A very young pulsar discovered in the Parkes Multibeam Pulsar Survey

In the past four years, the Parkes telescope and its multibeam receiver have been used to scan the Milky Way for pulsars. Pulsars are ultra-dense rotating neutron stars that pack more mass than the Sun into a radius of a small city. The Parkes Multibeam Pulsar Survey has been phenomenally successful, nearly doubling the known population of these exotic objects.

Among the survey's booty is a pulsar that is among the very youngest known in our Galaxy. PSR J1119-6127 rotates just over twice per second, but is slowing down extremely rapidly owing to the tug of its enormous magnetic field. Its spin parameters can be used to deduce that it is only 1,600 years old, making it the fourth youngest pulsar known in the Milky Way. Young pulsars are exciting to find for a variety of reasons. The youngest of all are usually associated with gaseous nebulae, the result of the cataclysmic supernova explosion that formed them. These supernova remnants (SNRs) are interesting in their own right, teaching us about how the explosion energy is transferred into the surrounding regions of the Galaxy. In addition, young pulsars have a tendency to suddenly start rotating faster. This behavior is known as "glitching" and provides one of the few ways to learn about the interiors of neutron stars. Indeed, a small glitch of magnitude $\Delta P/P = -4.4 \times 10^{-9}$ was observed in the period of PSR J1119-6127 in August 1999. Finally, young pulsars often emit observable X-rays and gamma-rays. Such observations can be used to learn about how neutron stars cool off after their formation, as well as about pulsar emission mechanisms.

An associated supernova remnant

All known pulsars younger than 5,000 years are associated with supernova remnants. Although no supernova remnant was known at the position of PSR J1119-6127, we used the Australia Telescope Compact Array in the 13-cm and 20-cm bands to search for one. The resulting images clearly show a shell of emission of diameter 15 arcminutes centred on the pulsar (Figure 14). This shell shows all the hallmarks of being a previously uncatalogued supernova remnant and we designate it, from its Galactic coordinates, as SNR G292.2-0.5. The estimated ages of the supernova remnant and pulsar are comparable. This and the fact that the pulsar sits precisely at the geometric centre of the shell argues that they are indeed both the result of a supernova explosion that occurred some 1,600 years ago.

We have also observed this system at X-ray wavelengths. Data acquired with the ROSAT and ASCA X-ray satellites reveal extended emission coincident with the supernova remnant (Figure 15). We also detect an X-ray point source, offset approximately 1.5 arcminutes from the pulsar position. No X-ray pulsations are

detected from this source, although the upper limit is quite high and does not rule out the source being the pulsar. Our team has requested time on the Chandra X-ray Observatory in order to continue the study of both the young supernova remnant and the point source.

The PSR J1119-6127/SNR G292.2-0.5 system is very different to the famous Crab pulsar and Nebula, which are often cited as being prototypical of young pulsar/supernova remnant systems. The Crab has a rapidly rotating (33 millisecond) pulsar that powers an extremely bright nebula, but shows no evidence for a surrounding shell emission. In contrast, the PSR J1119-6127/SNR G292.2-0.5 system contains a relatively slowly spinning pulsar, no evidence for a pulsar-powered nebula around the pulsar, but a clear shell.

In fact, for the past few years, evidence from a variety of lines of sources has indicated that the Crab pulsar is quite atypical of the young pulsar population. Our discovery of the PSR J1119-6127/SNR G292-0.5 system puts another nail in the coffin of the traditional view.

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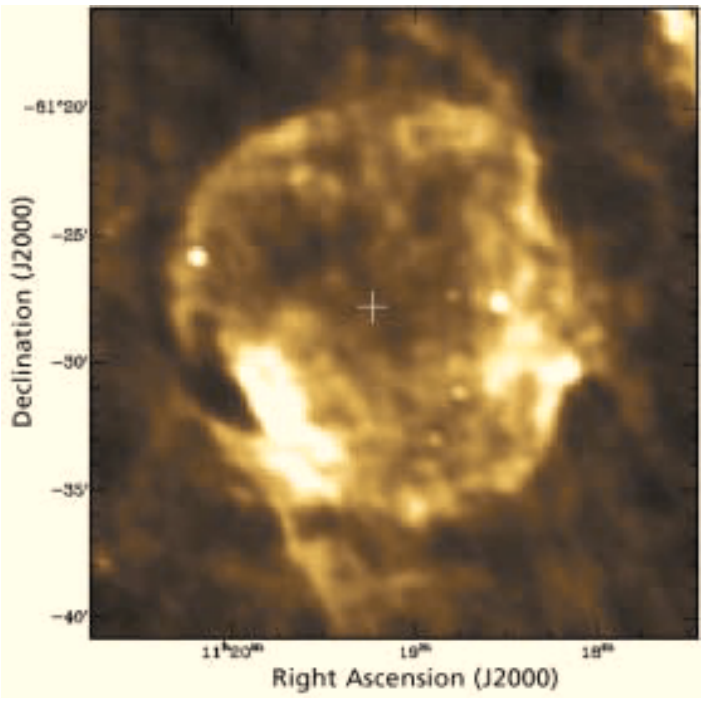

Figure 14 *Compact Array image of the radio continuum emission at 20 cm from a newly discovered young supernova remnant, G292.2-0.5. The cross marks the position of the pulsar.*

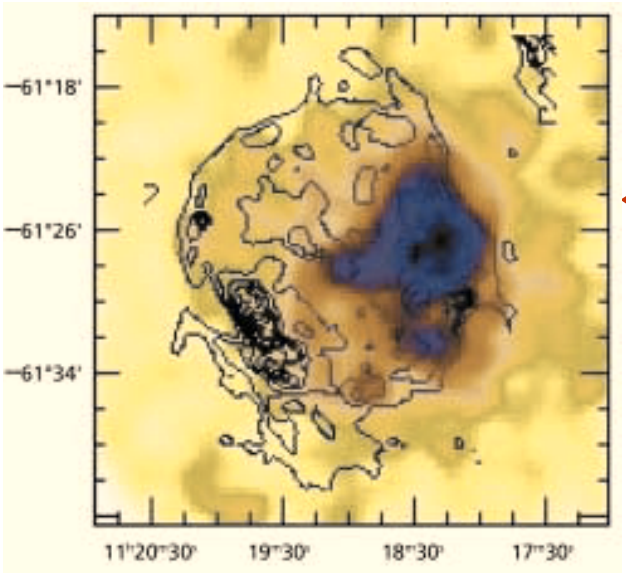

Figure 15 *False colour soft X-ray (0.8–3.0 keV) image of G292.2-0.5, obtained using the Japanese ASCA satellite observatory. The contours represent the 20-cm radio emission seen with Compact Array.*