High Precision Calibration of Wide Bandwidth Observations with the Green Bank Telescope

Ronald J. Maddalena[(1)]
(1) National Radio Astronomy Observatory, Green Bank, WV, 24944, http://www.gb.nrao.edu

The NRAO Robert C. Byrd Green Bank Telescope (GBT) has the exceptional potential to observe over very wide bandwidths with unprecedented sensitivity. The clear aperture of the GBT should nearly eliminate the baseline structures introduced by the standing waves that plague the optics of more conventional telescopes. The data from a clear aperture telescope should have improved calibration accuracy since the telescope has a nearly theoretical beam shape with low spillover and with few chances for radiation to scatter. Yet, the traditional calibration algorithms are insufficient to make full use of this potential.

The receivers on the GBT cover from 290 MHz to 50 GHz with fractional bandwidths of 20-40%. The GBT Spectrometer provides a wide variety of spectral line observing modes, including a maximum instantaneous bandwidth of 3.2 GHz. A 14-GHz wide analog spectrometer is under development in collaboration with the University of Maryland. Thus, a single spectrometer observation with the GBT can cover not only the full band of most receivers but also a substantial fraction of the complete bandwidth of the GBT. The traditional calibration algorithms were developed at a time when the bandwidth covered by a spectrometer was a small fraction of the observing frequency. The assumptions of the traditional algorithms no longer apply to the wide bandwidth observations of the GBT. The algorithms provide calibration accuracies of no more than 10% and baseline shapes that make many kinds of science impractical.

This paper will present calibration algorithms that no longer assume narrow bandwidths and provide significantly improved baselines over those produced by traditional algorithms. To increase the accuracy of the calibration, I will present methods for determining highly accurate intensities for the noise diodes (the calibration source used for cm-wave telescopes), improved models for removing the affects of the atmosphere, and how one can improve the calibration by compensating for some non-linearities in the detection system. Most of these results are applicable to other cm-wave telescopes.