The ATLAS Survey of the CDFS and ELAIS-S1 Fields

Emil Lenc[*]**, Ray Norris**
Australia Telescope National Facility
E-mail: Emil.Lenc@csiro.au, Ray.Norris@csiro.au

Andrew Hopkins, Rob Sharp
Anglo-Australian Observatory
E-mail: ahopkins@aao.gov.au, rgs@aao.gov.au

Minh Huynh
Infrared Processing and Analysis Center
E-mail: mhuynh@ipac.caltech.edu

Minnie Mao
University of Tasmania
E-mail: mymao@utas.edu.au

Enno Middelberg
Astronomisches Institut, Ruhr-Universität Bochum
E-mail: middelberg@astro.rub.de

Kate Randall
University of Sydney
E-mail: krandall@physics.usyd.edu.au

The first phase of the ATLAS (Australia Telescope Large Area Survey) project surveyed a total 7 square degrees down to 30 μJy rms at 1.4 GHz and is the largest sensitive radio survey ever attempted. We report on the scientific achievements of ATLAS to date and plans to extend the project as a path finder for the proposed EMU (Evolutionary map of the Universe) project which has been designed to use ASKAP (Australian Square Kilometre Array Pathfinder).

Panoramic Radio Astronomy: Wide-field 1-2 GHz research on galaxy evolution
June 2-5 2009
Groningen, the Netherlands

---

[*]Speaker.

1. Introduction

The first phase of the ATLAS (Australia Telescope Large Area Survey) project has surveyed a total 7 square degrees down to 30 μJy rms at 1.4 GHz and is the largest sensitive radio survey ever attempted. The survey has observed an area surrounding the CDFS (Chandra Deep Field South) and ELAIS-S1 (European Large Area ISO Survey - South 1) regions with the ATCA (Australia Telescope Compact Array). The survey areas were chosen to cover the Southern SWIRE fields, which have deep optical, near-infrared, and far-infrared (and in some parts of the field, deep X-ray) data, so that this combined SWIRE/ATLAS survey may be the most comprehensive multi-wavelength survey yet attempted.

The broad scientific goal of ATLAS is to understand the evolution of galaxies in the early Universe. The radio observations are important as they penetrate the heavy dust extinction found in the most active galaxies at all redshifts [1] and are particularly effective at detecting AGN buried within dusty galaxies (Figure 1).
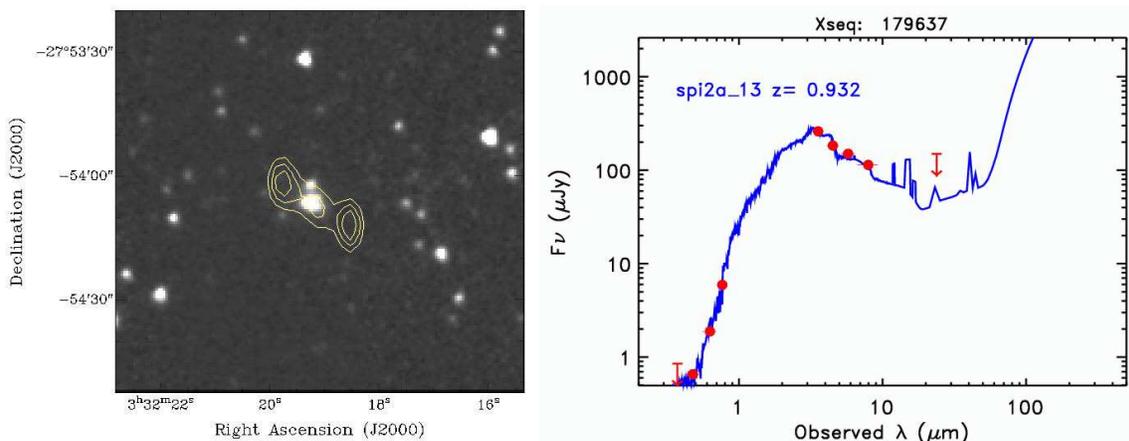

Figure 1: ATLAS contains unusual sources, such as these Powerful Radio Objects Nested in Galaxies with Star formation (PRONGS). These sources have the radio appearance of an AGN (left), but have a spectral energy density typical of classical star-forming galaxies (right), with no hint of an AGN [2].

2. Outcomes

The ATLAS team have already achieved the following:

- The first CDFS and ELAIS-S1 survey results have been published [3, 4].

- A new and unexpected class of object, Infrared-Faint Radio Sources (IFRS), have been discovered [3], catalogued and analysed [5], and observed using VLBI [6, 7].

- Discovered and explained a change in slope of the FIR-radio correlation at $S_{1.4} < 1$ mJy [8, 9].

- Discovered a z $\sim$ 0.2 cluster through the presence of a wide-angled tail ATLAS radio source [10].

• Begun analyses on the evolution of radio sources [11], and to optimise discrimination between AGN and star forming galaxies [12].

3. Current Status

The CDFS and ELAIS-S1 fields have been imaged down to 30 μJy rms at 1.4 GHz yielding a total of $\sim$ 2000 radio sources. Catalogues of these sources have been made publicly available through NED (the NASA/IPAC Extragalactic Database) and work is currently underway to provide VO (Virtual Observatory) access to the catalogues also.
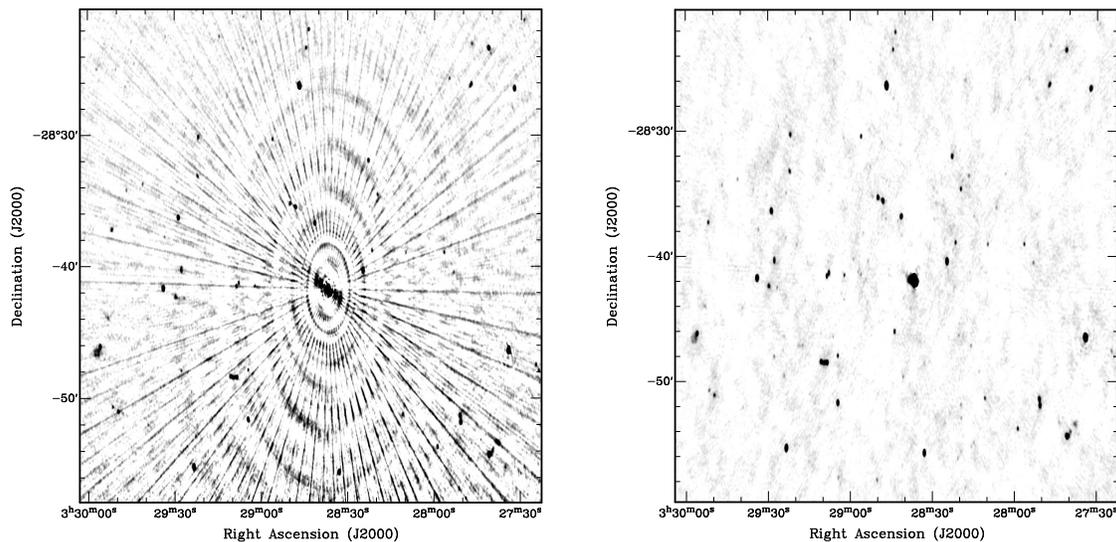

Figure 2: (a) Left, image of confusing source from first ATLAS data release. (b) Right, image with improved source modelling applied.

The 30 μJy rms limit of the first ATLAS data release was generally imposed by observational sensitivity, however, it was clear that further observations would be limited by our ability to mitigate the effects of bright sources in each field (Figure 2a). We have recently been successful in removing these limitations in one pointing of the CDFS region by modelling bright confusing sources in the u-v plane. This enabled self-calibration to converge on a more optimal solution, and after subsequent deconvolution, allowed the theoretical signal-to-noise to be achieved throughout the entire field (Figure 2b). We anticipate releasing an updated catalogue, utilising this improved imaging, by the end of the year.

We are now in the process of continuing observations of both ATLAS fields to achieve the originally proposed goal of 10 μJy rms over the full 7 sq. deg. These observations will make use of the Compact Array Broadband Back-end (CABB) which provides a continuous 0.5 GHz band at 1.4 GHz. We estimate the detection of 10000 radio sources with these observations.

4. ATLAS as an ASKAP Path-finder

EMU (Evolutionary Map of the Universe) is a proposed radio sky survey project designed to use the new ASKAP (Australian Square Kilometre Array Pathfinder) telescope. The EMU-wide project, will make a deep ($\sim 10\,\mu$Jy rms) radio continuum survey covering the entire Southern Sky as far North as $30°$. As a result, it will be able to probe star forming galaxies up to z= 1, AGNs to the edge of the Universe, and will undoubtedly uncover new classes of object. Similarly, the EMU-deep project will aim to observe a smaller region of the sky (~ 30 sq. degrees) down to an rms of about $\sim 1\,\mu$Jy.

It is envisaged that by pushing the ATLAS fields down to $10\,\mu$Jy rms we will be using it as a design study for ASKAP EMU-wide. This will result in a better characterisation of the challenges faced by deep surveys, such as EMU-wide and EMU-deep e.g. the effects of confusion. Subsequently, ATLAS will drive the development of new advanced calibration and imaging algorithms that will ultimately be used for future instruments such as ASKAP. The ATLAS project also plans to set up a pipeline for the automatic multi-wavelength cross-identification of radio sources. The output of this pipeline will be placed in the public domain in the form of images and source catalogues. Finally, ATLAS will provide the first preview of the science that can be achieved with surveys such as EMU. So watch this space, ATLAS has a great deal to offer over the next few years.

References

[1] S. C. Chapman, et al. 2003, *ApJ*, 585, 57

[2] R. P. Norris, E. Middelberg, & B. J. Boyle 2008, arXiv:0804.3998

[3] R. P. Norris, et al. 2006, *AJ*, 132, 2409

[4] E. Middelberg, et al. 2008a, *AJ*, 135, 1276

[5] M. T. Huynh, et al. 2009, *AJ*, submitted

[6] R. P. Norris, E. Middelberg, & B. J. Boyle 2007, Deepest Astronomical Surveys, 380, 229

[7] E. Middelberg, et al. 2008b, *AAP*, 491, 435

[8] R. P. Norris, et al. 2009, in prep.

[9] B. J. Boyle, et al. 2007, *MNRAS*, 376, 1182

[10] M. Mao, et al. 2009, in prep.

[11] M. Mao, et al. 2009 in "Starburst-AGN Connection", Shanghai, *ASPC*

[12] K. Randall, et al. 2009 in "Starburst-AGN Connection", Shanghai, *ASPC*