LOFAR/SKA Source Subtraction

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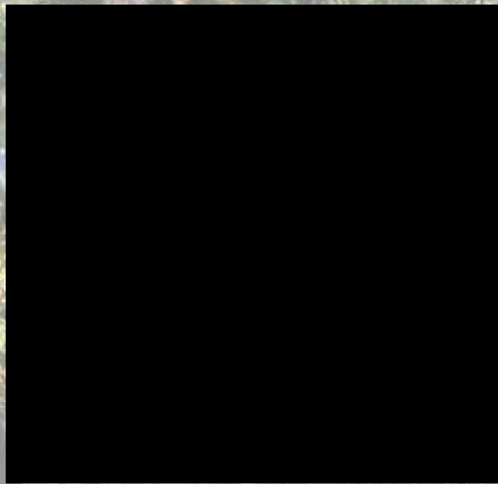
This (optical) image, made by ESO, *illustrates* some of the features of a typical LOFAR/SKA field. First of all, there are 3-5 very bright sources, which are important for ionospheric phase tracking, but which have to be subtracted with extreme accuracy. Secondly, up to 20 sources that are bright enough to be used to determine the 2nd-order ionospheric phase terms, and the shape of the main lobe of the station response beams. They are also subtracted individually. Thirdly, about 10.000 fainter sources, which are not used for calibration, and are subtracted in groups. In LOFAR/SKA images, the PSF pattern around the bright sources would be much more pronounced, and the PSF's of some sources in the far sidelobes of the station beams would also be visible.



Mosaic of residual facet images, after subtraction of all relevant foreground sources. The flux scale is the same as in the image on the left. One of the main science drivers for LOFAR/SKA is the detection of the Epoch of Re-ionisation. Any EoR signature will have to be distinguished from the many Cat III foreground sources that have not been subtracted, and from the remnants of incompletely subtracted Cat I/II sources.

Global Sky Model (GSM)

- One of the main LOFAR/SKA deliverables is a Global Sky Model, which contains models for all the sources that are detected during the lifetime of the telescope.
- The other main deliverable is a collection of residual images, from which all GSM sources have been subtracted. Both deliverables will be VO-compliant.
- The GSM is filled initially from existing catalogs, and updated continuously.
- Most source models will be parametrized (e.g. flux I,Q,U,V, position, shape, spectral index, intrinsic rotation measure, etc). Extended sources may be defined in terms of functions like gaussians, pixons or shapelets. All parameters are functions of time and frequency, just like the other parameters of the Measurement Equation. Any M.E. parameter can be solved for.
- The GSM also supports source models in the form of gridded images. This is useful for very extended sources, and collections of CLEAN components.
- Some RFI sources may be modelled as GSM sources.

Source Categories

- Cat I sources are so bright that they have to be subtracted individually, for maximum accuracy. Their parameters may be solved for.
- Cat II sources are all the other sources in the GSM that are relevant for a particular observation. For efficiency, they are subtracted in groups (patches), with somewhat limited accuracy.
- *Note that the distinction between Cat I and II is not an intrinsic source property, but a matter of choice. The difference lies in their treatment.*
- Cat III sources are too faint to be detected for inclusion in the GSM, and can therefore not be subtracted from the uv-data. Consequently, they are present in the residual image, convolved with a PSF which will be increasingly degraded towards the edge of the image.

Processing steps

- Solve for instrumental parameters (f,t) in the direction of Cat I sources, some of which may be in the far sidelobes of the station beam.
- Use these to derive interpolatable functions (l,m) for instrumental parameters like ionospheric phase screens and station voltage beam-shapes etc.
- If necessary, solve for Cat I source parameters (f,t) as well.
- Predict Cat I sources individually, using their own parameters for maximum accuracy, and subtract them from the uv-data.
- Predict Cat II sources in groups (patches), and subtract them from the uv-data.
- Make a mosaic of residual facet images, after correcting the residual uv-data for instrumental errors at the centre of each facet.
- Add the residual images to any already existing ones of the same area of the sky (EoR detection requires >100 hrs integration time).
- Analyse the integrated residual images to update Cat II source parameters, and to find new ones for inclusion in the GSM.
- Eventually, reprocess all uv-data with the final GSM. Then search for the EoR signature among the Cat I/II residuals and convolved Cat III sources.

An important question

- Source subtraction for LOFAR/SKA will be a very expensive process.
- In this context, a method to subtract a large number of sources without knowing their individual positions and fluxes would be very welcome.
- Does such a method exist, or can we prove that it is fundamentally impossible?

July 2004

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