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Probing the Cosmic Dawn with the OVRO-LWA Stage III

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The highly redshifted 21 cm emission line from neutral hydrogen has the potential to reveal the temperature, density, and ionization fraction of the intergalactic medium (IGM) during the Cosmic Dawn, when the first stars and galaxies illuminated the universe. The upgraded Long Wavelength Array at the Owens Valley Radio Observatory (OVRO-LWA) has substantially improved its sensitivity to this cosmological signal at redshifts $z \approx 16$-100. We describe the array upgrade and preliminary results toward deep limits on the 21 cm power spectrum from the Cosmic Dawn.

The OVRO-LWA is a low-frequency radio interferometric array in California's Owens Valley. It consists of simple dual-polarization dipole antennas in a pseudo-random configuration designed to maximize *uv* coverage. The upgraded Stage III array has 352 fully cross-correlated antennas, 243 of which are arranged in a dense core. The remaining 109 "outrigger" antennas extend the array's longest baseline to 2.4 km.

The recent upgrade to the OVRO-LWA is the instrument's second major upgrade, bringing it into "Stage III" of operation. This work expands upon that that of [1], which used data from the array's previous Stage II to produce an upper limit on the 21 cm at $z \approx 18.4$. However, due to systematic limitations, that result does not meaningfully constrain cosmological models. We discuss three aspects of the instrument upgrade that improves the array's capability for 21 cm science:

1. The upgrade added an additional 64 fiber-fed outrigger antennas. The new antennas extend the array's longest baseline to 2.4 km and will improve imaging resolution and precision calibration.
2. The overhauled analog signal processing and digital backend improves channel isolation, significantly reducing instrumental cross-talk. Additionally, the upgraded signal path reduces signal reflections and a produces a bandpass response with improved spectral performance.
3. The adoption of state-of-the-art calibration and power spectrum estimation techniques improves foreground isolation and 21 cm sensitivity.

We present preliminary results showing the array's performance and sensitivity to the 21 cm signal, and we describe key improvements with implications for other 21 cm cosmology experiments, including the upcoming Square Kilometre Array (SKA). We then outline next steps toward achieving a constraining upper limit on the 21 cm power spectrum at $z \sim 18$ with the OVRO-LWA.

References

[1] M. W. Eastwood *et al.*, "The 21 cm Power Spectrum from the Cosmic Dawn: First Results from the OVRO-LWA," *Astron. J.*, vol. 158, no. 2, p. 84, Jul. 2019, doi: 10.3847/1538-3881/ab2629.