PSR J1745-2900

The Galactic Center Pulsar

Geoffrey C. Bower (ASIAA, Hilo)

A strong magnetic field around the supermassive black hole at the centre of the Galaxy

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PULSE BROADENING MEASUREMENTS FROM THE GALACTIC CENTER PULSAR J1745-2900

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THE ANGULAR BROADENING OF THE GALACTIC CENTER PULSAR SGR J1745-29: A NEW CONSTRAINT ON THE SCATTERING MEDIUM

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The Proper Motion of the Galactic Center Pulsar Relative to Sagittarius A*

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Using Pulsars to Measure Spacetime Around Sgr A*



Liu et al 2012

Known GC Pulsars



PSR	P (ms)	B (10 ¹² G)	DM (pc cm ⁻³)	τ _{sc} (2 GHz; ms)
1746-28501	1077	38	962	100
1746-2850II	1478	3	1456	145
1745-2910	982		1088	
1746-2856	945	4	1168	
1745-2912	187		1130	144

Johnston et al. 2006 Deneva et al. 2009

Galactic Center Magnetar Discovery

X-ray Localization: ~2" to Sgr A*

X-Ray Burst





Radio Detection

- P = 3.76354676(2) s
- P/Pdot \rightarrow B ~ 10¹⁴ G
- T_{spindown}~ 9000 yrs
- DM = 1778 +/- 3 cm⁻³
 pc
- $RM = -7 \times 10^4 \text{ rad } \text{m}^{-2}$
- Flux ~0.2 1 mJy
- spectrum ~flat
- Only 4 radio magnetars known – chance alignment is 10⁻⁸

Eatough et al. 2013 Shannon and Johnston 2013

normalised flux

Dispersion in the Galactic Center

 $DM = \int n_e \, dl$



Largest Pulsar Rotation Measure Observed

 $RM = -66960 + / -50 rad m^{-2}$



 $RM = \int n_e \overline{B} \bullet dl$

Angular Broadening of the Pulsar



Temporal Scattering





Scattering Inhibits Imaging



Haggard & Bower, Sky & Tel, 2016

A New Distance for the GC Scattering Screen





Reid, Brunthaler, et al

Line of Sight Effects



Size vs. time (binned)



Does a Scattering Screen at Large Distances Make Sense? *Isn't the Galactic Center Special*?

- NGC 6334B & Cyg X-3 have similar scattering sizes and non-local scattering screens
- 50 pc diameter screen associated with HII regions or GMC surfaces can provide the scattering
- Missing extragalactic background sources?
- Apparent peak of OH/IR masers around Sgr A*?
- Patchiness?
 - Scale ~5' from G359.87+0.18





Other GC Pulsar Scattering



Preliminary Dexter et al

Astrometry of SGR J1745-29



The GC Pulsar Likely Originates in the Clockwise Stellar Disk



- V_{proj}=240 +/- 3 km s⁻¹
- R_{proj}=0.097 pc
- P>700 y



Acceleration Limits

- Current 3 sigma limits from astrometry
 - Declination < 0.5
 mas/yr²
 - $RA < 1 mas/yr^2$
 - Pdot provides a comparable constraint
- Acceleration measures

 |z| and would
 demonstrate that the
 PSR is bound to Sgr A*

Parallax Constraint



Astrometric Residuals





Revised PSR Sensitivity



Macquart & Kanekar 2014

Missing Pulsars?

- Anomalous scattering
 - Cordes et al
- Intermittent pulsation
 - Cordes & Shannon 2008
- Dark matter
 - Bramante & Linden 2014



The Young GC Cluster & Its Pulsar Population



WR+OB Stars Paumard et al 2006, Lu et al 2013

- T~2.5 5.8 Myr
- M~10⁴ M_{sun}
- High Multiple Fraction (~1)
- \rightarrow
- Cluster SNe only produce magnetars and BHs
- No ordinary pulsars if no other star formation since T_{pulsar}~10-100 Myr

Westerlund 1 A Young Cluster Analog of the GC Cluster



Muno et al 2006, Clark et al 2014

- T~6 Myr
- M~10⁵ M_{sun}
- Magnetar w/potential binary companion
- No Radio pulsars



High Mass Binaries Form Neutron Stars



Fryer et al 2002, Belczynski & Taam 2006

Does binarity in massive stars preferentially lead to magnetars?

MSPs in the GC



- MSPs and BHs should accumulate in the GC due to dynamical friction
- Nustar diffuse X-ray emission suggests a population of MSPs



What Has the GC Pulsar Taught Us?

- Central parsec B-field
- Scattering screen distance
- Low kick velocity for magnetars
- Origin in the CW disk
- Bound to Sgr A*?
- Not suitable for GR
- The Missing Pulsar Problem
- ...MSPs should be present and suitable for timing and GR tests

