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The Young Pulsar J1357-6429 and Its Pulsar Wind Nebula

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We observed the young pulsar J1357--6429 with the {\it Chandra} and {\it XMM-Newton} observatories. The pulsar spectrum fits well a combination of absorbed power-law model ($\Gamma=1.7\pm0.6$) and blackbody model ($kT=140^{+60}_{-40}$ eV, $R\sim2$ km at the distance of 2.5 kpc). Strong pulsations with pulsed fraction of $42%\pm5%$, apparently associated with the thermal component, were detected in 0.3--1.1 keV. Surprisingly, pulsed fraction at higher energies, 1.1--10 keV, appears to be smaller, $23%\pm4%$. The small emitting area of the thermal component either corresponds to a hotter fraction of the neutron star (NS) surface or indicates inapplicability of the simplistic blackbody description. The X-ray images also reveal a pulsar-wind nebula (PWN) with complex, asymmetric morphology comprised of a brighter, compact PWN surrounded by the fainter, much more extended PWN whose spectral slopes are $\Gamma=1.3\pm0.3$ and $\Gamma=1.7\pm0.2$, respectively. The extended PWN with the observed flux of $\sim7.5\times10^{-13}$ erg s^{-1} cm^{-2} is a factor of 10 more luminous then the compact PWN. The pulsar and its PWN are located close to the center of the extended TeV source HESS J1356--645, which strongly suggests that the VHE emission is powered by electrons injected by the pulsar long ago. The X-ray to TeV flux ratio, ~0.1, is similar to those of other relic PWNe. We found no other viable candidates to power the TeV source. A region of diffuse radio emission, offset from the pulsar toward the center of the TeV source, could be synchrotron emission from the same relic PWN rather than from the supernova remnant.

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