

Radio Surveys: an Overview

Raffaella Morganti^{1,2}

¹ Netherlands Institute for Radio Astronomy, Postbus 2, 7990 AA, Dwingeloo,
The Netherlands
email: morganti@astron.nl

² Kapteyn Astronomical Institute, University of Groningen, Postbus 800, 9700 AV Groningen,
The Netherlands

Abstract. Radio astronomy has provided important surveys that have made possible key (and sometimes serendipitous) discoveries. I will briefly mention some of the past continuum and line (HI) radio surveys as well as new, on-going surveys and surveys planned for the near future. This new generation of large radio surveys is bringing extra challenges in terms of data handling but also great new possibilities thanks to the wider range of data products that they will provide.

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Surveys (and deep fields) have played an extremely important role in radio astronomy. Now we are at a turning point, entering a new era for radio surveys. This is due to the new technologies developed for the upgrade of existing facilities (e.g. VLA, WSRT) and for the new facilities (e.g. LOFAR, ASKAP, Meerkat) on the way to SKA. Systems with wide field-of-view and/or broad bandwidth will soon allow larger and deeper surveys, in some cases providing simultaneously radio continuum and line (HI) data. In summary, the new generation of radio surveys will deliver a broader variety of products and give the chance for serendipitous discovery (see e.g. Kellerman *et al.* 2009). These surveys are starting to revolutionize the field and will provide exciting databases for the community.

Some of the characteristics of the available radio continuum surveys (and deep fields) are illustrated in Fig. 1 and discussed in more detailers in Norris *et al.* (2012 and ref. therein). For the largest continuum surveys, the number of sources detected ranges from 1.7×10^6 for NVSS at 1.4 GHz to $\sim 10^5$ for low-frequency surveys like SUMSS, WENSS and VLSS.

The “blind” HI surveys have been carried out so far with single-dish instruments, thus providing limited spatial and morphological information. Also the sensitivity of these surveys is limited, thus being able to trace HI only in the local Universe (see also Fig. 2). One of the main “blind” HI surveys is the HI Parkes All Sky Survey (HIPASS) that covers $\sim 2/3$ of the sky, out to 12700 km/s ($z \sim 0.04$) with a spatial resolution of ~ 15 arcmin and rms noise of 13 mJy/b/ch. This surveys had about 5300 extragalactic detections of HI emission. The other large HI survey is the Arecibo Legacy Fast ALFA (ALFALFA, Giovanelli *et al.* 2005) covering 7000 deg² up to $z \sim 0.06$, with a spatial resolution of ~ 3 arcmin and rms noise of 1.6 mJy/ch. About 30000 extragalactic detections HI emission are expected when the survey will be completed. A number of smaller samples - a few hundred objects - have been studied in more details (WHISP, THING, ATLAS3D etc.), providing important information about the morphology and kinematics of the HI and allowing major step forward in the study of ISM in nearby galaxies. All together, only ~ 100 objects have been studied in HI emission above $z = 0.1$.

In the near future, a number of new (continuum and line) surveys will be carried out and they will partly overcome some of the limitations related to spatial resolution, sensitivity and frequency coverage.

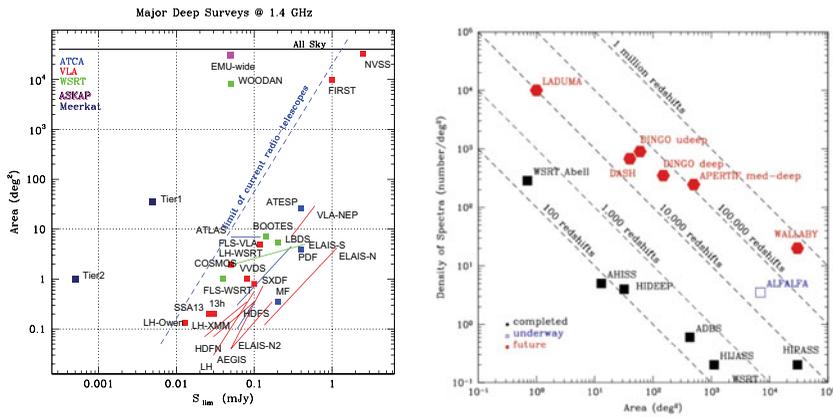


Figure 1. *Left* - Summary of the sensitivity and area covered by radio continuum surveys (and deep fields) done so far (from Norris *et al.* 2012, kindly provided by I. Prandoni). *Right* - Summary of the number of objects versus the area for HI surveys (Staveley-Smith *et al.* 2012, <http://www.astron.nl/ewass2012/Programme.html/Staveley-Smith.pdf>).

At low frequencies, LOFAR and GMRT are expecting to deliver very interesting databases. The TIFR GMRT Sky Survey (TGSS) survey at 150 MHz covers about 32,000 sq. deg north of declination -30° and is reaching an rms noise of 7-9 mJy/beam at an angular resolution of about 20 arcsec. The survey is expected to detect more than 2 million sources (<http://tgss.nrao.tifr.res.in>). For LOFAR, in addition to the planned large and deep surveys (Röttgering *et al.* 2011), the LOFAR Multifrequency Snapshot Sky Survey (MSSS, Heald *et al.* 2011) is expected to provide fluxes between 30 and 180 MHz for sources in the cover the northern sky and reach an rms noise of ~ 10 mJy/b, albeit with poor spatial resolution. Continuum all-sky surveys at 1.4 GHz from the SKA pathfinders/precursors at 20-cm (ASKAP/Apertif) are estimated to detected (Norris *et al.* 2011) of the order of 100 million sources (for rms $10 \mu\text{Jy}$ over the entire sky, see Fig. 1).

ASKAP and Apertif together will survey HI over the entire sky in an uniform way (Fig. 2). The expected number of detections of HI emission is of the order of 10^6 galaxies (out to redshift $z \sim 1$ for HI absorption). In addition, most of these HI detections will be spatially resolved. This will provide new possibilities for the science that will be done. The other major improvement will be the synergy between continuum and line surveys in the 20-cm band. It will be possible, by exploiting the broad band of the new receivers, to extract continuum and line information and study simultaneously e.g. the properties of the non-thermal activity and of the gas. One survey will fit all! This is bringing major challenges in the handling of the many products that these surveys will provide but it also promises to offer a amazing database for the community to exploit.

References

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