THE HIGH TIME RESOLUTION UNIVERSE

A survey for pulsars & fast transients





REVIEW OF HTRU

SURVEY OVERVIEW

- The High Time Resolution Universe survey for pulsars and fast transients -- HTRU
- An ambitious (~6000 hours) project to survey the *entire Southern sky* for radio pulsars and fast transients (<1s).
- Began in November 2008, still going strong!
 See Keith et al (2010) for full survey description.
 (*ATNF*) Keith, Johnston, Burke-Spolaor*; (*Swin*) Bailes, van Straten, Levin, Coster, (JBO) Stappers, Bates*; (*MPIfR*) Kramer, Ng; (*INAF*) Possenti, Burgay, Milia

SURVEY OVERVIEW

- Survey is split into three areas:
 - Low-latitude covers ± 3.5° from the plane
 - Mid-latitude covers ± 15° from the plane
 - High-latitude covers the remaining sky < 10° in dec
- There is a corresponding *northern hemisphere* survey at Effelsberg.



DISCOVERY COUNT

	High-lat	Mid-lat	Low-lat
Observed Fraction	11257/36583 30%	7312/7312 100%	548/1230 44%
Analysed Fraction	~few %	75%	3%
Simulated discoveries (MSPs)	24 (13)	80 (28)	293 (33)
Actual Discoveries (MSPs)	4 (1)	91 (20)	8 (0)

MILLISECOND PULSARS

- To date we have discovered 21 new MSPs, the first 12 have now been published with full timing solutions.
 - Bates et al. (2011), Bailes et al. (2011), Keith et al. (2011b)
- Two of the MSPs have unique binary parameters not seen in any other pulsar.
- High quality, multi-frequency polarisation profiles give us new and valuable data for understanding the emission properties of MSPs.

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"TRANSFORMATION OF A STAR INTO A PLANET IN A MILLISECOND PULSAR BINARY"

- As part of the Mid-latitude survey at Parkes we discovered PSR J1719-1438 - a
 5.7 ms pulsar in a 2.2 hour binary.
- Astonishingly the companion mass is
 ~1.2 Jupiter masses!
- Due to principally geometrical arguments we determined that this object must be a *carbon white dwarf*.
- Therefore a stellar mass object has undergone an incredible transformation, *ejecting more than 99.9% of it's mass* to become a planetary sized object.

Bailes et al. (2011)





"DIAMOND PLANET"

- Due to the exotic nature of the companion to PSR J1719-1438, it was described as a "diamond planet" in the media releases.
- Unsurprisingly this generated quite significant press coverage!

More: news.com.au » Technology » Sci-Tech Scientists discover the diamond planet

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SCIENTISTS have discovered a planet they believe is made of diamond.

The international team, which includes Australian scientists, believes the "diamond planet" is the only remnant left from what was a huge star in our own Milky Way galaxy.

The star, discovered in 2009, has become a pulsar - the dead remnant with about a diameter of 20km that emits beams of electromagnetic radiation.

It was detected by researchers from Swinburne University of Technology in Melbourne, led by Professor Matthew Bailes, using the Parkes radio telescope in central NSW.

A month later, they noticed the pulses were consistently interrupted - a sign of



The pulsar and its planet are part of the Milk stars and lie 4000 light-years away in the co Serpens. Picture: Courtesy of Swinburne As

VARIABLE & TRANSIENT DISCOVERIES

THE SUDDEN APPEARANCE OF PSR J1622-4950

- The very luminous PSR J1622-4950 discovered right in the middle of a well surveyed area of the Galactic plane
- This was quite surprising! Note that our new hardware doesn't help us with a 4.3 second pulse period.
- When we went back to the older surveys *no detection!*
- Interesting...

VARIABILITY OF PSR J1622-4950





1622-4950 at 17 GHz

Flux density variations of 1622-4950

Levin et al. (2010); Keith et al (2011a)

FIRST DISCOVERY OF A RADIO-LOUD X-RAY QUIESCENT MAGNETAR

First discovery of a magnetar from its radio emission

- Prior to this we knew of two magnetars for which we had seen radio emission, both discovered through X-ray flares.
- Will PSR J1622-4950 have detectable X-ray flares?
- We characterise radio magnetar by:
 - Long period, large period derivative... high inferred magnetic field
 - Large flux density variations

- Flat spectral index (observed > 100 GHz)
- Large variations in rotational period / period derivative
- Profile shape changes total intensity and polarisation

'RRAT'S

- "Rotating RAdio Transients" pulsars which typically emit 1 pulse in hundreds of rotations.
- HTRU has discovered 16 previously unknown RRATS to date, many more candidates.
- It is becoming clear that RRATS are part of a broad spectrum of sporadic emission modes in radio pulsars.

Burke-Spolaor et al. (2011)

'RRAT'S

- J0912-48 is detectable as a "normal" pulsar but clearly shows occasional RRAT-like pulses.
- J1014-48 was detected in one cluster of 16 rotations of the star but never again re-detected.
- J1854-1557 shows nulling, mode changing, sub-pulse drifting and RRAT-like emission.

Burke-Spolaor et al. (2011)

OTHER TRANSIENTS?

- So far we have yet to observe any "Lorimer" type "extragalactic" events, though the focus has been in the Galactic plane so far.
- We have not detected any "Perytons", broadband dispersed radio pulses theorised to have atmospheric origin (Burke-Spolaor et al. 2011).

CONCLUSION

The HTRU is an ongoing all-sky survey for radio pulsars at Parkes
Many discoveries, including exciting objects such as a magnetar, exotic binaries, RRATS, MSPs, etc.

-A significant focus on "single pulse" analysis aiming to detect fast transients.

-Radio pulsars continue to surprise through time-dependant variations on **all** time scales (ns -> decades)

