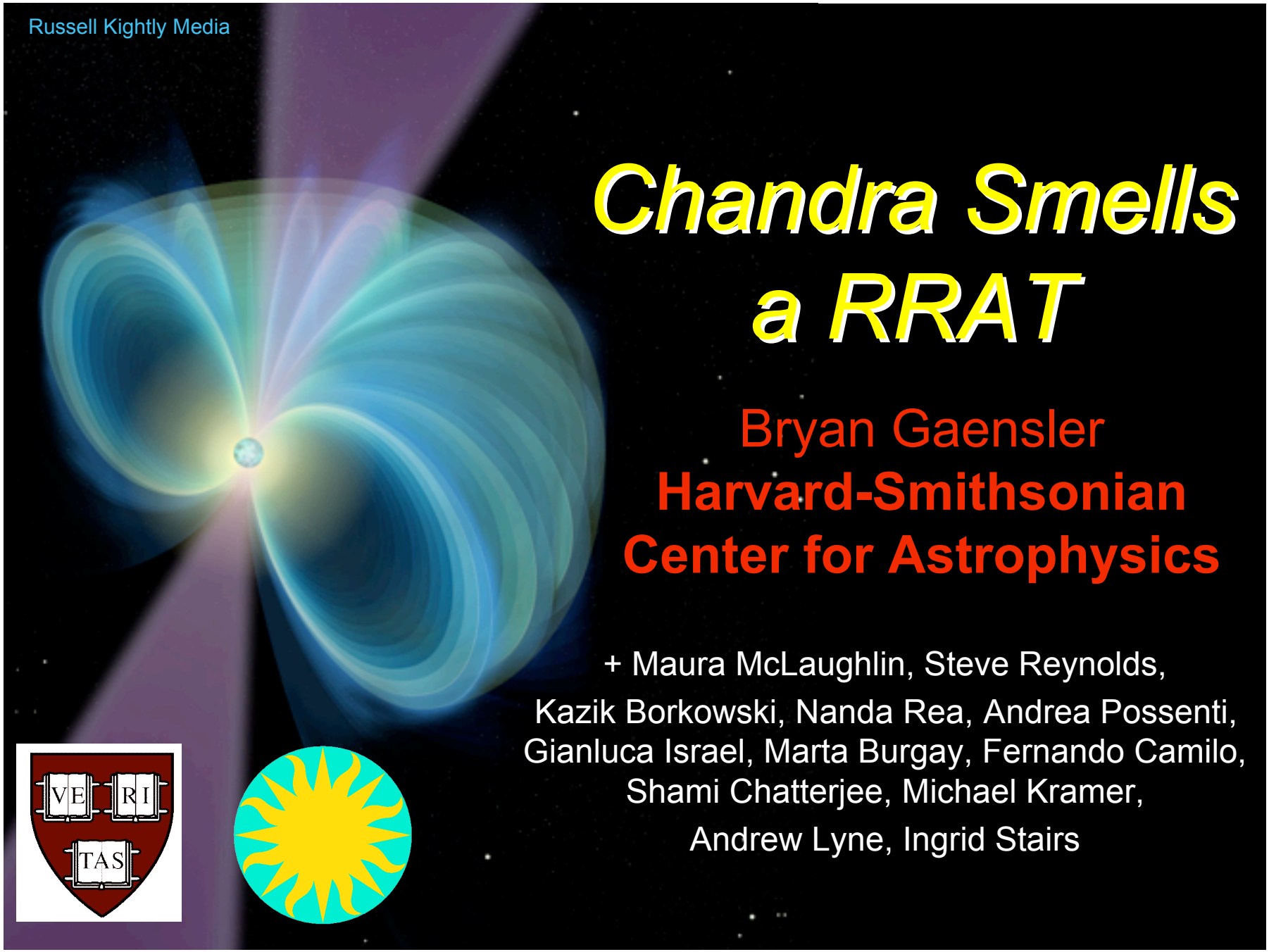
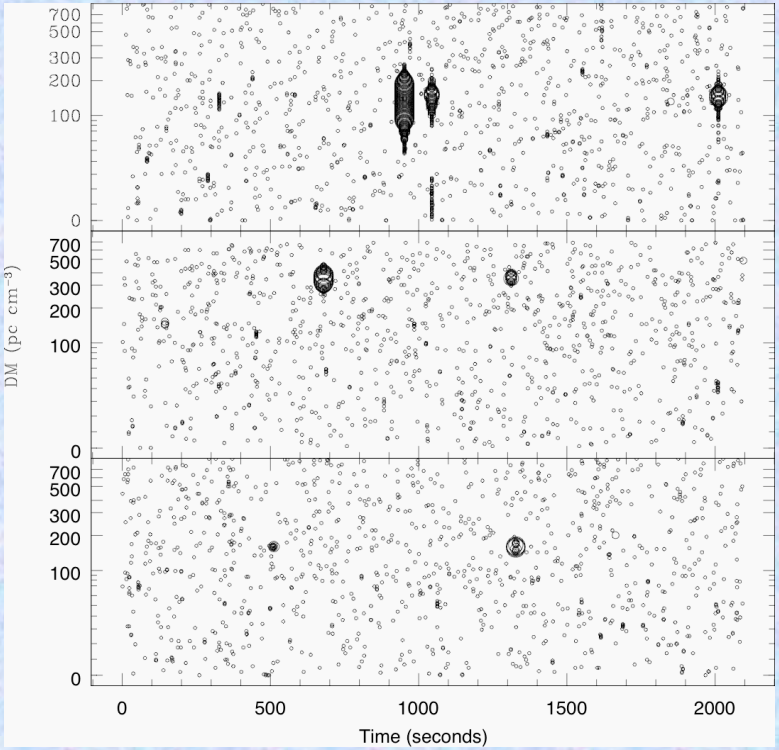

Russell Kightly Media
Chandra Smells a RRAT
Bryan Gaensler
Harvard-Smithsonian Center for Astrophysics
+ Maura McLaughlin, Steve Reynolds,
Kazik Borkowski, Nanda Rea, Andrea Possenti,
Gianluca Israel, Marta Burgay, Fernando Camilo,
Shami Chatterjee, Michael Kramer,
Andrew Lyne, Ingrid Stairs
VE
RI
TAS

The Neutron Star Zoo

- Radio pulsars
- AXPs & SGRs
- Central compact objects
- Isolated neutron stars



McLaughlin et al. (2006)

And now …

- "RRATs" (McLaughlin et al. 2006)
  - Rotating RAdio Transients
  - 11 known sources
  - repeated, irregular, radio bursts
  - durations 2-30 ms
  - interval between bursts ~4 min to ~3 hours
  - concentrated at low $|b|$, distances ~2-7 kpc

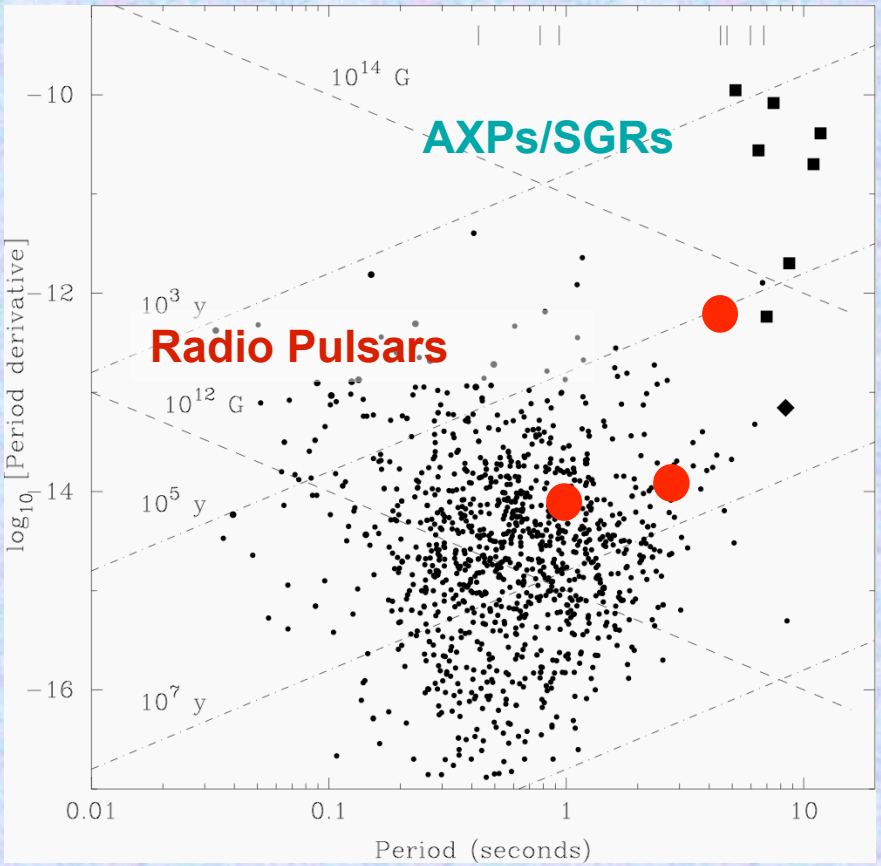
Periodicities in the RRATs

- Detection of many bursts reveals coherent solutions for P, dP/dt
- Observed periods 0.4 sec < P < 7 sec
- 3 RRATs with measured dP/dt

- *J1317-5759* : $P = 2.6$ sec, $B = 6 \times 10^{12}$ G, $\tau = 3.3$ Myr

- *J1913+3333* : $P = 0.92$ sec, $B = 3 \times 10^{12}$ G, $\tau = 1.9$ Myr

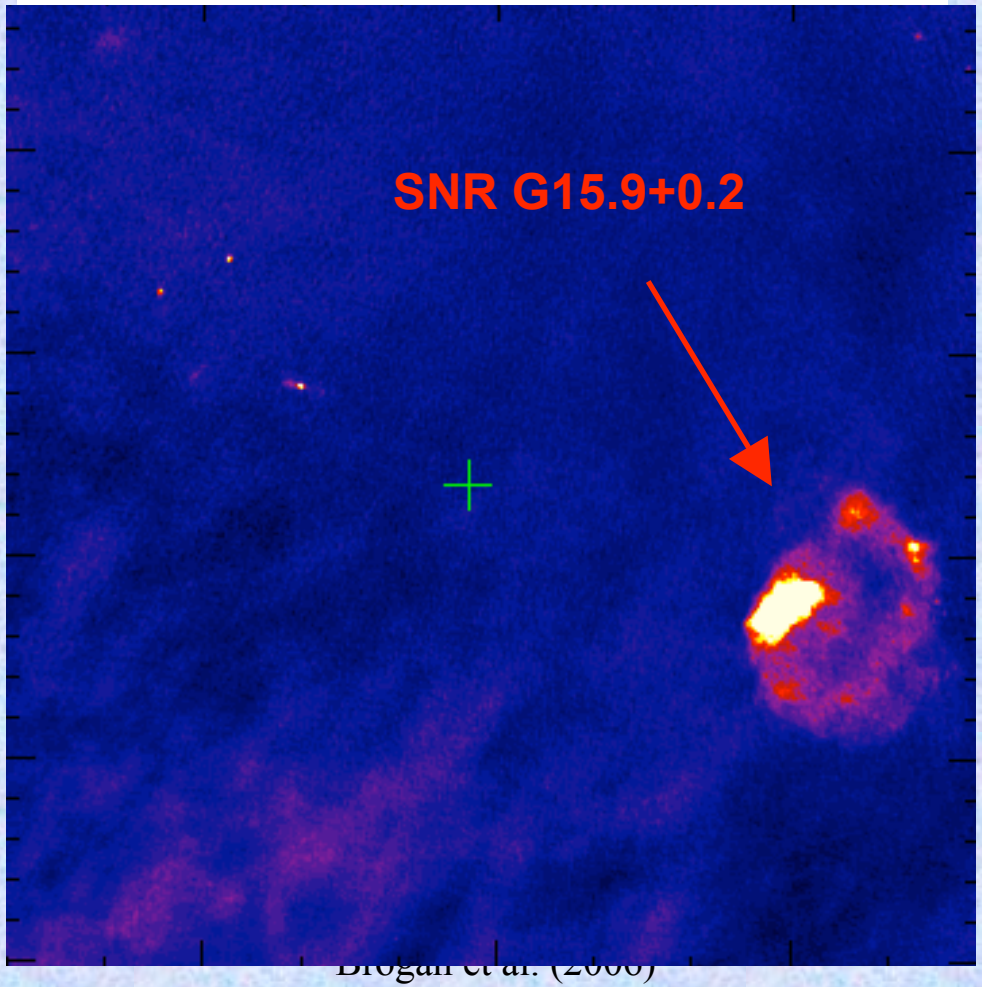
- *J1819-1458* : $P = 4.3$ sec, $B = 5 \times 10^{13}$ G, $\tau = 117$ kyr



McLaughlin et al. (2006)

RRAT J1819-1458

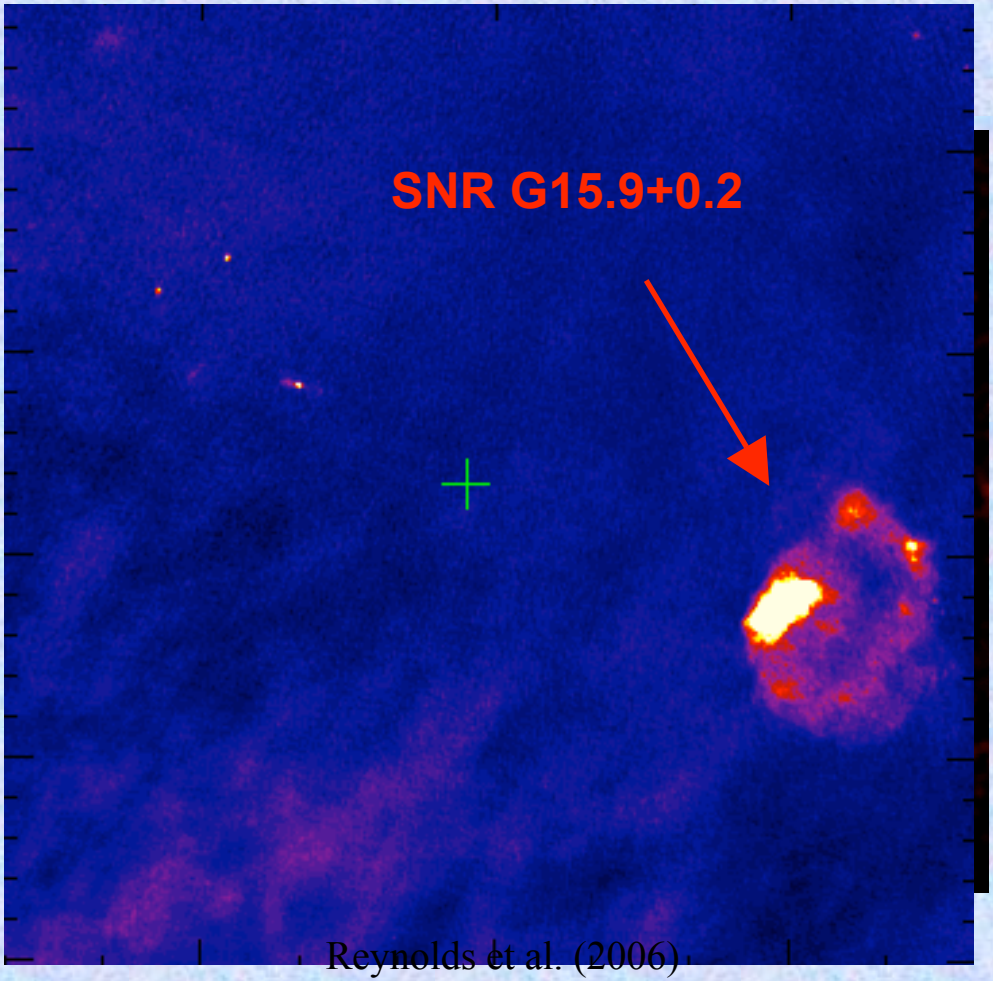
- $P = 4.3$ sec
- $B = 5 \times 10^{13}$ G
- $\tau = 117$ kyr
- Close to magnetars on P-Pdot diagram
- Bursts every ~3 minutes



Helfand et al. (2006)

X-ray Detection of J1819-1458

- 30 ks *Chandra* ACIS obs. of SNR G15.9+0.2 in May 2005
- RRAT J1819-1458 falls 11’ from aimpoint
- Clear detection of bright unresolved X-ray source within error circle
- Probability < 10^{-4}



Reynolds et al. (2006)
Helfand et al. (2006)

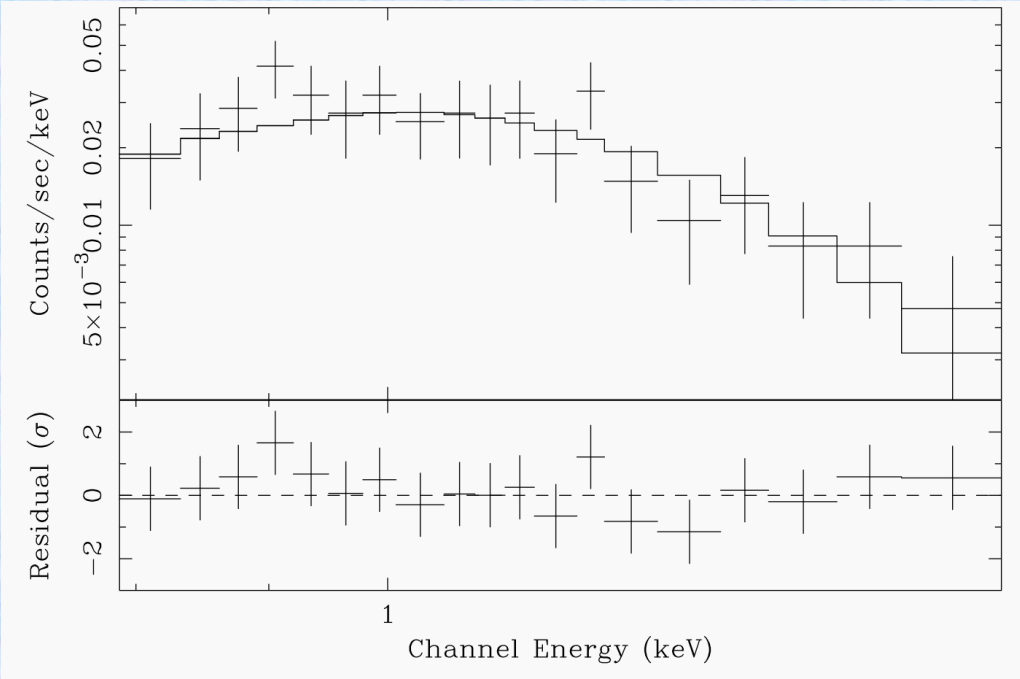
Spectrum & Variability

- 524 ± 24 counts
- Poor spectral fit to PL, good fit to blackbody ($R_{BB,\infty} \approx 20 d_{3.6}$ km)

$N_H = 7\ (+7,-4) \times 10^{21}$ cm^{-2} $\quad kT_\infty = 120 \pm 40$ eV

$f_{X,unabs} \approx 2 \times 10^{-12}$ ergs/cm^{-2}/s $\quad L_X \approx 3.6 d^2_{3.6} \times 10^{33}$ ergs/s (0.5-8 keV)

- No X-ray bursts, $E_{burst} < 10^{36} \times d^2_{3.6}$ ergs
- No variability seen on scales 3.2 sec to 5 days
- No (aliased) pulsations, $f <$ 70% for sinusoid



Reynolds et al. (2006)

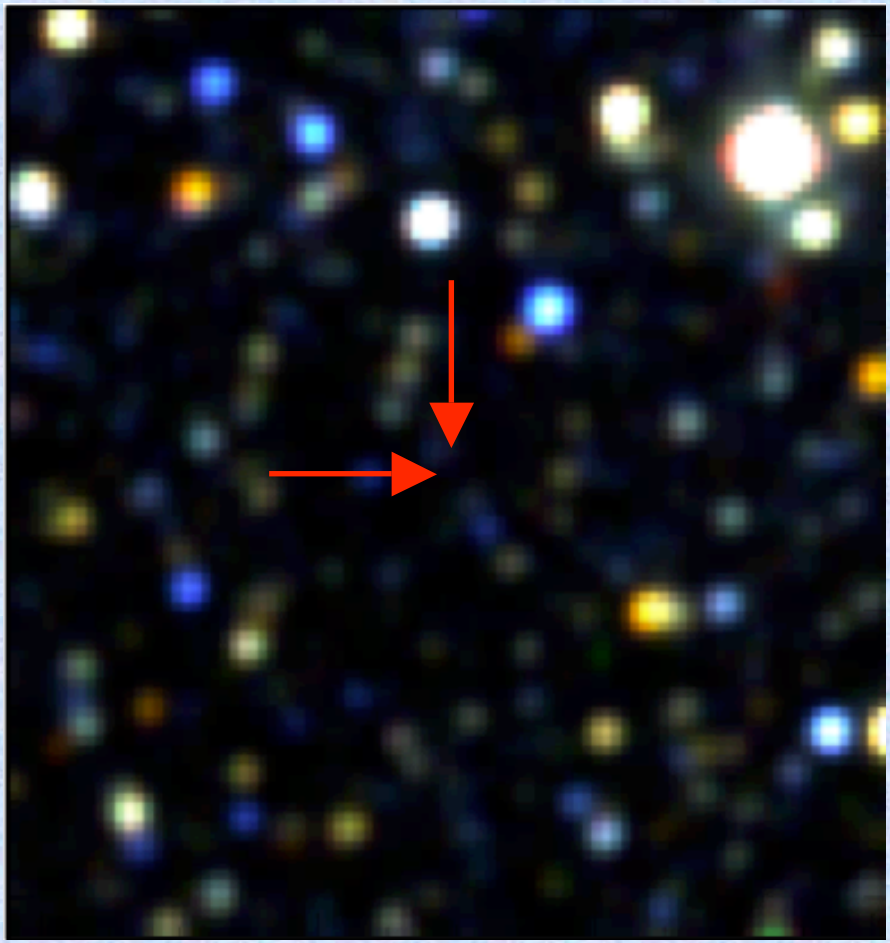
Data At Other Wavelengths

- Not seen with VLA, 2MASS or GLIMPSE

- $f_X / f_{IR} > 0.7$
  - not a star

- $N_H << N_{H,\mathrm{tot}}$
  - not bkg galaxy, AGN or cluster

- Consistent with thermal emission from neutron star surface



2MASS *J*, *H*, *K*

Comparison with Other Sources

- Pulsation limit unconstraining for thermal emission
- Much colder, less luminous than magnetars; no hard tail
  (although transient magnetar XTE J1810-197 : $kT_\infty \approx$ 150-180 eV)
- Much colder than central compact objects (and no SNR!)
- At upper end of distribution in kT, L_X for isolated neutron stars
- Good agreement with thermal cooling from radio pulsars
  RRAT J1819-1458 : $kT_\infty = 120 \pm 40$ eV (117 kyr)
  PSR B0656+14 : $kT_\infty = 70$ eV (110 kyr)
  PSR J0538+2817 : $kT_\infty = 160$ eV (30 kyr)
  … but longer periods

Interpretations & Further Observations

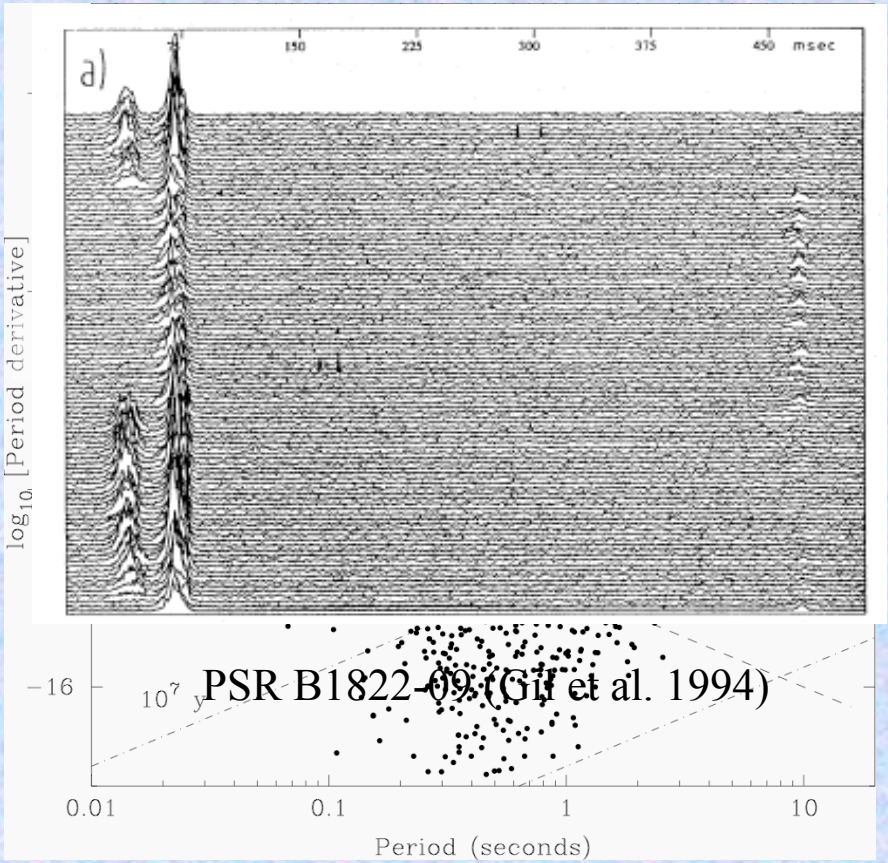
- Dead pulsars, for which multipole "starspot" temporarily reactivates radio beams (Zhang & Gil 2005; Zhang et al. 2006)
  - but not near death line: offset dipole?

- Temporary reversal of radio emission direction
  (Dyks et al. 2005; Zhang et al. 2006)
  - complement of nulling pulsars
  - but then should be RRATs with multiple successive bursts

- New searches for RRAT emission from all classes of neutron star

- Re-analysis of *SETI@Home* data

- Approved *XMM* Cycle 5 observations of RRATs J1819-1458, J1317-5759



PSR B1822-09 (Gil et al. 1994)

McLaughlin et al. (2006)

The Transient Radio Sky

- Only seeing tip of distribution
  → RRAT birth rate ~3-4 x radio pulsar birth rate
  (McLaughlin et al. 2006; Popov et al. 2006)

- Nullers
- Burster
- Winker
- Burper

Large population waiting to be discovered by next-generation radio telescopes!