33.10

An X-ray view of Millisecond Pulsars

W. Becker, V.E. Zavlin (MPE), G.G. Pavlov, D. Sanwal (PSU)

Millisecond pulsars were studied exclusively in the radio domain until the early 1990's, when ROSAT, ASCA, BeppoSAX and RXTE were launched. Today, after 10 years of dedicated pulsar studies, almost one third of the 36 detected rotation-powered pulsars belong to the group of ms-pulsars. Nevertheless, the origin of the detected X-rays is not well constrained. Whether the group of X-ray detected ms-pulsars has to be divided into hot polar-cap and non-thermal magnetospheric emitters, or whether the emission arises entirely from non-thermal processes, isn't clear so far. The existing data are not conclusive in this respect but observations with XMM-Newton and Chandra will provide the desired sensitivity to finally identify the emission processes. Our contribution will summarize the current observational status and report on new results from the solitary ms-pulsar PSR J0030+0451 and recent Chandra observations of PSR J0437-4715.

33.11

Chandra observation of PSR J0437-4715

V.E. Zavlin (MPE), D. Sanwal, G.G. Pavlov (PSU), W. Becker (MPE)

We present results of the spectral analysis of X-ray data on the 5.75 ms pulsar J0437-4715 obtained in a 25 ks observation with *Chandra* on May, 29-30 (2000). We supplemented the new data with those from *ROSAT* and *EUVE*. We find that all data are consistent only if one assumes a model containing two components, a thermal and a nonthermal. This model suggests that a fraction of the pulsar's X-rays originate from the pulsar's co-rotating magnetosphere, whereas the rest part of the radiation is emitted from hot polar caps on the neutron star surface.

This work is partially supported by a grant from SAO.

33.12

The Orbit and Spin-down of the 34 ms Binary Pulsar SAX J0635+0533

P. Kaaret (Harvard-Smithsonian CfA), G. Cusumano, B. Sacco (IFCAI/ CNR, Palermo)

Modulations detected in the observed spin period of the 34 ms x-ray pulsar SAX J0635+0533 have allowed us to measure the orbital parameters of the system. Combination of observations spanning two years place a lower bound on the intrinsic period derivative of the pulsar of 3.8×10^{-13}. The period derivative implies a high torque on the neutron star which would require a very high mass accretion rate, in excess of $6 \times 10^{-7} M_\odot \mathrm{yr}^{-1}$, if produced via accretion. The torque and x-ray luminosity are both within the range typical of young, rotation-powered pulsars. We suggest that SAX J0635+ 0533 is a very young, less than 1400 year old, rotation-powered pulsar in a binary system.

33.13

The Proper Motion, Parallax, and Origin of the Isolated Neutron Star RX J185635-3754

F. M. Walter (SUNY Stony Brook)

HST WFPC2 obervations over a 3 year baseline have yielded the proper motion and parallax of the isolated neutron star RX J185635-3754. It is the closest known neutron star, at a distance of 62 pc. The projected proper motion of 85 km s^{-1} places the neutron star in the vicinity of the Upper Scorpius OB association, and in close proximity to the runaway O star ζ Oph, about 1.1 million years ago.

I will discuss implications for the radius of the neutron star. The likely age of this neutron star yields a clean point on the cooling curve. On the assumption that RX J185635-3754 was the binary companion to ζ Oph, the kick velocity imparted at birth must have been about 200 km s^{-1}.

This research is supported by STScI.

33.14

Mass and Radius determination of the Isolated Neutron Star RX J185635-3754

J.A. Pons, F.W. Walter, J.M. Lattimer, M. Prakash (SUNY at Stony Brook)

We present an investigation of the mass (M) and radius (R) determination of the isolated Neutron Star RX J185635-3754. We compute non-magnetized model atmospheres and emergent spectra for different compositions and gravities, and discuss model fits to ROSAT, EUVE and HST/ optical data. The spectral energy distribution is consistent with a heavy element (Iron, Silicon) atmosphere, while light element atmospheres seem difficult to reconcile with the data, even with the presence of a strong magnetic field. Our fits allow us to determine the effective temperature and the M/R and R/D ratios. These ratios, together with recent parallax measurements which give a distance to the object of $D \approx 60$ pc, result in the first direct measurement of the mass and radius of a Neutron Star. The implications on the equation of state of dense matter and the possible presence of exotic phases at several times nuclear saturation density are outlined.

33.15

The Cause of the Age Discrepancy in Pulsar B1757-24?

D. Marsden (NASA/GSFC), R.E. Lingenfelter (CASS/UCSD), R.E. Rothschild (CASS/UCSD)

Radio pulsars are thought to spin-down primarily due to torque from magnetic dipole radiation (MDR) emitted by the time-varying stellar magnetic field as the star rotates. This assumption produces a 'characteristic age' for a pulsar which has generally been assumed to be comparable to the actual age. Recent observational limits on the proper motion of pulsar B1757−24, however, revealed that the actual age ($>$ 39 kyr) of this pulsar is much greater than its MDR characteristic age (16 kyr) – calling into question the assumption of pure MDR spin-down for this and other pulsars. To explore the possible cause of this discrepancy, we consider a scenario in which the pulsar acquired an accretion disk from supernova ejecta, and the subsequent spin-down occurred under the combined action of MDR and accretion torques. We find that a simplified model of the accretion torque involving a constant mass accretion rate can explain the age and period derivative of the pulsar for reasonable values of the pulsar magnetic field and accretion rate.

D.M. acknowledges the support of a National Research Council Research Associateship hosted by the NASA/Goddard Space Flight Center, and R.E.L and R.E.R. acknowledge support from NASA.

33.16

Atomic calculation for the model atmospheres of cooling neutron stars

Kaya Mori, C.J. Hailey (Columbia Astrophysics Laboratory)

Complete modeling of radiative transfer in neutron star atmospheres is in progress, taking into account the anisotropy induced by magnetic fields, non-ideal effects and general relativity. As part of our modeling, we present a novel atomic calculation method (Multiconfigurational Effective Potential Method) producing an extensive atomic data set including energy values and oscillator strengths in the so-called Landau regime ($B > 4.7 \times 10^9 Z^2$ G). Conventional atmosphere models for $B = 0$ are not applicable to typical field strengths of cooling neutron stars (B $\sim 10^{12} - 10^{13}$ G), since an atom no longer keeps its spherical shape so the wave functions must be expanded in terms of Landau states and a component along the field. The composition and the configuration of the magnetic field in the atmosphere are presently unknown, so that atomic data must be produced for ground and excited states of several ion states in various magnetic fields. To accomplish this, we reduced computation time significantly by minimizing the iterations in the Hartree equation and treating exchange terms and higher Landau states by perturbation methods. Inclusion of higher Landau states gives us much more