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PRESENTATION OF THE LOW FREQUENCY ARRAY (LOFAR)

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Abstract. The Low Frequency Array (LOFAR) is a multi-purpose, low frequency (10-250 MHz) sensor array. LOFAR is a radio-interferometer with most stations inside a 100 km disk and with longest baseline around 1500 km. It is based on relatively cheap and numerous stations across the Europe centred in the Netherlands and use real-time software correlation. Its main purposes are to study radio sky sources at these frequencies (including pulsar), transient phenomena, magnetism in the universe and to create an accurate sky model at these frequencies. Technical description of the array, as well as a description of its astronomical possibilities, are presented.

1 Introduction

Lofar (Falker et al. 2007) is a new generation radio telescope. It is an array of numerous (25000) and cheap antennas, connected directly through internet to a software correlator : LOFAR can be referred to a software telescope.

2 Description of the array

Each station is composed of tenths of Low Band Antennas (LBA) and of tenths of High Band Antennas (HBA). LBA are sensitive to the 10-90 MHz band and HBA are sensitive to the 110-240 MHz band.

LOFAR is composed from a core in the north part of the Netherlands, of some remote stations across the Netherlands and of some stations in the nearby countries (Germany, France, Sweden, United Kingdom).

Various baseline lengths start from several meters in the inner core to $\sim$ 1500 km between international stations. The angular resolution with only the Dutch array is between a few arc-seconds to a few tenths of arc-seconds depending of the frequency. Expected sensibilities will be around 10 mJy for the LBA and below 1 mJy for the HBA for 1 hour integration time.

3 Key science projects

LOFAR is mainly designed for 6 key science projects.

- Deep extragalactic surveys : LOFAR sensitivity and its possibility to observe many sources in the sky at the same time (through software created multi-beams) will create an accurate model of the sky at these frequencies, as well as it will bring insights in stars and galaxies formation at $z > 6$, intercluster magnetic fields, etc...
- Epoch of reionisation : The H1 line at 21 cm is in the frequency range of LOFAR at z between 6 and 11.5. As the reionisation epoch is known to start at $z \sim$ 15-20 and end at $z \sim 6$ (WMAP experiment, Hinshaw et al. 2009), LOFAR will be an excellent tool to explore this almost unknown period.
- Pulsars/transients : with the LOFAR μ-second time resolution, it is possible to observe pulsars and even to detect single pulses. As more and more stations will be available, sensitivity will increase and more pulsars and transient phenomenas (such as extrasolar planet bursts) will be detected and studied.

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- Solar physic and space weather : the study of the Sun will imply routine imaging, Solar burst mode triggering observations, joint observation campaigns of LOFAR with other ground- and space-based instruments and single stations used as spectrometers to monitor the Sun. As well, angular resolution of LOFAR will permit direct observations of the corona radio emission.
- Cosmic Magnetism : Faraday screens and rotation measure synthesis/Faraday tomography will be used to investigate the 3-D structure of local magnetic fields in the Milky Way and probe the magneto-ionic structure of the very local ISM surrounding the Sun. Spectro-polarimetry with LOFAR will allow the study of the so far unexplored domain of very small Faraday rotation measures and weak magnetic field strengths.
- Cosmic Rays : using self-triggered data acquisition boards, LOFAR offers a unique possibility for studying the origin of high-energy cosmic rays through the detection of air showers of secondary particles caused by interaction of cosmic rays with the Earth's atmosphere.

4 A French station

A French LOFAR station will be built at the radio observatory of Nancay. Beside the standard international LOFAR station (composed by an electronic back-end, 96 LBA and 96 HBA antennas), a non-standard equipment is under study.

This new equipment is made of 96 modules connected to the already existing back-end. Each module is composed by a ten antennas array, and is designed to observe frequencies below 85 MHz and especially below 30 MHz (where LOFAR stations are less sensitive).

5 Telescope time

A call for proposal was released with a deadline in September 2009. This call was mainly designed for the key science projects during the commissioning phase. During that time, any experiment useful for the commissioning of LOFAR can also be selected.

The commissioning phase will last until the release of a Global Sky Model which might be obtained later this year or early next year (beginning or spring of 2010). Other calls for proposal will be released afterwards for open time experiments.

To have more informations about LOFAR and the proposal submission, please contact lofarproposal@astron.nl or sciencesupport@astron.nl. The LOFAR project is still in commissioning phase so any technical, software, or science insight is welcome.

6 Conclusion

LOFAR is a new generation radio-telescope : its adaptability is provided by software created beams, buffer boards and real-time correlation and pre-processing. LOFAR is the first SKA precursor in the field.

It will give us new insights in galaxies formation ($z > 6$), cosmic magnetism, cosmic rays, transient phenomena and pulsars,... It will also give us a better understanding of radio-objects at its observing frequencies, widely unknown for now.

LOFAR is now in building and commissioning phase. All projects relative (or not) to the Key Science Projects are welcome.

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References

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