Unbiased Flux Calibration for Single-Dish Telescopes Using Advanced Observing Techniques

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In recent years radioastronomical receiving systems have seen huge improvements in terms of bandwidth and back-end processing capabilities. As an example, the new K-band receiver that is currently under test at the Effelsberg 100-m radio telescope provides 8-GHz of instantaneous bandwidth and, using stacked FPGA-based FFT spectrometers, a total of more than 1 million spectral channels per polarization. While such new devices offer great potential to the modern observatory facilities, they also demand completely new data reduction software. On the one hand, the sheer amount of data produced needs sophisticated programming techniques to make use of parallel/distributed computing. One the other hand, for an accurate calibration, it must be taken into account that quantities like system temperature, T_{sys}, the intensity, T_{cal}, of calibration normals (noise diodes), and receiver and antenna gains are not constant over the large recorded bandwidth.

In Winkel, Kraus, & Bach (2012, Astronomy & Astrophysics **540**, 140) we introduced methods to incorporate frequency dependence into the flux calibration scheme for the widely used position- and frequency-switching techniques. They are based on modeling the quantity T_{sys} / T_{cal} using the raw input data. Primary calibration uses astronomical sources ("calibrators") to initially infer a value for T_{cal}. While this works completely fine for many cases, we realized, that bad weather conditions, which cause changes of T_{sys} on rather short time scales, make the resulting T_{cal} value subject to unacceptably high scatter.

We will present new procedures to improve on this shortcoming. Applying different observing schemes, like cross-scanning (in spectroscopy mode) allows to keep track of total-power changes and leads to a greatly improved determination of T_{cal} from primary calibrators. Compared to position switching, this is much less efficient with respect to observing time. However, it turns out that the target sources can still be observed using position switching using the calibration scheme proposed in Winkel, Kraus, & Bach. Building up a database of high-quality T_{cal} spectra as averaged from many different measurements and observing sessions would be beneficial.

Furthermore, other aspects of wide-band flux calibration will be discussed: (1) Antenna parameters (e.g., sensitivity, beam size, and efficiencies) vary with frequency – not only as a simple function of frequency, but the feed taper properties also change. (2) Doppler correction for the Topocentric-LSR frame conversion is affected by differential effects. (3) Atmospheric opacities must be taken care of in a frequency-dependent manner.