LOFAR - The First Operational Precursor to the SKA

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Introduction

On June 12, 2010, the low frequency array (LOFAR) was officially taken into use. LOFAR is a phased array radio telescope covering the 10 – 240 MHz frequency range [1]. It is built in the Netherlands with extensions throughout Europe providing a maximum baseline of about 2000 km. LOFAR is the first operational astronomical facility based on phased array technology. It is also the largest and most complex radio telescope built to date and thus provides a first glance at future SKA issues. In this presentation, I give an overview of these issues and the routes that were taken or are being explored to mitigate them. I will highlight some of these techniques with some of LOFAR's early results.

System overview

LOFAR exploits two antenna types. The low band antenna (LBA) covers the 10 – 90 MHz frequency range and is designed as two orthogonal inverted V-shaped dipoles. The high band antenna (HBA), covering the 110 – 240 MHz range, consists of two orthogonal droopy dipoles. The HBAs are grouped in compound elements or *tiles*, in which the signals from 16 HBAs arranged in a 4×4 uniform rectangular array are combined by an analog beam former. The antennas are grouped in stations with on-site signal processing hardware to digitize the signals and perform initial processing such as spectral separation and beam forming. The station signals are sent to a central processing facility, which performs further processing and produces the astronomical data products.

Calibration and imaging challenges

LOFAR provides a first glance at future SKA issues, such as

- confusion limited wide-field high dynamic range imaging;
- dealing with direction dependent effects;
- a full beam forming and calibration hierarchy [2];
- fully automated on-line data processing to reduce the date stream to manageable proportions.

Many of these issues are resolved by introducing model based array signal processing techniques in the domain of radio astronomy.

Early results

In this presentation I will highlight several early results including recent imaging results with the full LOFAR array, all-sky imaging with a LOFAR station and successful pulsar observations. The data already look impressive but are only a glimmer of what is yet to come. It shows that we are on the right track towards the SKA, but still have a lot of work to do.

References

[1] Marco de Vos, Andre W. Gunst and Ronald Nijboer, "The LOFAR Telescope: System Architecture and Signal Processing", Proceedings of the IEEE, V97, no. 8, pp1431-1437, August 2009.

[2] Stefan J. Wijnholds, Sebastiaan van der Tol, Ronald Nijboer and Alle-Jan van der Veen, "Calibration Challenges for Future Radio Telescopes", IEEE Signal Processing Magazine, V27, no. 1, pp30-42, January 2010.