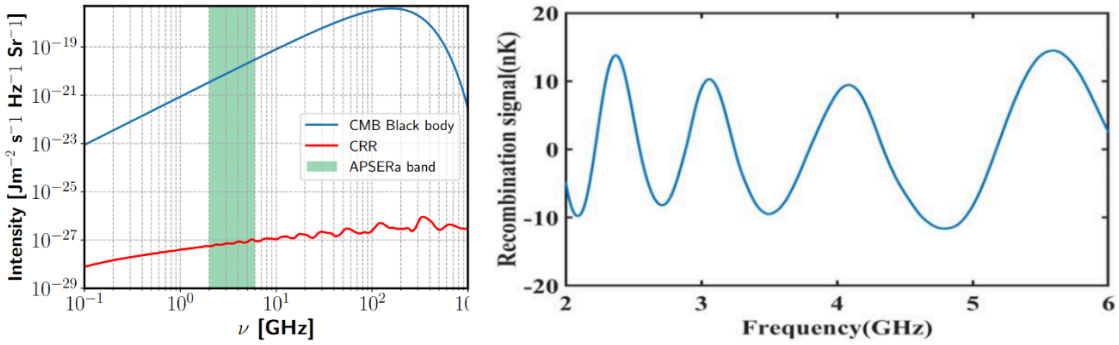


**Figure 1.** Additive spectral distortions from the CRR lines and the CMB black body spectrum intensities. The 2-6 GHz band for APSERa is shown (left). ERA signal expected to be detected as residuals in the APSERa band (right).

The Array of Precision Spectrometers for the Epoch of RecombinAtion - APSERa is an upcoming cosmological experiment to detect these lines over an octave band in 2-6 GHz where they have a peak-to-peak brightness temperature of ~10 nano Kelvin. In this talk, we will present the scientific motivation to detect the CRR lines from ERA and some recent developments, including antenna design [3], setup of a cryo-cooled receiver, and the digital processing backend. These subsystems will be integrated to form the first APSERa element, designed to have a sensitivity of 1 part per 1000 to 1 part per 10000.

1. Rao, M. S., Subrahmanyan, R., Shankar, N. U., & Chluba, J. (2015), "On the detection of spectral ripples from the recombination epoch", *The Astrophysical Journal*, **810(1)**, 3, https://doi.org/10.1088/0004-637X/810/1/3.
2. Chluba, J., & Ali-Haimoud, Y. (2016), "CosmoSpec: fast and detailed computation of the cosmological recombination radiation from hydrogen and helium", *Monthly Notices of the Royal Astronomical Society*, **456(4)**, 3494-3508, https://academic.oup.com/mnras/article/456/4/3494/2892008.
3. Sathish, K., Sathyanarayana Rao, M., and Sarkar, D. (2024), "Antenna Design for Absolute Sky Measurements at Gigahertz Frequencies—a First Step toward Detecting CMB Spectral Distortions from Recombination", *The Astronomical Journal*, **168(1)**, 39, https://doi.org/10.3847/1538-3881/ad4a74.