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X-ray emission from the Be star/pulsar system PSR 1259-63

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The collaboration involved researchers at Columbia University (M. Tavani), ISAS-Tokyo (F. Nagase, M. Hirayama), Princeton University (V. Kaspi) for the data analysis part, and UC Berkeley (J. Arons) for the theoretical analysis. Four different ASCA observations of the Be star/pulsar system PSR 1259-63 were successfully carried out in 1994. Data for the first three observations near periastron were analyzed first, and the analysis was completed in 1995 and a summary paper was published by the Astrophysical Journal [1]. The unpulsed X-ray flux observed near periastron is on the average relatively low ($L_x \sim 10^{34}\,\mathrm{erg\,s^{-1}}$) and varies by a factor of a few with a minimum at periastron. The X-ray spectrum is consistent with a power-law of photon index $\sim 1.6 - 1.9$, with no line features and a very low and *constant* column density $N_H \simeq 6 \cdot 10^{21}\,\mathrm{cm^{-2}}$. A search for pulsed X-ray emission resulted in an upper limit for the pulsed fraction amplitude near 10% of the total. These results are in agreement with the calculated properties of the emission powered by a strong shock due to the interaction of the pulsar relativistic wind with its nebular surroundings. The ASCA observations of the PSR 1259-63 system show for the first time that accretion is unlikely to power the emission in binary pulsars with the characteristics of PSR 1259-63.

A fourth ASCA target-of-opportunity observation of PSR 1259-63 was carried out in February 1995 [2], when radio pulsations from the radio pulsar PSR 1259-63 were again detectable. The X-ray emission for this last observation could not be caused by accretion. The ASCA flux and spectrum observed in February 1994 are similar to those observed near periastron a few months earlier, and therefore strongly support the interpretation in terms of shock-powered emission.

A comprehensive theoretical analysis of the X-ray data together with the results of the simultaneous GRO gamma-ray observational campaign [3] was carried out and the results published in a series of papers [4,5,6,7]. We find that the ASCA results can strongly constrain outflow models from the Be

star companion of PSR 1259-63 as well as the radiation mechanisms as the pulsar orbits around the periastron region. The X-ray data suggest a misalignment between the pulsar orbital plane and the Be star outflow equatorial plane. We find that shock-driven emission from synchrotron radiating electron/positrons of the pulsar wind is in agreement with all data obtained. For the first time in a plerionic system, particle acceleration can be shown to be more efficient and fast than inverse Compton and synchrotron radiation cooling of typical timescales near $10^2 - 10^3$ sec. These results are of great importance for the theory of particle acceleration in transverse shocks. A second theoretical paper on the study of the relativistic pulsar wind and shock acceleration mechanisms is being completed [7].

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