Should I worry about line features in my calibrators?

Sarah Wood - 2024-03-06 - Offline Data Reduction and/or CASA

An ALMA execution block usually involves observing a FLUX calibrator, a BANDPASS calibrator, and a PHASE

calibrator, along with the SCIENCE source in several spectral windows (SpWs), each characterized by a

specific spectral width and resolution. The raw data provides uncalibrated complex visibilities for each of

these sources, and the amplitudes of these visibilities must be scaled to reflect true physical units.

The process of absolute amplitude calibration involves comparing the visibilities of the FLUX calibrator with

a model. Typically, this model comprises a single power-law in frequency, fitted to fluxes measured over a

short time window, usually about a week or less from the science observations. These fluxes are

independently calibrated against solar system objects. ALMA offers online tools that automatically select the

data, conduct the fitting, and estimate the true fluxes at the observed science Spectral Windows (SpWs) for

FLUX calibrators. For a more detailed explanation, please visit https://almascience.org/alma-data/calibrator-catalogue.

Clearly, if the assumption of a single power-law spectrum for the FLUX calibrator is invalid, the interpolated

flux obtained under this assumption will be inaccurate. One potential reason for the departure of integrated

flux in a Spectral Window (SpW) from this hypothesis is the presence of spectral lines in the source's

spectrum. If these lines constitute a significant portion of the SpW, the flux calibration for that particular SpW

will be incorrect. It is important to note that in most observations, the BANDPASS and FLUX calibrators refer

to the same source. Therefore, assuming that this source exhibits a smooth, featureless spectrum is

essential for accurately determining the absolute flux density calibration and the relative channelized

spectral response in the SpWs. ALMA meticulously selects BANDPASS and FLUX calibrators to prevent such

issues, and occurrences where these calibrators exhibit spectral lines are exceedingly rare.

In contrast, the presence of spectral line features in PHASE calibrators, assuming their Signal-to-Noise Ratio

(SNR) meets the required criteria, and the assumed or inferred flux values of these calibrators, tend to have a

relatively minor influence on the calibration process. While absorption or emission lines associated with the

PHASE calibrator can introduce variability in visibility amplitudes across different frequencies, the impact of

this effect is typically negligible. Extended emission lines emanating from regions within the field of the

phase calibrator are less common, and their potential impact on the accuracy of gain calibration is only

significant if their spectral range covers a substantial portion of the SpW.

The reason for this lies in the calibration procedure, which remains agnostic regarding the spectral behavior

of PHASE calibrators. Since these source are quasars, there is a reasonable expectation that their spectra

resemble power-law distributions. Any deviations from this behavior should be scrutinized by the data

reducer. It's important to emphasize, however, that this assumption is not utilized in the calculation of any

amplitude calibration solutions.

The current data processing and delivery practice policy from the ALMA Data Management Group is to reobserve

in case of line features in either the BANDPASS or FLUX calibrators. These quasars are reported and

then excluded so they will not be used again as BANDPASS or FLUX calibrators. In exceptional

circumstances, the data could be useful for the science objectives regardless of the problem and they could

be delivered previous consultation with the PI. Due to the lack of impact in the amplitude calibration and the

possible negative impact on the phase calibration solutions, the current practice and recommendation is not

to flag the line features occurring in the PHASE calibrator.

Attachments

- Line-features-in-calibrators.pdf (445.00 KB)