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Direction-Dependent Effects in High-Dynamic Range WSRT Observations & The Availability Of SKA Calibration Beacons

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The WSRT is a very "dynamic range-friendly" instrument due to its design (equatorial mounts, stable beams & pointings, tiny closure errors), and is capable of achieving over a million dynamic range in a single 12-hour run with regular selfcalibration. Still, even the best WSRT maps show significant artifacts from direction-dependent effects (DDEs) that selfcal does not address. At 21cm, these are thought to be caused by pointing errors, tropospheric refraction, etc. The severity of WSRT's DDEs ranges from "luxury problem" (continuum observations) to "limiting factor" (spectral line work.)

I will present the results of a "differential gains" calibration of the field around the bright source 3C147. This achieves the same 1.5+ million dynamic range as regular selfcal with the NEWSTAR package (previous reported by Ger de Bruyn), while completely removing the off-axis artifacts associated with direction-dependent effects: http://www.astron.nl/dailyimage/index.html?main.php?date=20100215.

Surprisingly, a study of the differential gain solutions (http://www.astron.nl/dailyimage/index.html?main.php?date=20100223) suggests that the dominant source of direction-dependent errors in this particular observation is of global origin (i.e. not a pointing problem), and much stronger than we would expect from the troposphere! The DDEs show both a global amplitude and phase effect; the phase component is extremely well-fitted by a time-variable gradient over the array. We do not yet have an alternative explanation for the gradient (though this may well change by the time of the conference...)

Whatever the source of WSRT DDEs, this result is of extremely high relevance to SKA calibration. SKA will require precise estimation of DDEs, which in turn requires a grid of calibration "beacon" sources that can be used to fit for the parameters of beamshapes, ionosphere, etc. At higher frequencies, the availability of sufficient numbers of sufficiently bright beacons is a worry. Differential gain solutions around 3C147 show that even relatively weak (~10 mJy) sources provide enough S/N, thus significantly lowering the bar on potential beacons.

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