Interferometric Measurement of the Absolute Flux Density of Bright Unresolved Sources Below 100 MHz

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With increasing interest in radio astronomy at long wavelengths, there is increasing need for accurate estimates of the flux density and spectrum of bright sources; in particular for the "A Team" comprising the four brightest sources visible in the Northern hemisphere: Cyg A, Cas A, Tau A, and Vir A. Flux density models such as those described in Baars et al. (1977), Kühr et al. (1981), Helmboldt et al. (2007), and Scaife and Heald (2012) represent the state-of-the-art, but are inaccurate (errors O[10%] or greater) or inapplicable over segments of the frequency range of interest. The principal difficulty in making accurate measurements in this frequency range is isolating the source from the bright, diffuse, and poorly-known sky brightness temperature, and subsequent calibration of the antenna pattern and internal systematics. Ironically, the new radio telescopes developed over the past decade which are most likely to benefit from such measurements are themselves ill-suited to make them, due to a combination of limited angular resolution and poorly-known antenna patterns and systematics.

We are now engaged in a project to precisely measure the absolute flux density of the A Team calibrators over the frequency range of 30-80 MHz on a 5 MHz grid, with a goal of 1% accuracy. We have completed the development of a portable battery-powered two-element interferometer using thin dipoles that permits measurement on baselines up to 300 m ([30,80] λ at [30,80] MHz). The use of widely-spaced pairs of thin dipoles largely mitigates pattern, polarization, and mutual coupling uncertainty associated with more complex antennas. Sources are isolated from background flux and other sources by fringe rate filtering, and then calibrated to a relative scale using a combination of a priori measurements and parametric fitting to low-order models representing residual uncertainty in antenna pattern, ground effects, and impedance mismatch. Uncertainty is further mitigated by repeating measurements while varying baseline orientation. Absolute power density calibration is achieved using three-state (sky, active noise source, ambient temperature load) input switching. We have developed a new RF front end that delivers input-referred noise temperature of 700 K with 1 dB input compression point +11 dBm, which is greater by at least 20 dB than front ends currently in use by LWA, EVLA, or LOFAR. The front end is also protected by notch filtering from strong RFI associated with the Citizens Band (≈27 MHz) and the FM broadcast band (88-108 MHz), obviating the requirement to perform these measurements at sites with extraordinarily low interference.

In this talk we provide a technical description of the instrument, present commissioning data demonstrating the efficacy of the proposed measurements using the new instrument, and show results from the first round of single frequency measurements.