Enabling future low-radio-frequency astronomy with e-Science

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Introduction: Soon, the next generation of low-frequency radio telescopes will begin to deliver data capable of answering fundamental questions in astrophysics and astroparticle physics, but these data will arrive at a rate which we do not yet know how to handle. Dedicated effort is urgently required to determine how distributed global resources, enabled by GRID technology, can be used to ensure PPARC science is extracted from the data flow. Oxford scientists are playing a leading role in the design of next-generation radio telescopes like the Square Kilometre Array (SKA), but we need to be able to fund a student, proficient in computer science, to work with us as we develop skills in handling, visualising and distributing the data which is already in hand from existing interferometers and which will soon start to flow from SKA prototypes (Summer 2007 in the case of LOFAR).

The new capabilities of next-generation radio interferometers will make radio techniques central to the most significant discoveries concerning the physics of the Universe. The importance of *low-frequency* surveying is twofold: (i) the neutral Hydrogen (HI) line is redshifted into frequencies well below 1 GHz and (ii) at longer wavelengths one observes much more sky area in one pointing. For example, the SKA will, by 2020, measure the 3D positions of all of the $\sim 10^9$ massive galaxies in the observable Universe, yielding definitive answers to fundamental questions like the nature of dark energy. We must therefore meet the severe challenges of incorporating low-frequency radio datasets within e-science initiatives such as the International Virtual Observatory Alliance (IVOA) and AstroGrid. The scale of this challenge can easily seen by considering just the raw data rates of the SKA which even with severe time averaging (say over 10 sec timescales), and moderate (say arcsec) spatial resolution will easily reach the Petabyte per day level.

Supervision and collaborations: The research will be undertaken in the sub-department of Astrophysics at Oxford, supervised jointly by Drs Katherine Blundell and Steve Rawlings. We will benefit from a few key collaborations, namely: (i) with Professor Paul Jeffreys, the Director of the Oxford e-science Centre, whose input will be vital as we integrate our software and databases within the GRID infrastructure; (ii) with Dr Anita Richards, working for IVOA at Jodrell Bank Observatory, whose input will be vital as we integrate with IVOA/AstroGrid; (iii) colleagues in the USA, notably Dr Eric Greisen at the US National Radio Astronomy Observatory, who have pioneered the field of wide-field, low-frequency imaging of interferometric data, with whom we have worked closely on a number of projects; (iv) with the LOFAR team in the Netherlands and in the USA. The student will be expected to follow both graduate training at the Oxford e-science Centre and the normal graduate training programme in Astrophysics (providing the necessary background on PPARC-related physics).

Proposed Student Project: Oxford has been the largest international user of what is effectively a prototype of the next-generation radio telescopes: the Giant Metrewave Radio Telescope (GMRT) in India. While we have successfully made the first ever deep, low-frequency (200 MHz) images of the sky using the GMRT, this has only been achieved by accepting severe data loss and at the cost of a huge (human) time investment. We need to move from this position to an automated method of mapping the low-frequency sky which makes efficient use of the data, which can be run by non-expert remote users, and which can be adapted to the orders-of-magnitude larger data rates that the new-generation radio telescopes will deliver.

The student project will have the following components. First, consideration and adaptation of existing software (AIPS and what remains of AIPS++) to allow automation of analysis of GMRT Fourier (UV) data; this will yield a software package that can be run, via GRID enabled technology, at Oxford so that non-radio-expert astronomers can, for the first time, see the low-frequency sky with the 'Virtual Observatory'. Second, scientific exploitation of these techniques by automating searches for HI absorption which will pinpoint galaxies and quasars at redshifts 3–5 (with existing GMRT data), and, excitingly, at redshifts 5–10 (with LOFAR data). Third, development of techniques to adapt these methods for use with first LOFAR, and ultimately SKA, data streams.