Search for non-thermal emission from isolated magnetized white dwarfs with *INTEGRAL*

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Abstract

In order to search for possible non-thermal emission like AE Aquarii (Terada et al. 2008), we picked up magnetized isolated white dwarfs (WDs) in addition to binaries including magnetized cataclysmic variables. Recently, many magnetized WDs are found by Sloan Digital Sky Survey project reaching 9300 objects (Kauwa et al.2006), including WDs showing a magnetic field strength of B $\sim 10^9$ G. 21 objects were selected with known magnetic field strength and spin periods in terms of magnetic dipole momentum. The most promising object was EUVE J0317-855, which has B $\sim 4.5 \times 10^9$ G and spin period of 725 sec. Among them, non thermal emission from best ten objects were searched from the archive data-sets with *INTEGRAL* IBIS/ISGRI in 20 - 40 keV band. As a result, no significant emissions were detected from these WDs with *INTEGRAL* sensitivities, and estimated upper limit of their flux as $2.8 \times 10^{-12} \sim 3.0 \times 10^{-11}$ erg $s^{-1}cm^{-2}$.

Key words: acceleration of particles - isolated magnetized white dwarf

1. Introduction

Since the discovery of cosmic-rays by Hess in 1912, the origin of high-energy particles and the mechanism of the acceleration have remained a long-standing mystery for 100 years. Among many candidates of cosmic-ray origins, neutron stars and supernova remnants have been argued as the Galactic cosmic-ray origins. However, numerically the number of these objects may not be sufficient to explain the whole flux and the spectrum of the cosmic-rays. Are their any other particles accelerator? Hillas-plot (Hillas 1984) suggests white dwarfs (WDs) may be candidates as another particle accelerator. In fact, recently, *Suzaku* discovered a possible non-thermal pulsation from a magnetic WD, AE Aquarii (Terada et al. 2008), like neutron star pulsars. The pulses may exhibits non-thermal emission from accelerated particles.

2. Selection of isolated magnetized white dwarfs as particle accelerator

The next step is to search for a possible non-thermal emission from a normal white dwarf including not only those in binaries but also isolated WDs. No systematic searches from isolated magnetized WDs have been performed as particle accelerators. Recently, many magnetized WDs are found by Sloan Digital Sky Survey project, reaching 9000 objects (Eisenstein et al. 2006).Among list, 480 objects have strong magnetic fields above 10^4 G (Kauwa et al. 2006) and objects in 480 magnetized WDs are measured their spin periods. We sorted these objects in the P-B diagram as shown in Fig.1, to evaluate their electric potentials and their magnetic dipole radiation energy. The most promising object was EUVE J0317-855, which has B $\sim 4.5 \times 10^9$ G, spin period of 725 sec. This object has magnetic dipole radiation $E_{\rm rad} \sim 1.1 \times 10^{29}$ erg/s larger than that of AE Aquarii 3.2×10^{28} erg/s.

3. *INTEGRAL data analysis*

We searched for non-thermal emission from isolated magnetized WDs listed in section 2 with *INTEGRAL* IBIS/ISGRI in 20 - 40 keV band from launch to the end of July 2009. After reconfirmation of detection of magnetic cataclysmic variables with INTEGRAL by Bird et al.2007, we found any significance signal from no isolated WDs. In table 1, we estimated 3-sigma upper limits.

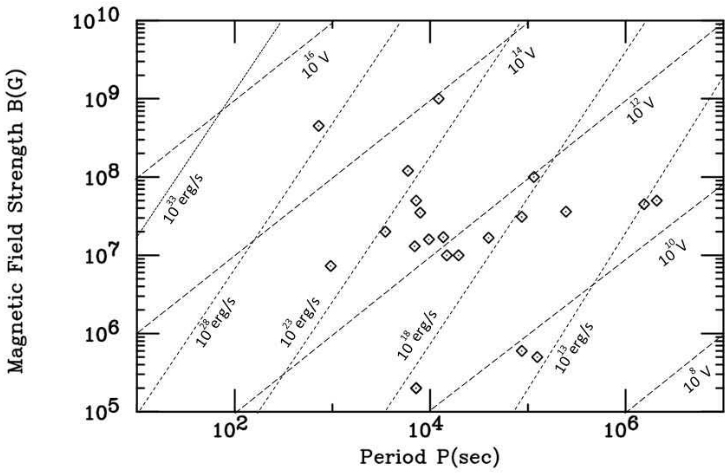

Fig. 1. P-B diagram : isolated magnetized white dwarfs , long dot line: electric potential, dot line : magnetic dipole radiation energy

Table 1. target parameters and results of data analysis

object name	P (sec)	B (MG)	$E_{\rm rad}$ (erg s^{-1})	Flux (erg s^{-1}cm^{-2})	Exposure (ksec)
EUVE J0317-855	725	450	1.1×10^{29}	$< 6.3 \times 10^{-12}$	1211
LHS 1734	960	7.3	9.4×10^{24}	$< 1.0 \times 10^{-11}$	857
PG 1031+234	12239	600	2.4×10^{24}	$< 2.0 \times 10^{-11}$	355
PG 1015+014	5925	120	1.8×10^{24}	$< 2.3 \times 10^{-11}$	129
G 99-47	3492	20	4.0×10^{23}	$< 6.3 \times 10^{-12}$	962
HE 1211-1707	7200	50	1.4×10^{23}	$< 6.3 \times 10^{-12}$	1019
Feige 7	7896	35	4.7×10^{22}	$< 2.3 \times 10^{-11}$	192
GD 356	6938	13	1.1×10^{22}	$< 1.7 \times 10^{-11}$	490
HE 1045-0908	9720	16	4.3×10^{21}	$< 2.0 \times 10^{-11}$	258
KPD 0253+5052	13644	17	1.3×10^{21}	$< 4.2 \times 10^{-12}$	2236

4. Results

We found no significant detection from these WDs with *INTEGRAL*, and estimated upper limit of their flux as $2.8 \times 10^{-12} \sim 3.0 \times 10^{-11}$ erg s^{-1}cm^{-2} (Table.1). The obtained upper limits are still larger than we expected for the magnetic WDs, as far as we assume pulsar analogy. We need better sensitivity to detect the expected non-thermal emission from magnetic WDs. We have a plan to observe isolated magnetic WDs with *Suzaku*, having sensitivity $\sim 10^{-13}$ erg s^{-1} cm^{-2}.

References

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