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ASKAP observations of known and new Galactic SNRs

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Abstract

The Australian SKA Pathfinder (ASKAP), one of the three SKA precursors, entered its early-science phase in late 2017 and it is now approaching the full-regime period. In the wide context of the preparation for the EMU survey, one of the large program approved for ASKAP, we used ASKAP between January 2018 and May 2019 to observe at 0.9, 1.2 and 1.6 GHz the 'SCORPIO field', a patch of about 40 square degrees on the Galactic plane, previously imaged with the Australia Telescope Compact Array to serve as validation for ASKAP. We detected all the 17 SNRs known from literature lying in our field. For these objects ASKAP data are allowing us to derive a very accurate flux density, disentangling the remnants from nearby sources (especially in particularly crowded regions), make a comparison with infrared images at about the same resolution, and build radio spectral index maps. The ASKAP images are also revealing several other previously undetected or unclassified sources that we are proposing as SNRs.

1 Introduction

The Australian SKA Pathfinder (ASKAP) is one of the three precursors of the Square Kilometre Array (SKA), along with MeerKAT and MWA. ASKAP consists of 36 antennas, all fully operational since March 2019, and it is specifically designed to conduct large deep surveys in very short amounts of time, thanks to the Phased Array Feed technology. One of these large surveys is EMU (Norris et al., 2011), an all-sky continuum survey conducted at a frequency of ~1 GHz with a target sensitivity of 10 µJy/beam. EMU is going to observe about 75 percent of the Galactic plane. Within this framework, SCORPIO is a small (~40 deg^2) pathfinder survey for the Galactic part of EMU. The field was initially observed between 2011 and 2016 with the Australia Telescope Compact Array and then, starting from

2018, with ASKAP. SCORPIO is aimed at predicting the scientific return of EMU and other future surveys in the Galactic plane and studying the technical challenges in data reduction and analysis (Umana et al. 2015; Umana et al. *in prep.*).

2 Observations

The SCORPIO field was observed with ASKAP between January 2018 and May 2019 as the only Galactic field of the ASKAP early-science program. In a first observation run, SCORPIO was observed in all the three bands of ASKAP using respectively 15, 36 and 28 antennas. The data reduction process of band-1 observations (0.7 − 1.0 GHz) was performed using ASKAPsoft, and it is complete. The global map in band 1 is shown in Figure 1. Details on the data reduction and on the ASKAPsoft fine tuning for Galactic plane observations are discussed in Umana et al. (*in prep.*). The data reduction of band-2 and -3 observations (respectively 1.1 − 1.4 GHz and 1.5 − 1.8 GHz) is ongoing. Once data reduction in band 2 and 3 is completed, spectral information from all the sources will be extracted. A second observation run was carried out in May 2019 with 36 antennas, using all the three bands. Data reduction is about to start.

3 Supernova remnants in SCORPIO

ASKAP is proving formidable in imaging Galactic fields, providing simultaneously a high resolution (less than 10 arcsec in band 3) and a good sensitivity to extended structures. At 0.9 GHz, its largest angular scale, i.e. the largest angular structure that ASKAP is capable to properly image, is about 40 arcmin. These two capabilities are fundamental for Galactic studies, where many objects appear as sources extending for several arcminutes, but also where arcsec resolution is needed to avoid confusion limits and recover the source fine details. In the band-1 image, we were able to observe a few hundreds Galactic objects and in particular supernova remnants (SNRs).

The observed field harbours 17 SNRs known from the literature. All of them are detected in our map. Flux density measurements are ongoing for those SNRs with an angular diameter below 30 arcmin. Our preliminary results show a good agreement between ASKAP flux densities and values from literature. Details on flux density measurement will be presented in Loru et al. (*in prep.*). In order to identify new possible SNR candidates detected in ASKAP, we used a multiwavelength approach. We selected all the roundish unclassified radio source and looked for a weak or absent infrared counterpart (using images from *Spitzer* and *Herschel*). We are going to propose about 20 new SNR candidates, showing the great discovery potential of these observations (Bufano et al. *in prep.*). Studying in detail single objects is another valuable effort to validate ASKAP early-science data, search for new features and refine known parameters. Spectral energy distributions for these SNRs will be derived once ASKAP data from all bands will be reduced. We also plan to build spectral index maps, searching for spectral index variations as sign of different local plasma conditions (Loru et al. *in prep.*).

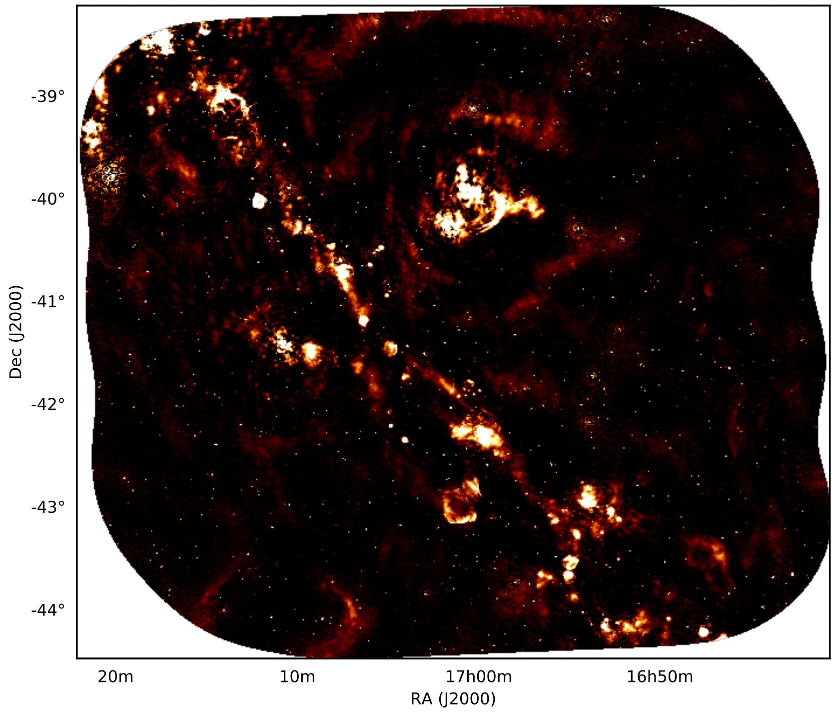

Figure 1: Global view of the ASKAP image of the SCORPIO field at 912 MHz. This image was obtained tuning the ASKAPSOFT pipeline to fit the Galactic plane data reduction needs, in terms of accounting for the huge number of extended sources and the Galactic diffuse emission (Umana et al. *in prep.*). More than 3500 sources have been extracted and their characterisation is in progress.

We finally remark that the study of SNRs in SCORPIO is also part of the Italian project 'Gamma-prop' aimed at studying cosmic accelerators (including SNRs and pulsar wind nebulae) in view of the construction of the Cherenkov Telescope Array (CTA) and SKA and their synergical use.

Acknowledgments

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References

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