EPSC Abstracts,
Vol. 4, EPSC2009-4, 2009
European Planetary Science Congress,

RX J0720.4-3125 - a precessing X-ray pulsar?

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Abstract

Among ≈ 2000 known neutron stars (NSs) RX J0720.4-3125 belongs to a group of seven isolated NSs with similar properties - the so called "Magnificent Seven" (see [2] for a review), hereafter M7. These NSs are radio-quiet soft X-ray sources (temperatures of about 45-100 eV) with faint optical counterparts (26 - 28 mag in B filter) emitting as a black body with absorption features in some cases. In contrast to most of the other NSs the M7 have long pulse periods of about 3-12 s and a typical magnetic field strength of $\approx 10^{13}$ Gauss. The black body radiation is supposed to originate from the surface, so that the M7 offer the opportunity to study dense matter under extreme conditions directly.

RX J0720.4-3125 does not only show variations in the X-ray flux indicating the spin period of 8.4 s, but also a long term variability in its spectral properties like temperature, size of the emitting area and equivalent width of the absorption feature (at ≈0.3 keV) on time scales of years ([2] & [3]). Applying a phase coherent timing solution ([4] & [7]) for the period P and a constant derivative $\dot{P}$, RX J0720.4-3125 exhibits relatively large, energy dependent, phase residuals ([2] & [3]). The origin of this behaviour is still unknown, but might be caused by a glitch event ([7]) or precession of the NS ([1]). Incorporating the most recent Chandra HRC/LEGT-S observations supports a periodic variation in the phase residuals approaching a new minimum, which favours the precession model (see Fig. 1). This claim is supported by the switch of the phase shift between hard (400 - 1000 eV) and soft (120 - 400 eV) photons ([3]), but contradicts at theoretic conclusions about the expected behaviour of super fluid matter (see [5]). An unseen companion is most likely excluded ([6].

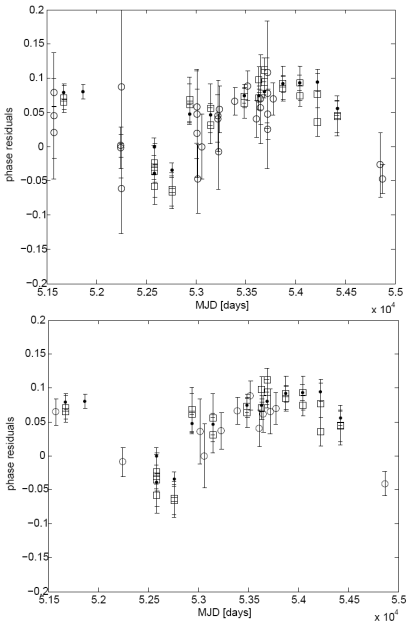

Figure 1: Top: Phase residuals of RX J0720.4-3125 derived using a new timing solution (Hohle et al, in prep.) based on observations of Chandra ACIS and HRC (open circles), XMM-Newton EPIC-pn (dots) and EPIC-MOS (squares). Errors denote the 1σ uncertainty. The Chandra observations with the same instrument setup, which are only hours or days apart are merged to obtain smaller error bars (bottom). Except of the Chandra HRC data, in all cases photons between 400 and 1000 eV are used.

References

[1] de Vries et al. (2004), *A&A*, 415, L31.

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[5] Link, B. (2006), *A&A*, 458, 881.

[6] Posselt, B., Neuhäuser, R., Haberl, F. (2009), *A&A*, in press.

[7] van Kerkwijk et al. (2007), *ApJ*, 659, 149.