An L-band panoramic view of Galactic supernova remnants with the Australian SKA Pathfinder

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Abstract

With the Evolutionary Map of the Universe (EMU) and the Polarization Sky Survey of the Universe's Magnetism (POSSUM), the touchstone radio continuum and polarization surveys of the Southern hemisphere are now under way. EMU and POSSUM use the Australian SKA Pathfinder (ASKAP) telescope to image the southern sky to a sensitivity of 20 μJy/beam r.m.s. with a resolution of 15″ over the next five years. Covering the southern hemisphere, EMU is ideal for observing the Milky Way, cataloguing stars, planetary nebulae, supernova remnants (SNRs), HII regions, and more, in various stages of evolution, while POSSUM provides sensitive polarization and Faraday rotation images to study magnetic fields in supernova remnants and pulsar wind nebulae and probing the Galactic magneto-ionic medium in their environment. The superior resolution and sensitivity of these surveys have opened up a new window of opportunity for research into Galactic SNRs. Here, I will discuss the analysis of a EMU/POSSUM Galactic pilot field in which we found 21 new SNR candidates over a Galactic longitude range of only 7 degrees. Only 7 SNRs where previously known in this area. With the ASKAP surveys continuing, we are applying our new techniques to all Galactic fields uncovering more of the missing supernova remnants, allowing for a better and more complete characterization of the Galactic SNR population.

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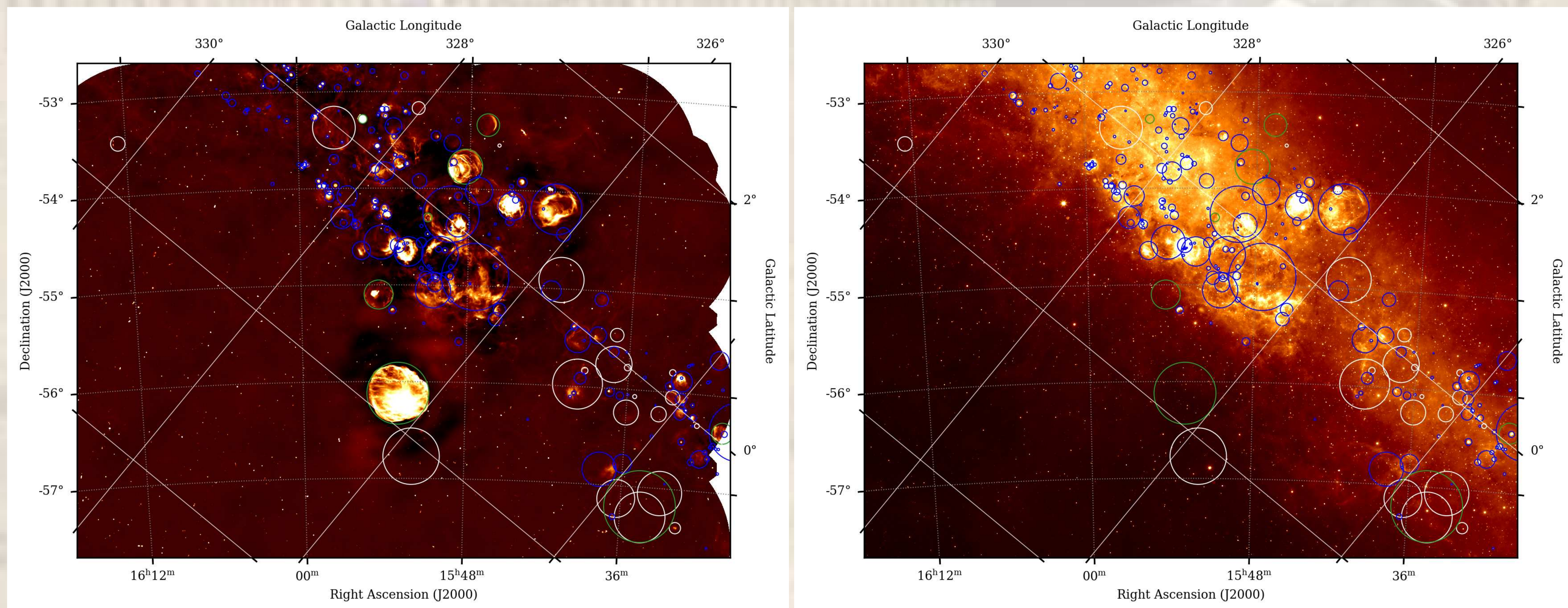
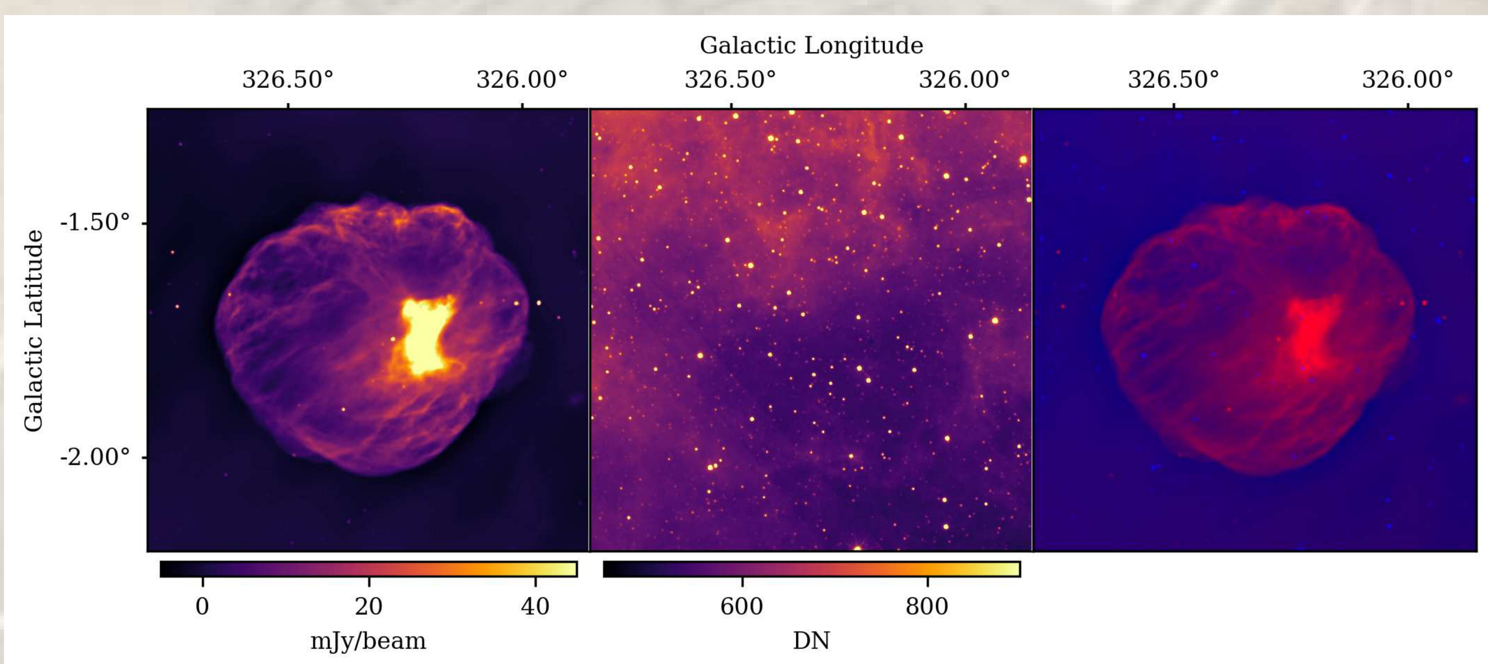
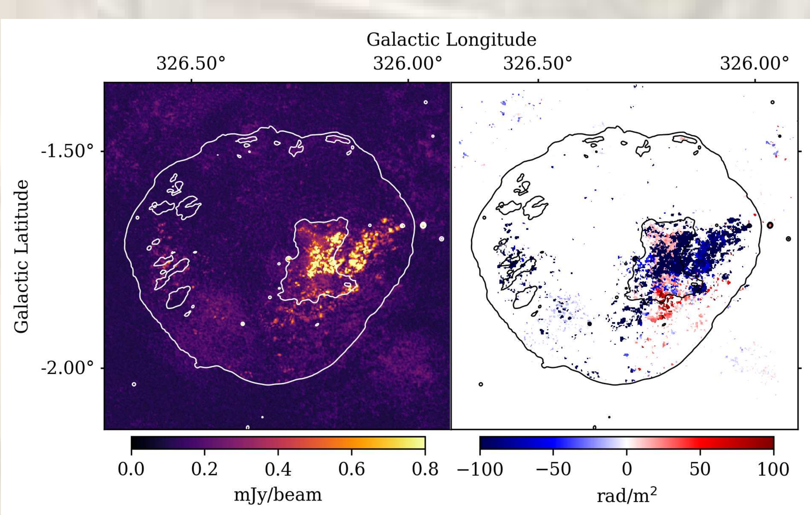
The EMU/POSSUM Galactic Pilot Field

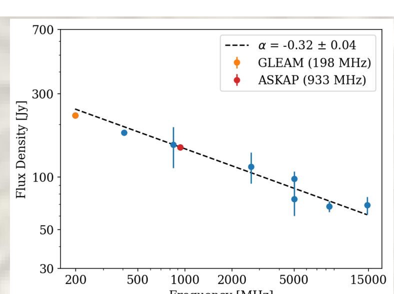


The EMU/POSSUM Galactic pilot data as observed by ASKAP (943 MHz) and the same field in the mid-infrared (MIR) as observed by WISE (12 microns). The field looks across the Galactic plane, with an approximate longitude and latitude range of $323^\circ \leq l \leq 330^\circ$ and $-4^\circ \leq b \leq +2^\circ$, respectively, along a tangent to the Norma arm and across several other spiral arms. This gives us a long line of sight through the inner Galaxy, up to distances of about 18 kpc. Known SNRs (green), HII regions (blue), and our new SNR candidates (white) are indicates by circles.

SNR G326.3−1.8 (MSH 15−56)



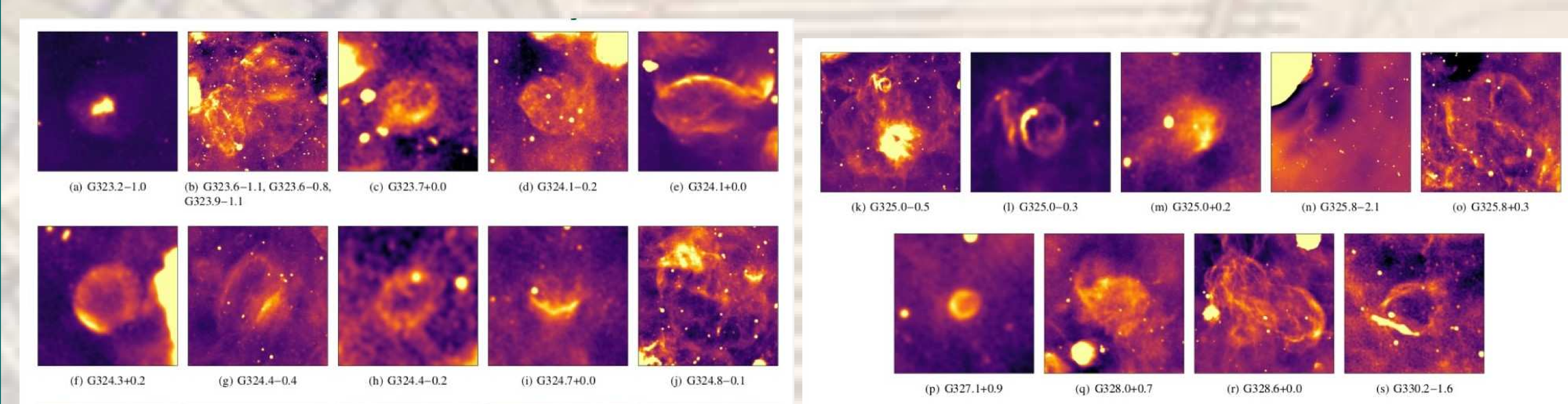


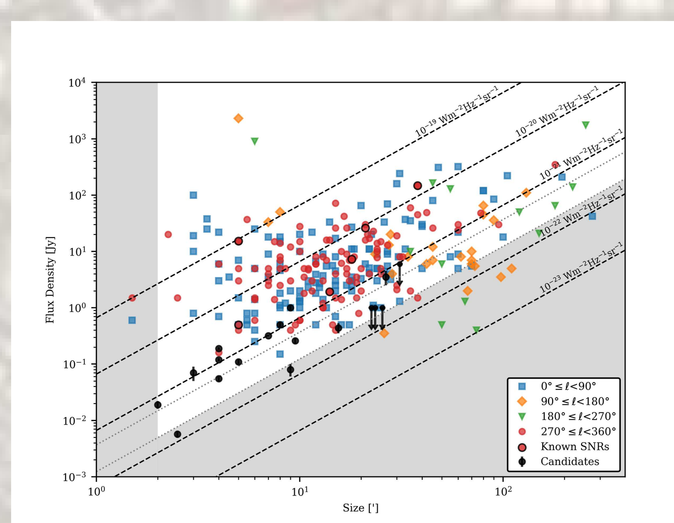


Images of SNR G326.3−1.8, also known as MSH 15−56. Top row: in radio (left), MIR (middle), and a combined image with radio in red and MIR in blue (right). The radio continuum spectrum is shown above and the polarized intensity (left panel) and rotation measure (right panel), taken from the peak of the Faraday depth function, are shown on the left.

The Missing SNR Problem and our 21 new SNR Candidates

The so-called "Missing SNR Problem" describes the discrepancy between the number of SNRs that are believed to exist in our Galaxy and the number that have been discovered at radio wavelength. The exact size of the discrepancy is still debated as accurately quantifying this problem is challenging due to variations in SNR density and radio visibility across the Galactic plane. We can form conservative limits based on the supernova rate and radio lifetime and estimate that at any given time, between 1000 to 3000 radio SNRs should be detectable in our Galaxy. So far we have only discovered somewhere in the range of 300 to 400.





We identify 21 SNR candidates primarily by looking for radio-emitting shell-like structures that lack clear MIR counterparts. Comparing radio and MIR fluxes can help to distinguish nonthermal SNR emission from thermally emitting sources like HII regions and planetary nebulae as SNRs have significantly lower MIR to radio flux ratios. Further evidence of SNRs are:

- The presence of a young pulsar, which indicates that a supernova explosion has recently occurred.
- A steep negative spectral index and linear polarization, which indicates non-thermal synchrotron emission.

The sizes and flux densities of our SNR candidates compared to the known Galactic SNR population. The shaded regions indicate what we estimate to be the limits of what can be detected with the ASKAP data. Many of our candidates are smaller and fainter than most known SNRs, indicating there is likely still a large population of undetected SNRs. Improvements in the angular resolution and sensitivity of radio telescopes should allow for the detection of more SNRs in future sky surveys. Background emission also plays a role in setting detectability limits, particularly in regions with a high concentration of thermal emission/HII regions.

Where are the SNRs???