The New Gamma-ray Pulsar PSR J2229+6114, its Pulsar Wind Nebula, and Comparison with the Vela Pulsar

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Abstract

We describe in further detail our *Chandra* ACIS-I observation of the newly discovered radio and X-ray pulsar PSR J2229+6114 and its pulsar wind nebula (PWN). With a period of 51.6 ms and spin-down power 2.2×10^{37} ergs s^{-1}, PSR J2229+6114 is a compelling identification for the EGRET source 3EG J2227+6122 in which error circle it resides. PSR J2229+6114 is 3 times more energetic than the Vela pulsar, and its X-ray morphology scales accordingly. Approximately 70% of the 2–10 keV X-ray emission is from a centrally peaked, diffuse nebula of radius 100 arcsec with a power-law spectrum of photon index 1.5 ± 0.2. The pulsar itself has a marginally harder spectrum with photon index 1.0 ± 0.3. Striking features of the X-ray image are an incomplete circular arc, similar to the structures that dominate the appearance of the Vela PWN, and a possible jet. For an assumed distance of 3 kpc estimated from its X-ray absorption column density of 6×10^{21} cm^{-2}, the ratio of X-ray luminosity to spin-down power of PSR J2229+6114 is only 8×10^{-5}, smaller than that of most pulsars, but similar to the Vela pulsar. Surrounding the X-ray PWN and apparently containing it is an incomplete radio shell with a flat radio spectrum that is at least 25% linearly polarized. We discuss a model in which inefficient X-ray emission is the signature of a highly magnetized pulsar wind that prevents an internal MHD shock, as revealed by an X-ray arc, from strongly compressing the flow. The incompleteness of the X-ray arc is shown to be consistent with beamed emission from a moderately relativistic equatorial outflow, while the radio shell is probably the forward bow shock in the surrounding ISM.

An MeV source at this location was previously detected by the COMPTEL experiment on *CGRO*. This, plus its flat X-ray spectrum in the 2–10 keV band, suggests that PSR J2229+6114 is one of the brightest pulsars at 1 MeV, even while it is inconspicuous at radio through X-ray wavelengths, and as steep as the Crab pulsar above 100 MeV. The apparent variety of broad-band spectra displayed by high-energy pulsars bolsters the theory that rotation-powered pulsars dominate the unidentified Galactic EGRET source population. However, a more complete understanding of the physics of this likely γ-ray pulsar awaits a better determination of its distance, for which estimates ranging from 0.8 to 12 kpc have been suggested. We will also evaluate the evidence from the DRAO Canadian Galactic Plane Survey for a larger radio supernova remnant associated with this 10,500 yr old pulsar.

CATEGORY: SUPERNOVAE, SUPERNOVA REMNANTS AND ISOLATED NEUTRON STARS