Suzaku Discovery of Hard X-ray Pulsations from the Rotating Magnetized White Dwarf, AE Aquarii

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Abstract

The fast rotating magnetized white dwarf, AE Aquarii, was observed with Suzaku, in October 2005 and October 2006 with exposures of 53.1 and 42.4 ks, respectively. In addition to clear spin modulation in the 0.5–10 keV band of the XIS data at the barycentric period of 33.0769 ± 0.0001 s, the 10–30 keV HXD data in the second half of the 2005 observation also showed statistically significant periodic signals at a consistent period. On that occasion, the spin-folded HXD light curve exhibited two sharp spikes separated by ~ 0.2 cycles in phase, in contrast to approximately sinusoidal profiles observed in energies below ~ 4 keV. The folded 4–10 keV XIS light curves are understood as a superposition of those two types of pulse profiles. The phase averaged 1.5–10 keV spectra can be reproduced by two thermal components with temperatures of 2.90^{+0.16}_{−0.16} keV and 0.53^{+0.14}_{−0.13} keV, but the 12-25 keV HXD data show a significant excess above the extrapolated model. This excess can be explained by either a power-law model with photon index of 1.12^{+0.63}_{−0.62} or a third thermal component with a temperature of 54_{−4}^{+32} keV. At a distance of 102 pc, the 4–30 keV luminosities of the thermal and the additional components become 1.7_{−0.6}^{+1.3} and 5.3_{−0.3}^{+15.3} \times 10^{29} erg s^{-1}, respectively. The latter corresponds to 0.09% of the spin down energy of the object. Possible emission mechanisms of the hard pulsations are discussed, including in particular non-thermal ones.

Key words: acceleration of particles – stars: white dwarfs – X-rays: individual (AE Aquarii)

V \sim \left( \frac{2\pi R}{P} \right) BR
\sim 6 \times 10^{16} \left( \frac{P}{1 \text{s}} \right)^{-1} \left( \frac{B}{10^{12} \text{G}} \right) \left( \frac{R}{10^{9} \text{cm}} \right)^2 \text{V}
(1)

where R is a typical radius from the NS center at which the electric acceleration takes place.

Magnetized white dwarfs (WDs) are similar systems to pulsars; rotating compact objects with strong magnetic fields. Since a typical magnetized WD has P \sim 5 \times 10^3 s, B \sim 10^6 G, and R \geq 10^9 cm, we expect V \sim 10^{13} \text{ V} from equation (1). Therefore, magnetized WDs should be a promising candidate of new particle acceleration sites, although efficiencies of the particle acceleration and the