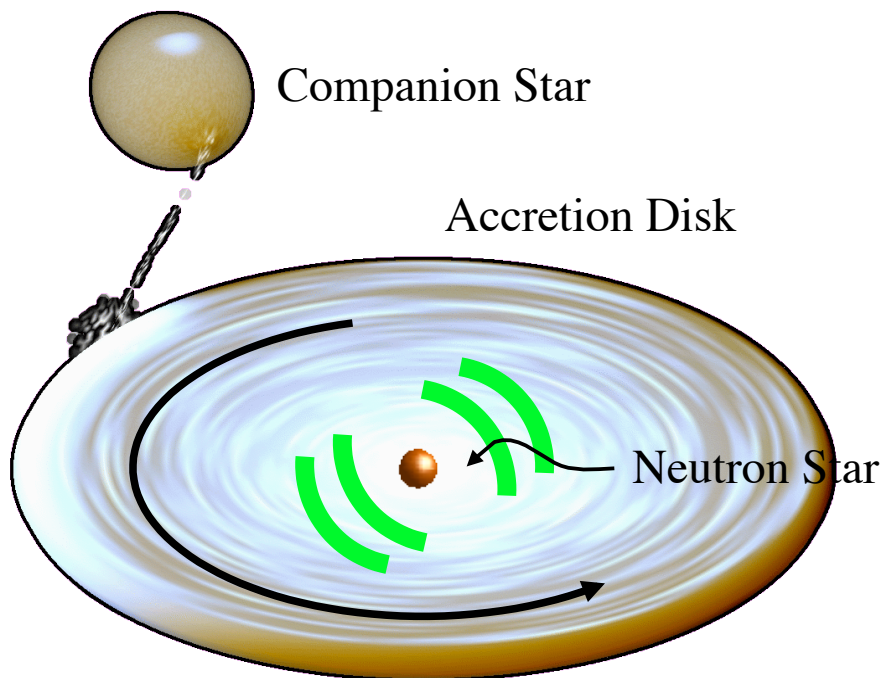


The New Millisecond X-ray Pulsar
IGR J17511-3057
(and friends)

Craig B. Markwardt
(U. Maryland & NASA/GSFC)
and collaborators

“Low Mass” X-ray Binaries

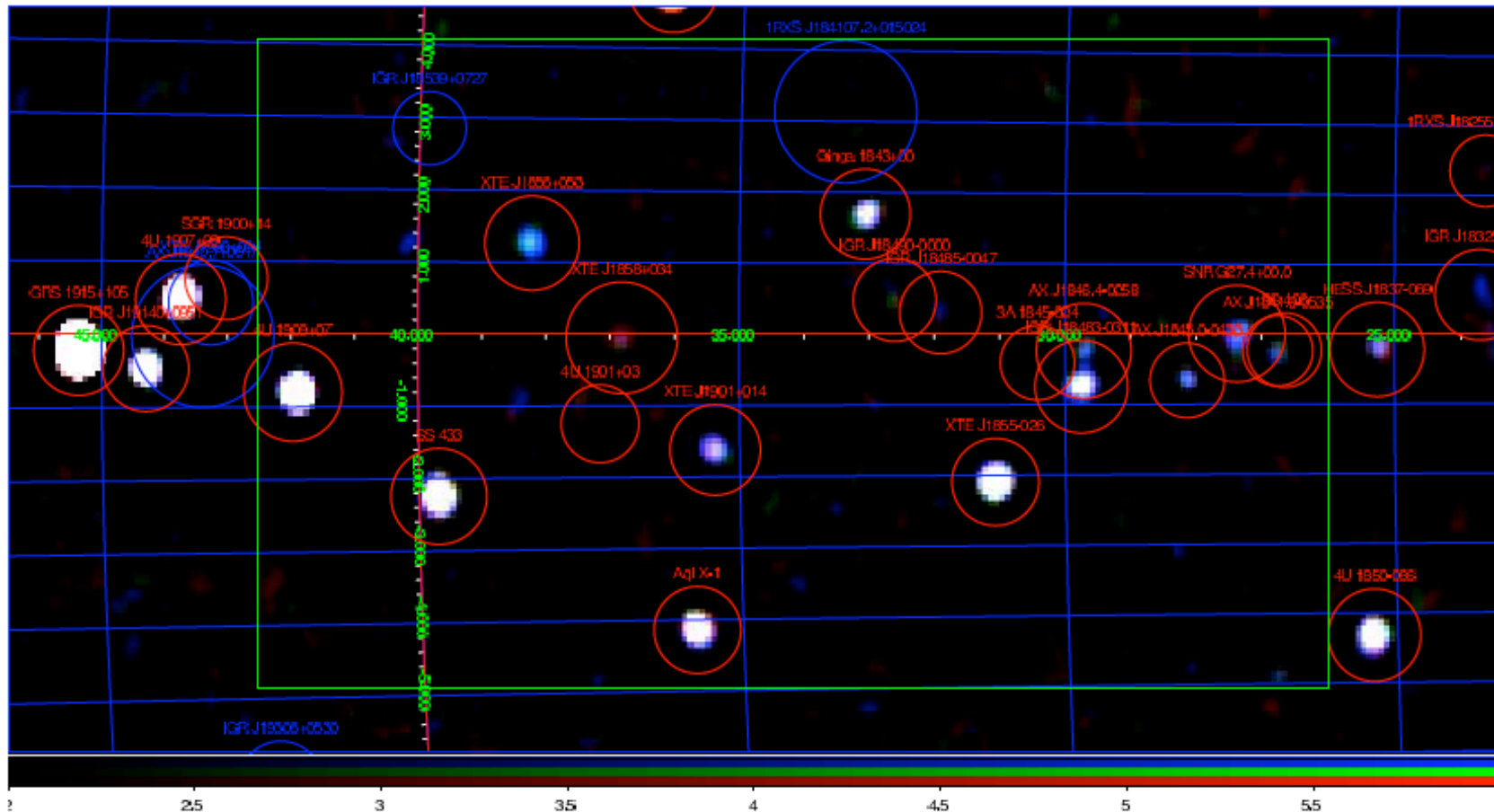


- Neutron star (or BH)
- Companion star with mass $< 1 M_{\odot}$
- Mass transfer occurs when the companion overflows its Roche lobe
- Torque from accretion disk spins up neutron star to msec periods
- Until the RXTE era, it was impossible to detect NS pulsations

Current State of Affairs


- Twelve known millisecond X-ray pulsars
 - First SAX J1808.4-3658 detected in 1998
 - Many are concentrated in galactic center region
 - New in the past several years
 - Transient pulsars
 - Aql X-1
 - NGC 6440 globular cluster (SAX J1748.9-2021)
 - New “Persistent” pulsars
 - IGR J17511-3057
 - New outbursts of known pulsars
 - SWIFT J1756.9-2508
 - XTE J1751-305
 - New discovery strategies
 - Existing PCA scans of galactic center
 - New scans of the Aquila region along the galactic ridge

Galactic Ridge Extension 2009: Aquila Region



Started Feb 2009

RXTE PCA FOV
~1.1 deg radius

 XTE J1751-305

RXTE PCA FOV
~1.1 deg radius

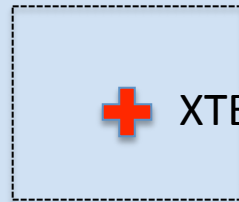
Swift XRT



XTE J1751-305
(not there!)

RXTE PCA FOV
~1.1 deg radius

Swift XRT

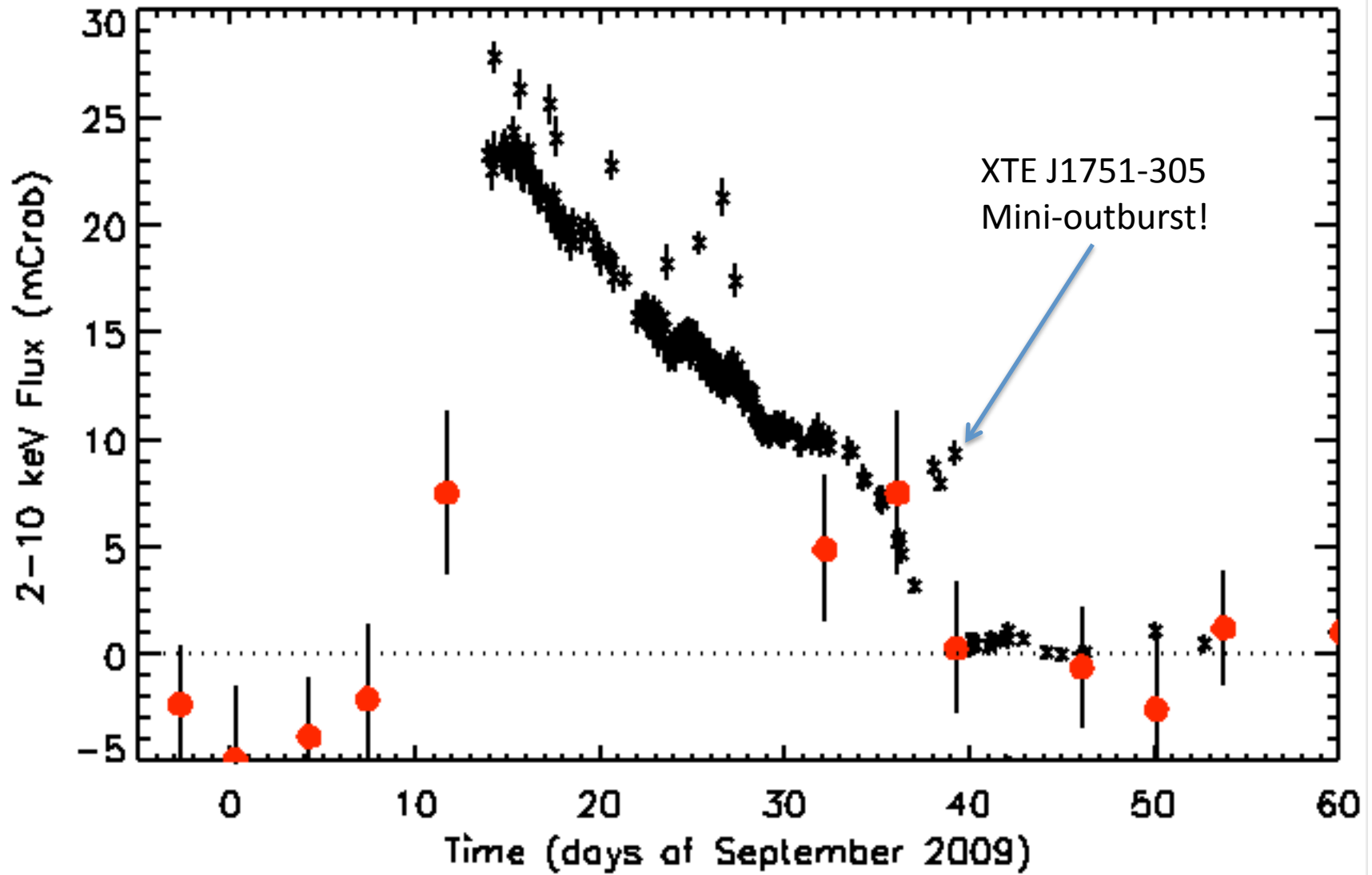


XTE J1751-305

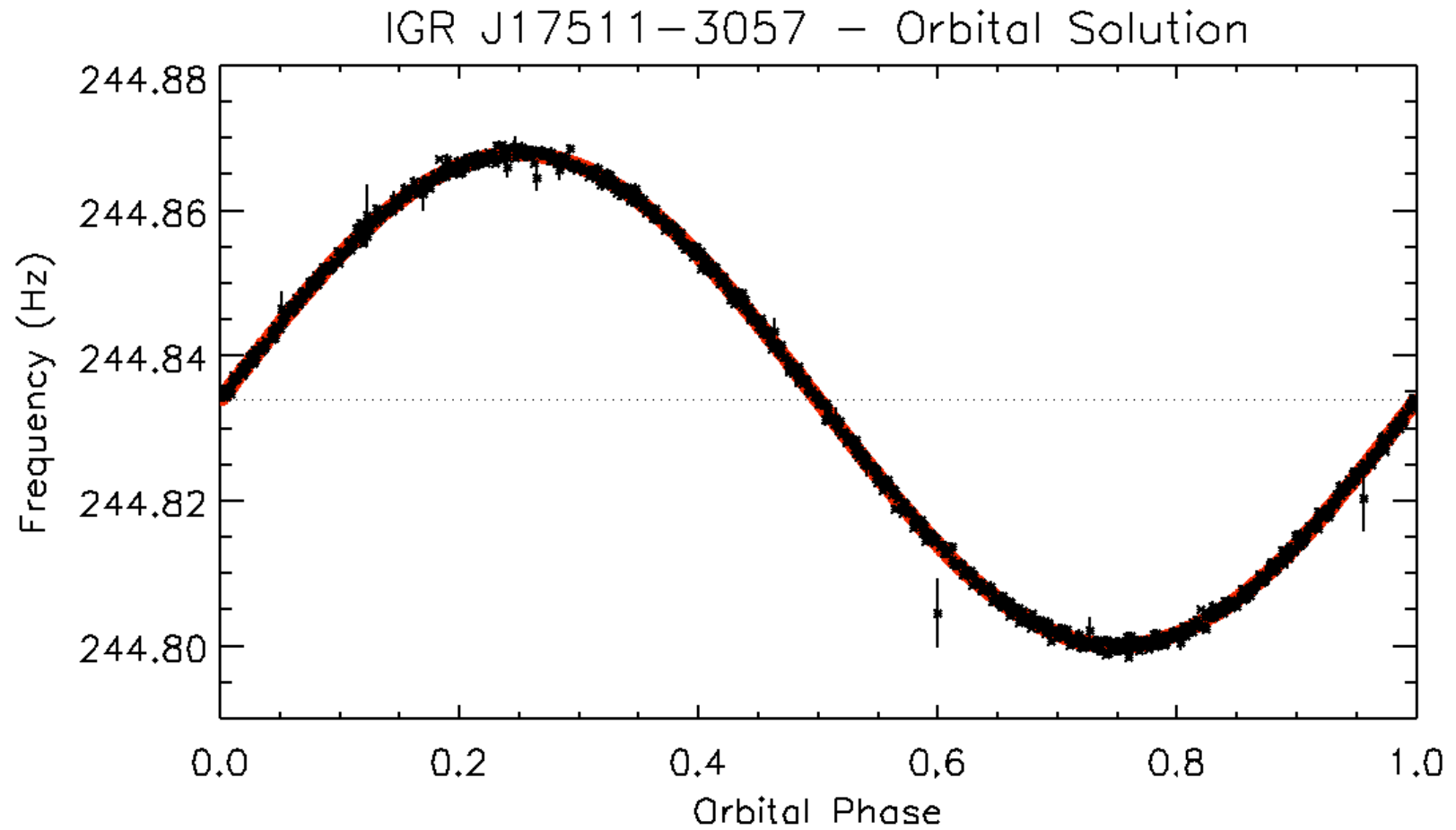


IGR J17511-3057

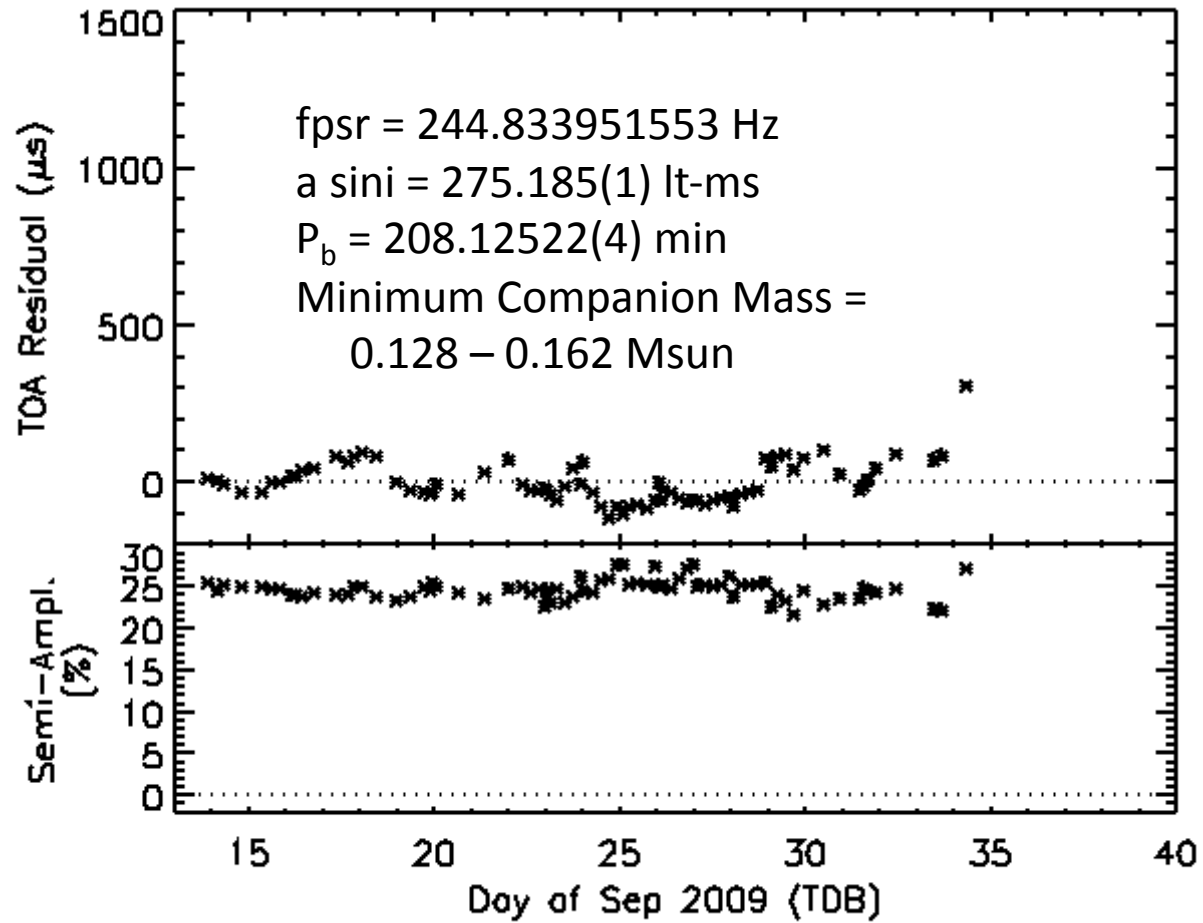
IGR J17511-3057 Outburst



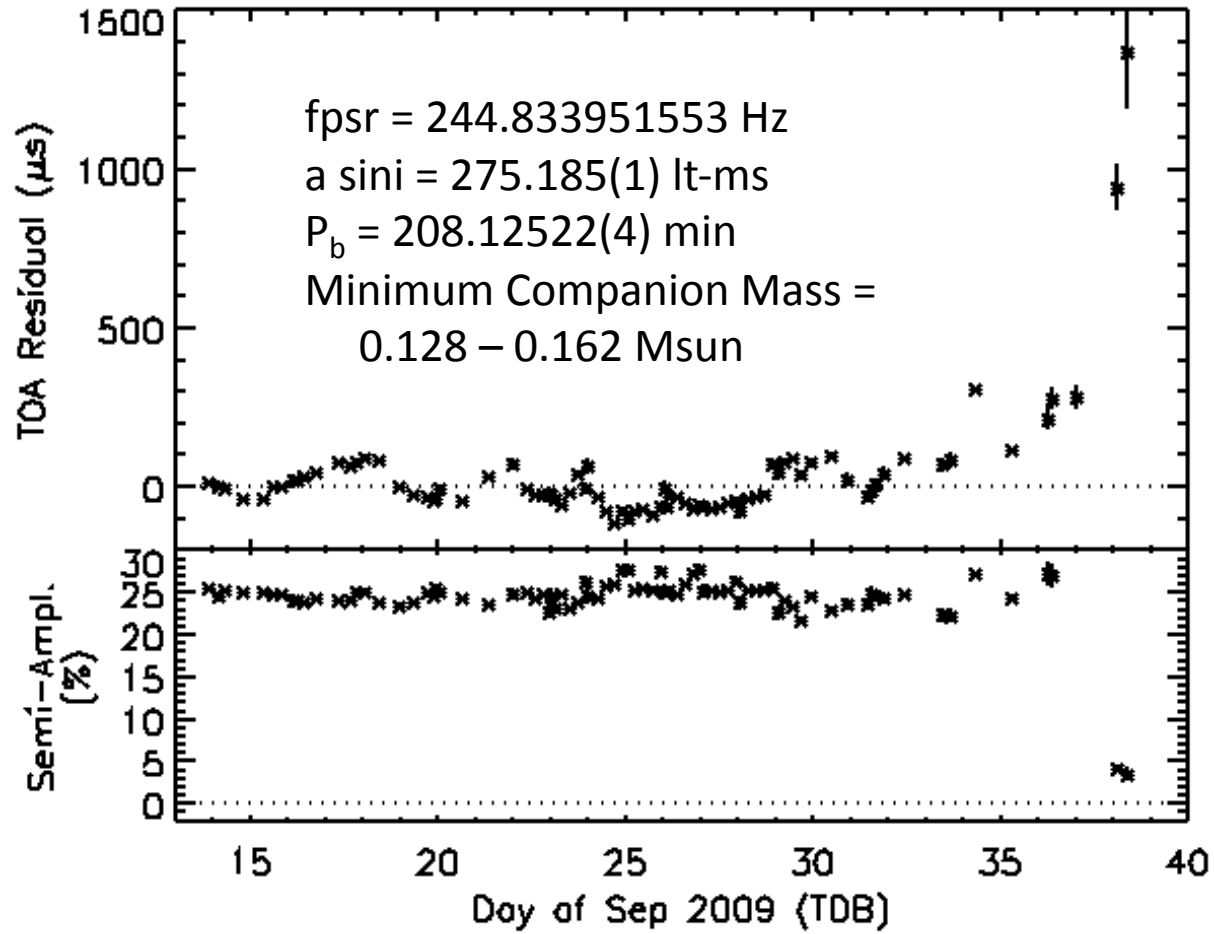
IGR J17511 Orbital Doppler Shift



IGR J17511 Time of Arrival Residuals

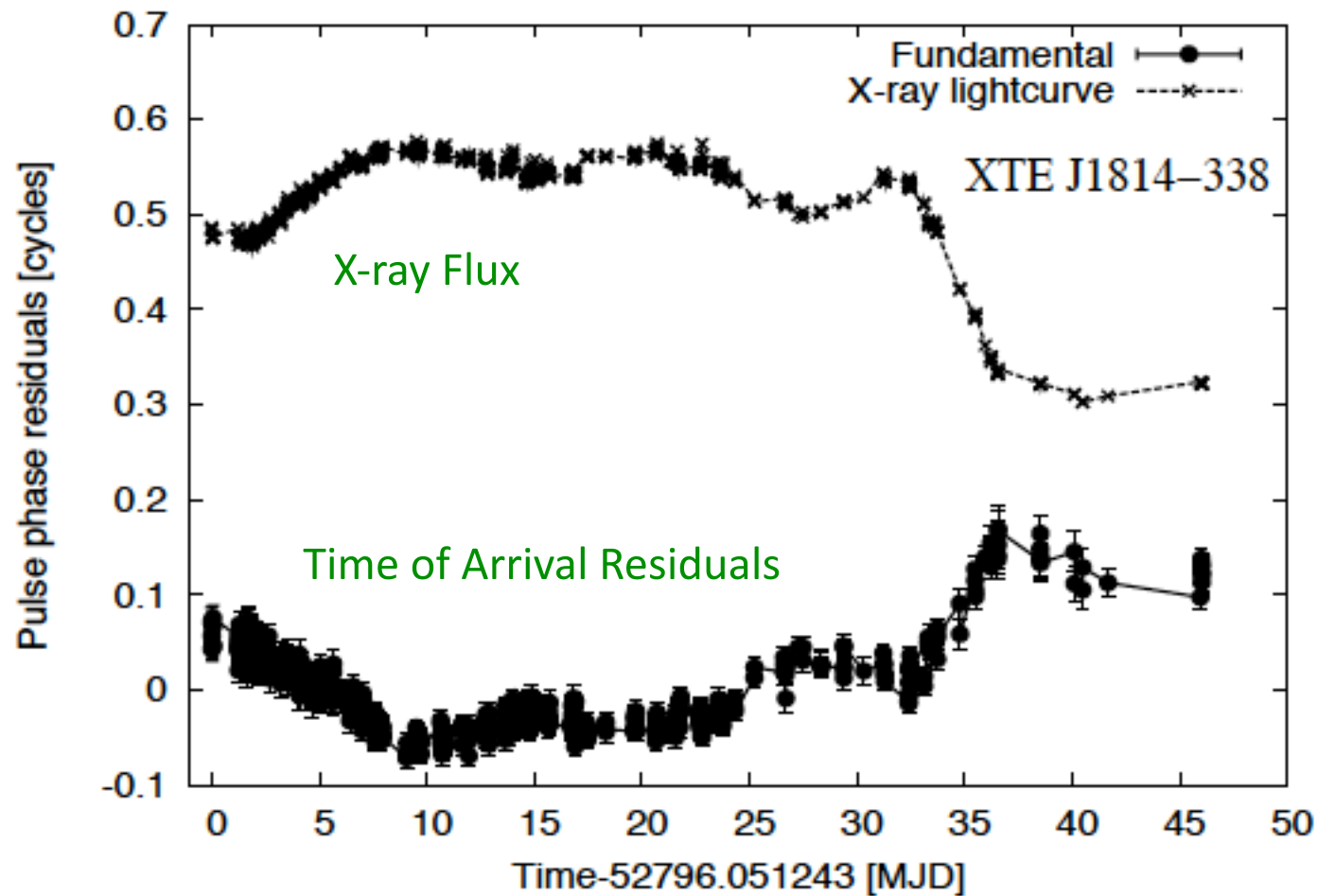


IGR J17511 Time of Arrival Residuals

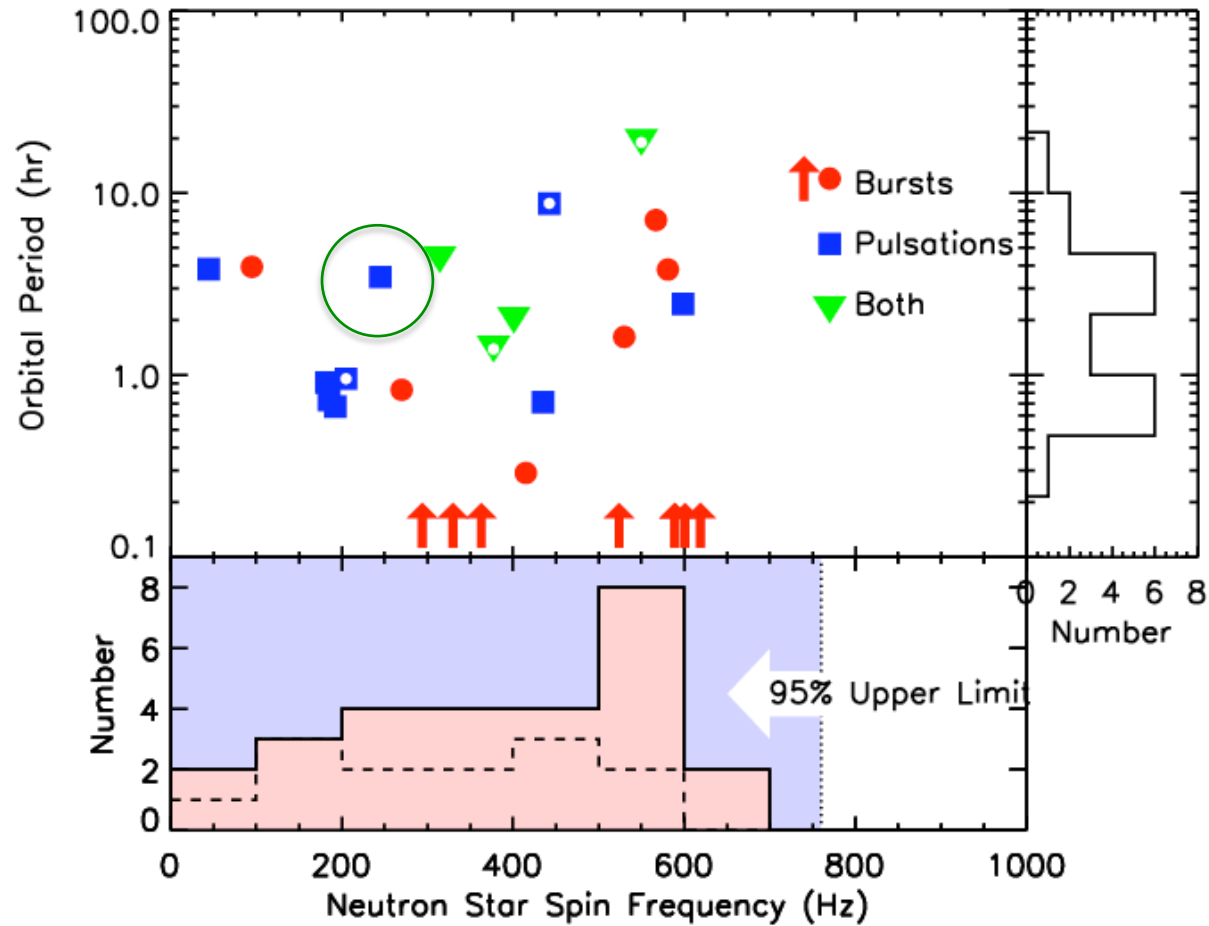


Apparent
spin-Down of
 $\sim 4 \times 10^{-14}$ Hz/s

Comparison to XTE J1814-338



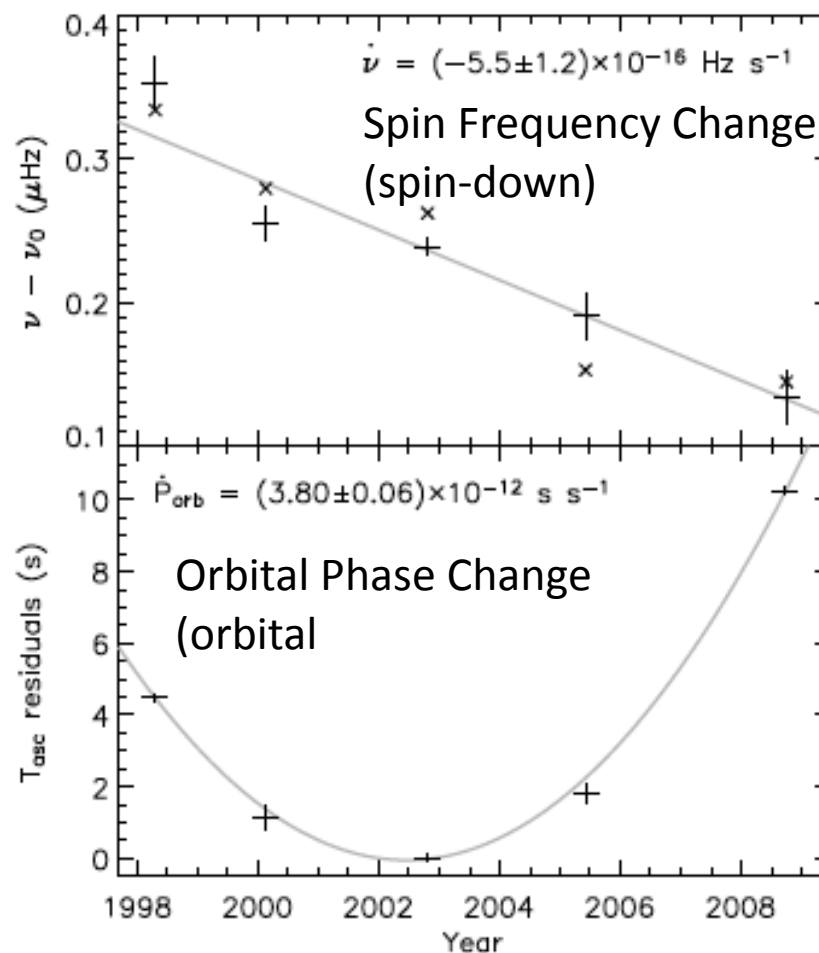
Distributions of Spin and Orbital Periods



U.L. calculated in 2003 by Chakrabarty

SAX J1808.4-3658: Spin and Orbital Evolution

- Detection of long term pulse spin-down
 - occurs primarily between outbursts
 - consistent with magnetic dipole radiation
- Orbital period is lengthening
 - apparently inconsistent with conservative mass transfer
 - ~95% would need to be ejected in a wind
 - Possible comparison to eclipse timing source EXO 0748-676, which has orbital timing jitter



Outlook for the Future

- On average, RXTE detects ~ 1 per year new millisecond X-ray pulsars
 - RXTE is the only mission that can sensitively detect and characterize these systems in detail
 - 37% of them have orbital period < 1 hour
 - several outburst recurrences during the RXTE era (only SAX J1808 has had strong outbursts)
- Changes in observational strategy
 - Ex. Galactic center scans with the PCA
 - Possible future: Monitoring of globular clusters?
- Cross-correlation with LIGO searches for gravitational waves