Bima memo 50

COMMENTS ON SELF CALIBRATION AND FAST SWITCHING

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ABSTRACT

We briefly discuss the relative merits and problems of self-calibration and fast switching calibration for the BIMA a-array. Self-calibration is very successful for strong sources, but can lead to spurious results for small arrays of antennas if the source is weak or too complex. Fast switching between a source and a nearby calibrator can reduce the rms phase on baselines longer than few hundred meters. Switching times of a few seconds are desirable, but are inefficient.

1. Introduction

Measurements of atmospheric phase fluctuations on a 1 km baseline show RMS pathlength variations of 1 mm on 10 s timescales at millimeter wavelengths. The standard phase calibration is inadequate; modified observing and data reduction procedures are required for aperture synthesis at millimeter wavelengths on long baselines.

2. Self Calibration

A successful self-calibration depends on the strength and structure of the source. The best situation is obtained if there is strong unresolved structure so that we can self-calibrate using an interval shorter than the fluctuation time scale of the atmosphere. A strong, compact spectral line, such as the Orion SiO maser can be used to calibrate extended spectral or continuum emission in the band at the same time; or a compact continuum source, such as the Cygnus A nucleus, can be used to calibrate more extended structures. If a compact continuum source is embedded in strong extended structure, such as in SgrA*, it may not be possible to self-calibrate on a short time scale because the extended structure changes the phase of the visibility data, and using a longer time interval to average out the extended structure does not remove the atmospheric phase fluctuations. If the source is too weak, or too complex it is possible to produce false structures using self-calibration on data with large phase errors.

If self-calibration can not be used initially, it may still be useful to clean up an image once we have a good source model, either a model based on other data, or from an initial image obtained using a-priori calibration.

3. Fast Switching

Standard phase calibration using a nearby quasar is usually inadequate on long baselines. Fast switching between the source and a nearby compact continuum or spectral calibrator will reduce the atmospheric phase fluctuations if the effective distance between the source and the calibrator, $d = \sqrt{(h(s - s_0))^2 + (v\Delta T)^2}$ is smaller than the interferometer baseline, b , where h is the height of the turbulence in the direction of the source, and v the mean turbulent velocity over an interval ΔT (Holdaway and Owen, 1995; Wright, 1996). Both source and calibrator suffer atmospheric phase fluctuation given by the phase structure function $D\phi(b) = \langle(\phi(x + b) - \phi(x))^2\rangle$, where b is the interferometer baseline. After calibration, the phase fluctuations will be reduced if $d < b$. Assuming $h = 2$ km, a source-calibrator separation = 10 degrees, $v = 5$ m/s, and a switching time, $\Delta T = 1$ minute, these parameters imply $h(s - s_0) = 350$ m and $v\Delta T = 300$ m. In these conditions, atmospheric phase fluctuations will be reduced on baselines longer than about 460 m. A greater improvement is expected if the turbulence is closer to the antennas, or the mean turbulent velocity is smaller than assumed.

4. Conclusion

If the source is strong (SNR $>$ 1 in 10 s) and compact (0.4 to 0.″7) then self-calibration is better than fast switching. If the source is weak, or extended, then we must observe a quasar as often as possible. Alternating between source and calibrator every 2 min say, may not be good enough. Alternating between source and calibrator every integration may be too inefficient, and not much faster unless the calibrator is very close to the source; better to select a calibration interval which is reasonably efficient. At least observe a strong quasar every 30min to calibrate the relative phase of sidebands and spectral windows.

REFERENCES

Holdaway, M.A. and Owen, F.N., 1995, NRAO. Millimeter Array Memo 126.
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