White Dwarf Pulses Like a Pulsar, Discovered by *Suzaku*

New inspects to the mystery of the origin of Cosmic rays, discovery of a new candidates

Yukikatsu Terada

Tel&FAX: +81-48-858-3365

E-mail: terada@phy.saitama-u.ac.jp

【Long mystery】 What is the cosmic rays?

High energy particle in the Universe

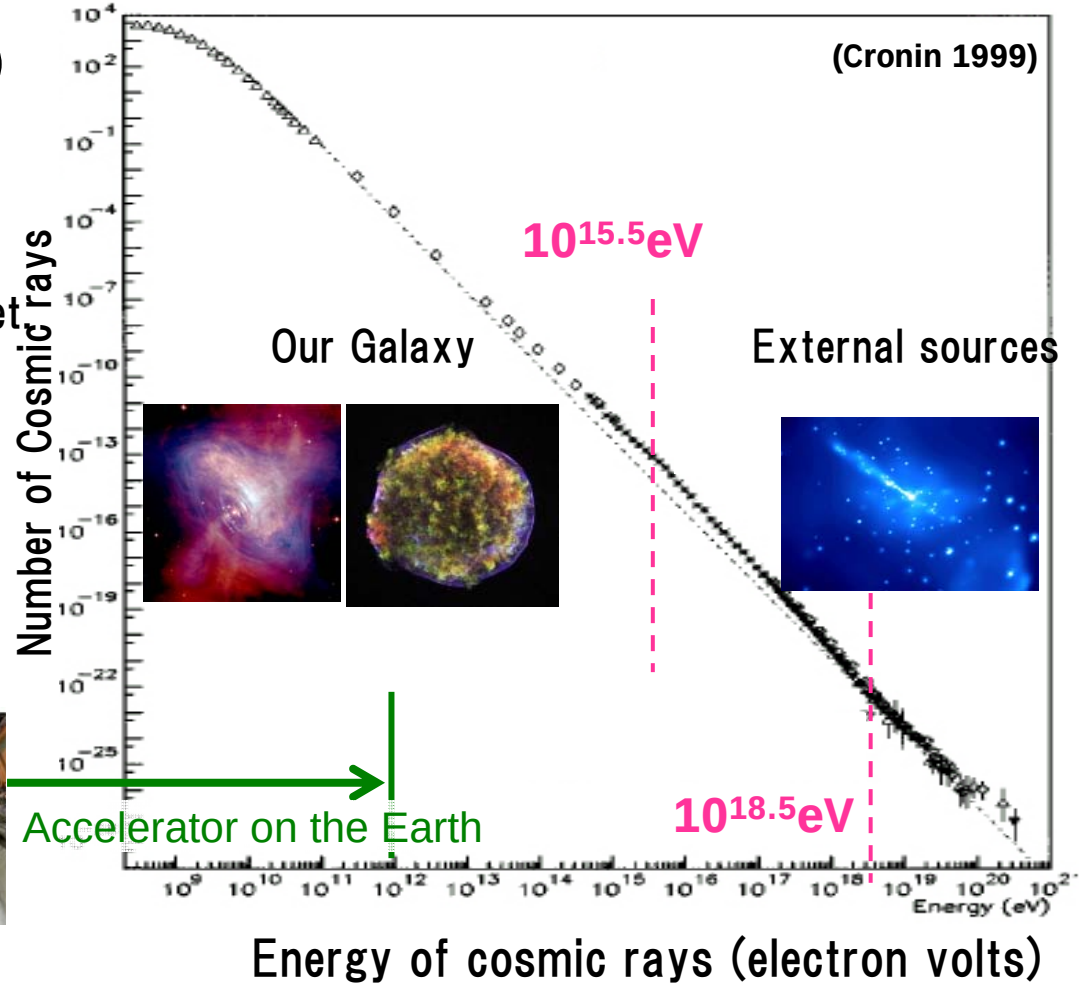
1912 discovered by Hess
(1934 got the Nobel prize)

Feature 1. Ultra high energy

there exist particles with huge energy,
where human beings could not reach yet

Feature 2. Commonly exists

Basic elements in the Universe
~1 c/cm^2/s



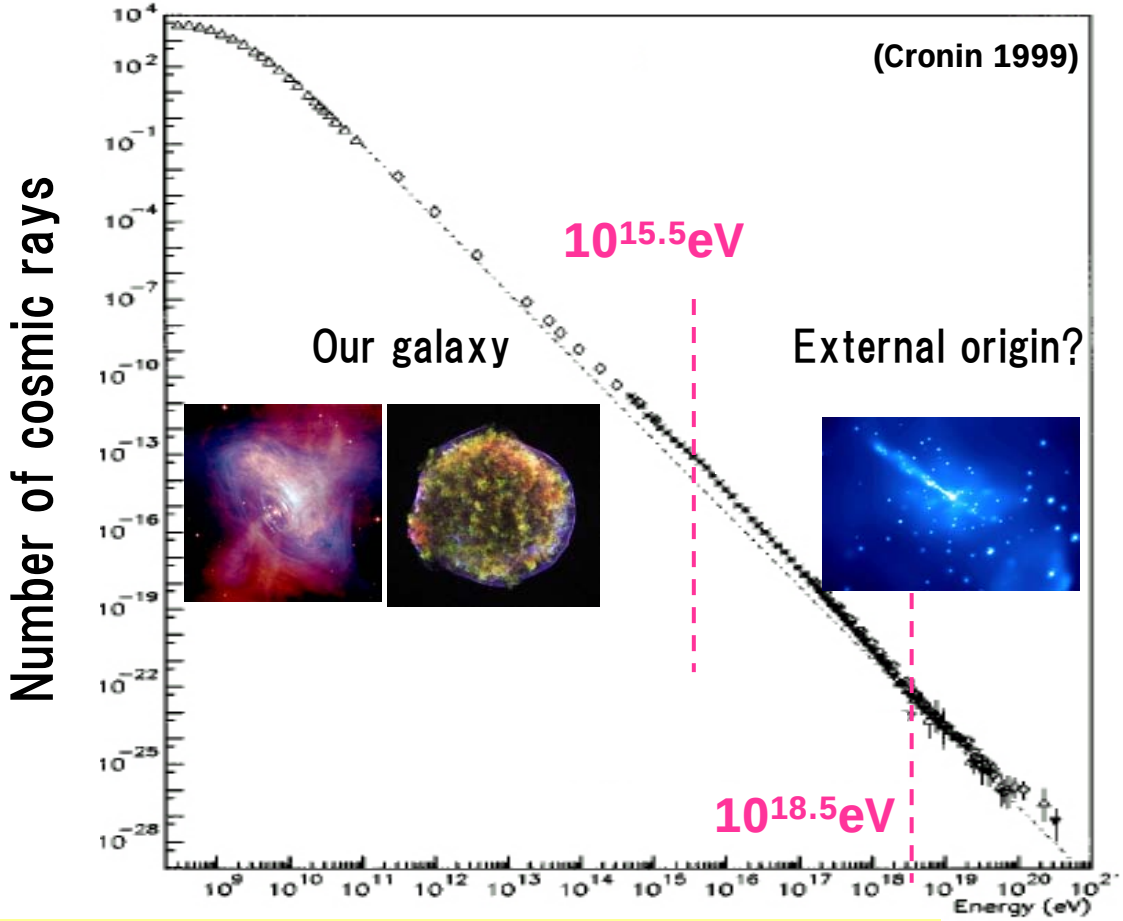
There exists many active particles around us.

【long mystery】 What is the origin of Cosmic rays

Long mystery of near 100 years!

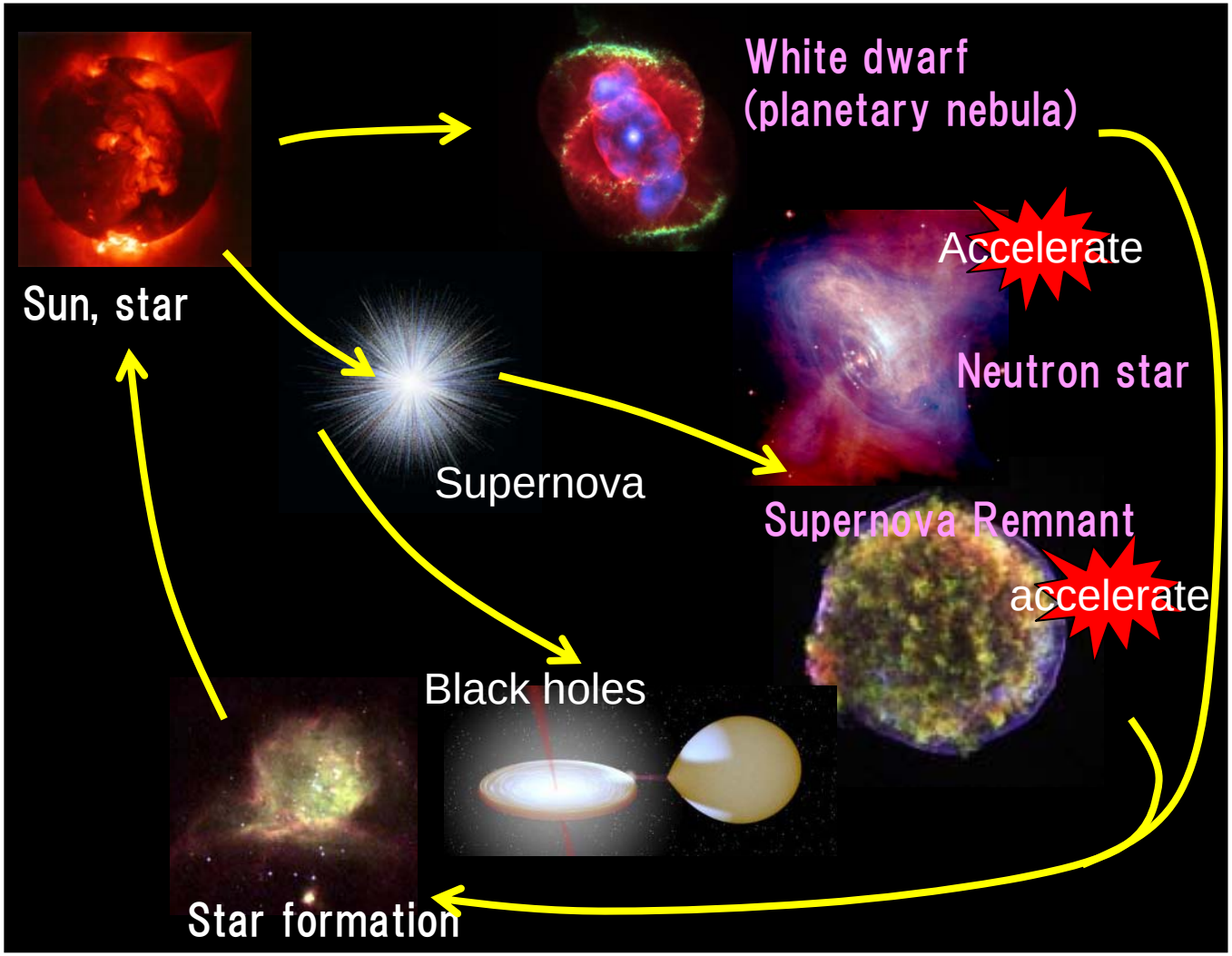
Canditates:
- Neutron star pulsars
- Supernova remnants
- etc..

But, number is small.



One of the important mystery to solve for the Physics.
There should be an unknown accelerator in the universe!

Star's life:
White dwarfs, Neutron stars, Black holes



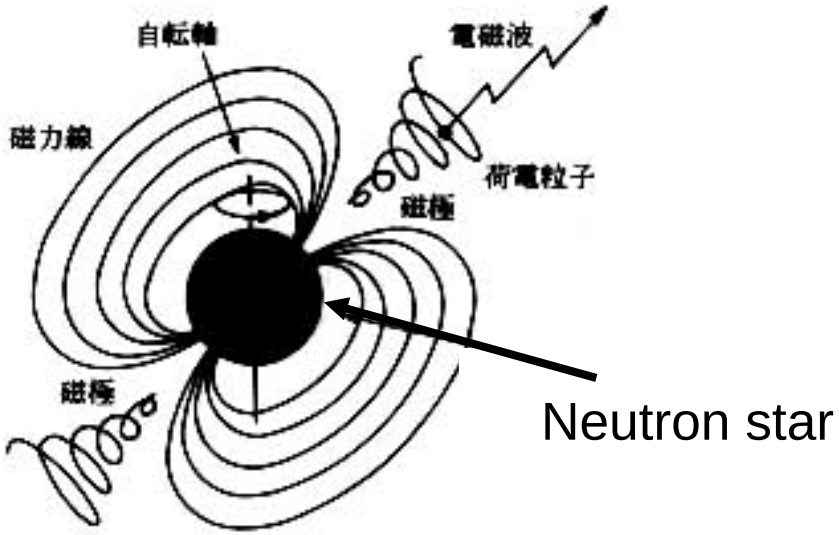
White Dwarfs
numerous!
(one is WD around 3 stars)

Neutron Star
Some are the accelerator
small number

Supernova Remnant
Some are the accelerator
small number

Particle acceleration in the Neutron star Pulsars

Acceleration site (generation of Cosmic rays): Neutron star pulsars



Size 10 km
Magnet 10^{12} ～ 10^{13} Gauss
Rotation period a few ms ～ s
Induced Electric potential 10^{16}～10^{18} Volts

Dynamo of bicycles

Size a few cm
Magnet 100 ～ 1000 Gauss
Rotation period a few hundred ms ～ s
Induced Electric potential 1～5 Volts

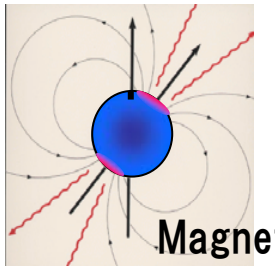
- Electric field is induced by a rotating magnetic field
- Charged particles are accelerated by the induced electric field

→ Generation of cosmic rays
but,, number is small to account for all the cosmic rays

【Our idea】
White dwarfs should be a Pulsar？

① White dwarfs with strong magnetic field can generate high energy particles

Neutron Stars



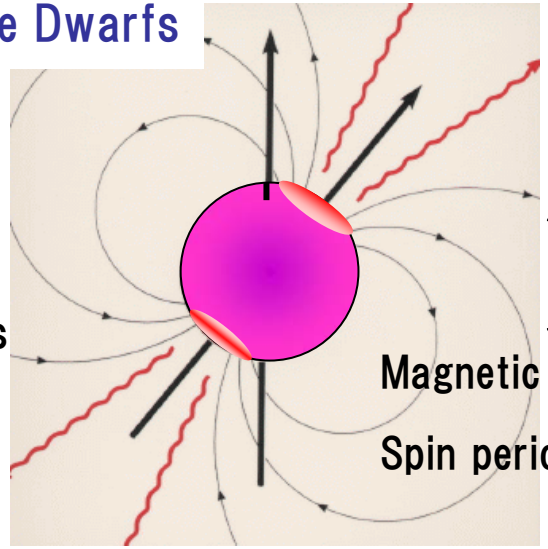
Size～10 km

Magnetic field～10^{12}—10^{13}Gauss

Spin period～a few ms—s

Induced potential ～10^{16}—10^{18} Volts

White Dwarfs



Size～10000 km

Magnetic field～10^{5}—10^{7}Gauss

Spin period～a few sec—hr

Induced potential～10^{14}—10^{16} Volts

White dwarfs can generate high energy particles!
although nobody considered them as a acceleration site,

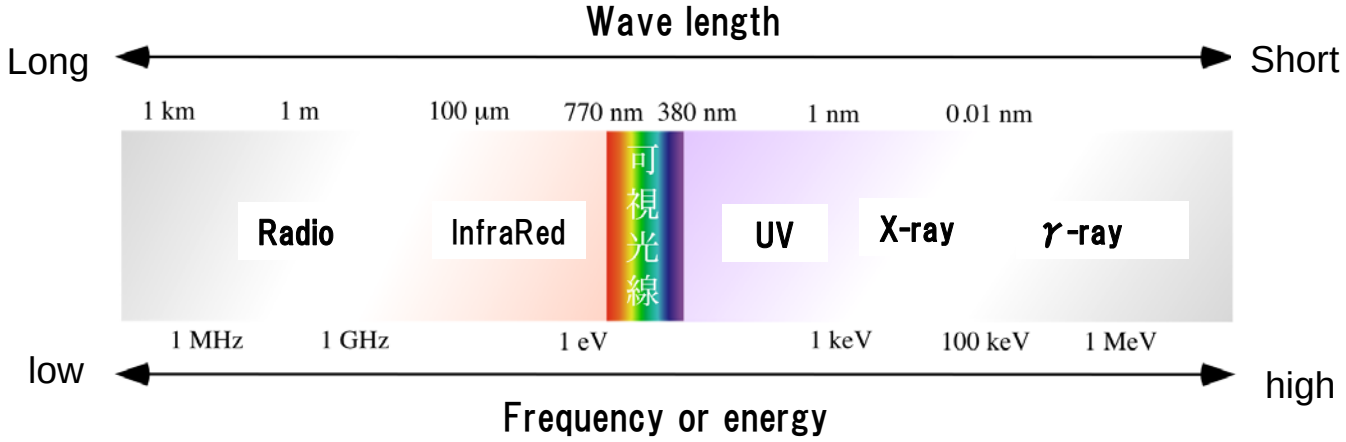
② White dwarfs exists about three order of magnitude than neutron stars

Too many white dwarfs around the Earth!

→ White dwarfs can be a quiet but numerous accelerator

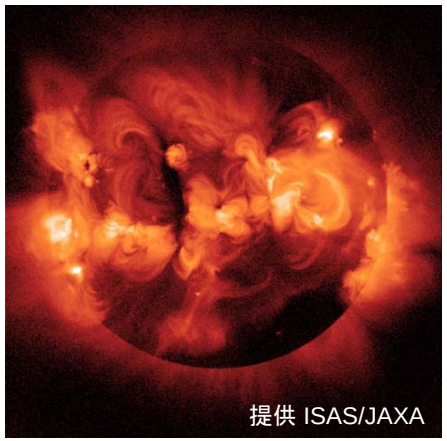
【X-ray universe】

X-rays = wave with higher energies than visual lights



We can observe very active universe with X-ray lights

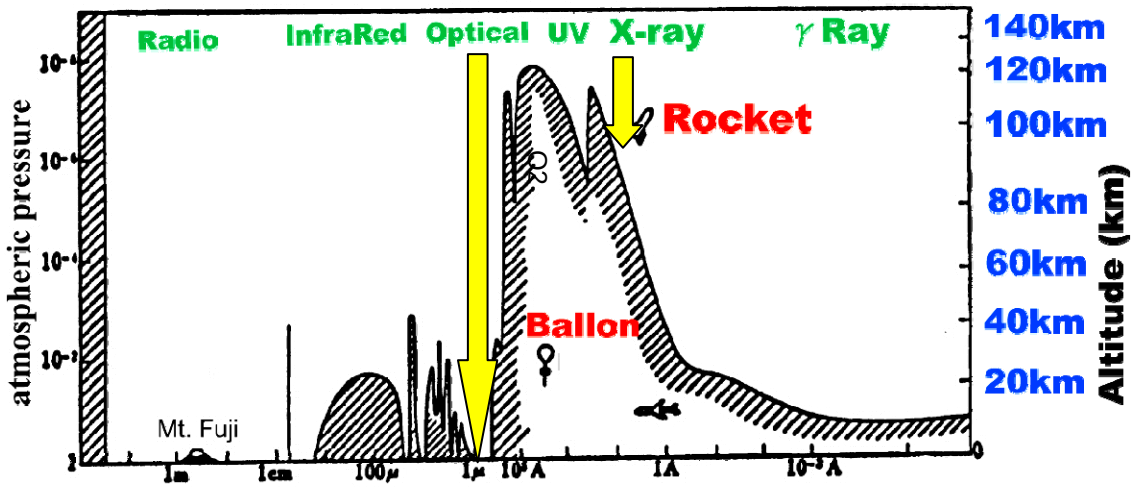
Sun with visual lights



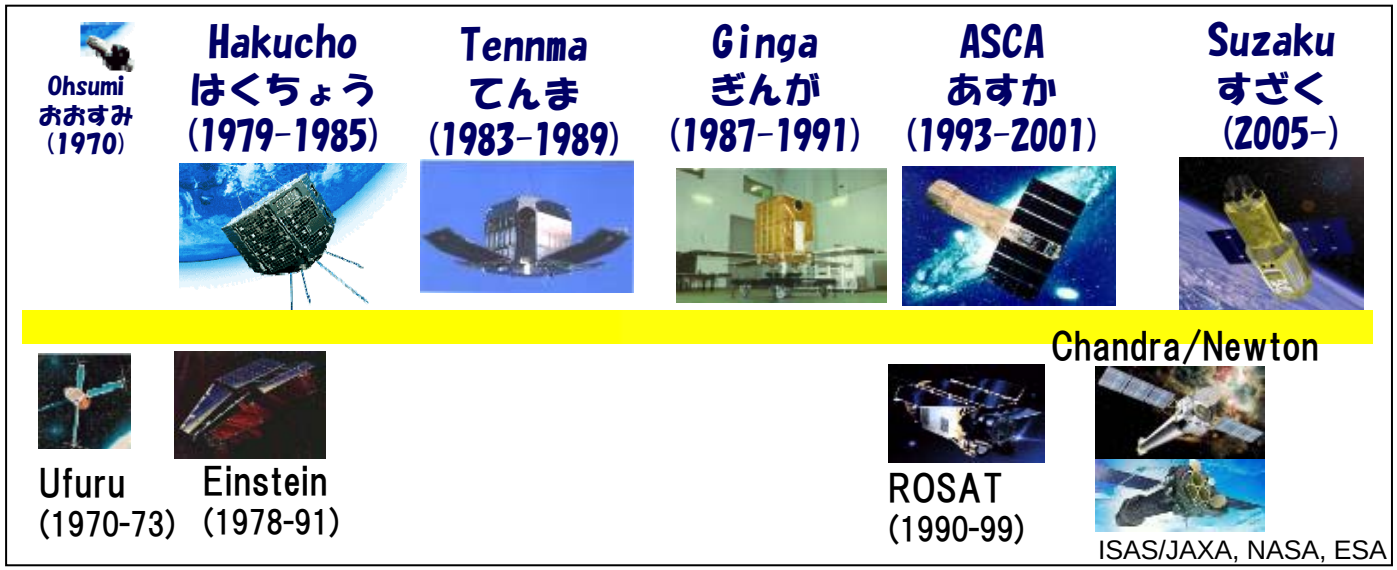
Sun in the X-ray

【X-ray Universe】

X-ray observation: should go out to the Space!



X-ray satellites



For Press release 2008.1.17

【X-ray universe】Japanese-US X-ray satellite *Szaku*

launch: 10th July 2005, 03:30UT

Me Suzaku

Credit ISAS/JAXA

Detectors

- X-ray CCD camera (0.3– 12 keV)
  spectroscopy & Imaging with low background
- Hard X-ray detector (10 – 600 keV)
  spectroscopy with the highest sensitivity

Make the best use of the Suzaku sensitivity!

Saitama University: development and maintenance of the detector

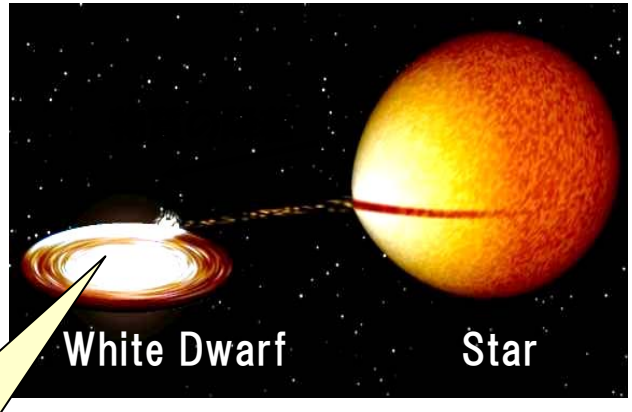
【Observation with Suzaku】 Magnetized white dwarf, AE Aquarii

Purpose：Search for possible signals of particle acceleration from white dwarf

Most promising object: AE Aquarii

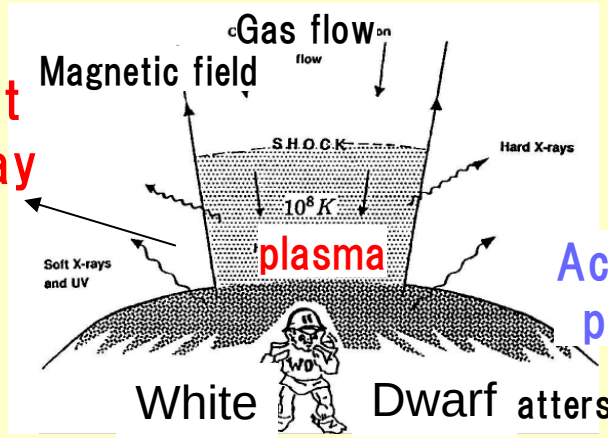
- Binary system with a magnetized white dwarf
- Fastest spin period around this class (33 sec)
- Previous repots with Radio and TeV gamma-rays.
- Stable Spin down. (～5×10^{33} erg/s)

Image of magnetized white dwarf binary



On the magnetic pole of the white dwarf

Search for hard X-ray signals in the intense soft X-ray lights from a plasma



Soft X-ray

Hard X-ray

Accelerated particles?

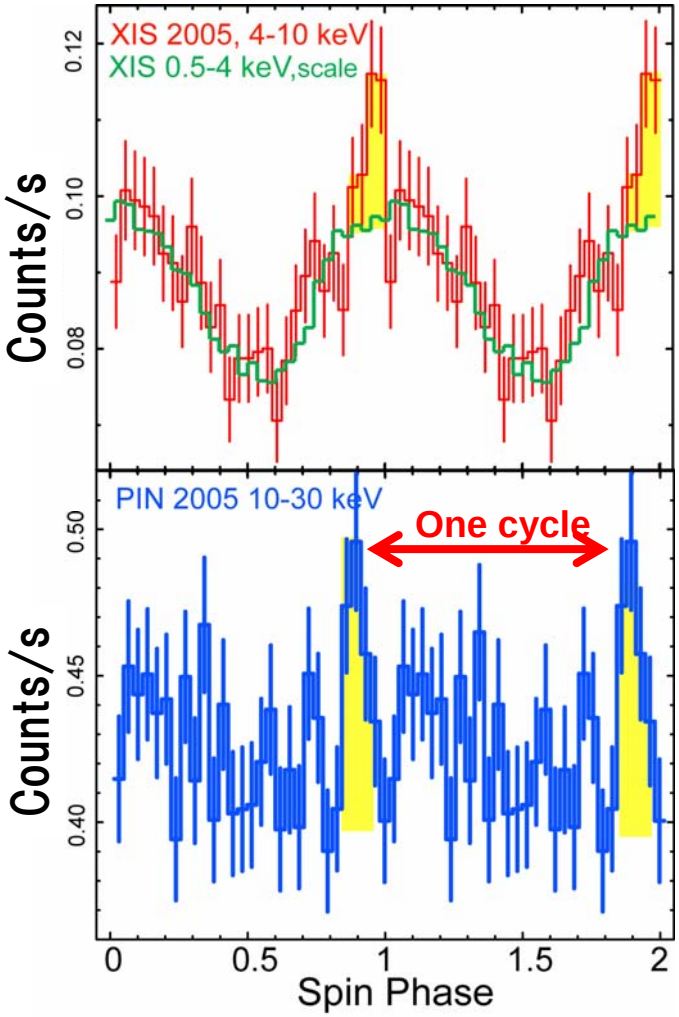
atterson '91)

Suzaku Observations
30 October 2005 &
25 October 2006
(twice)

For Press release 2008.1.17

【Observation with Suzaku】
Discovery of Hard X-ray pulsations!

X-ray modulation with spin period



Green:Soft X-ray(0.5～4 keV)
Red: Hard X-ray(4～10 keV)

Blue: Hard X-ray(10～30 keV)

Sharp Pulses seen
only in the hard X-ray band

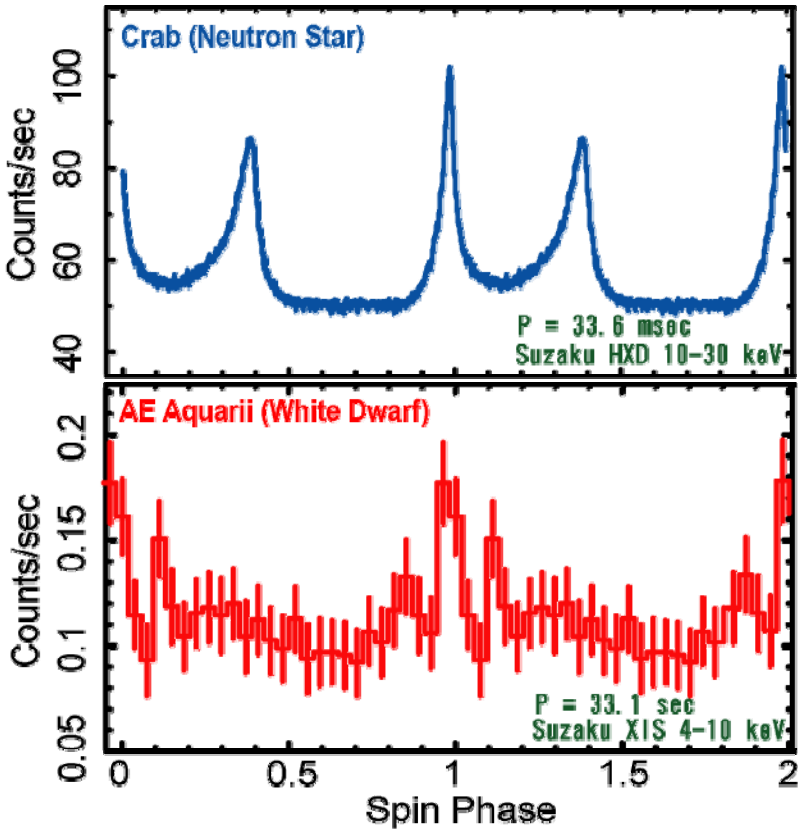
New discovery!

Will be published on PASJ vol 60. No.2

【Observation with Suzaku】
Similar signals with Neutron Star pulsars

Neutron Stars　　Crab

White Dwarfs　　AE Aquarii

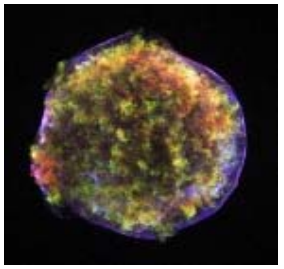


"AE Aquarii seems to be a white dwarf equivalent of a pulsar" says Terada.
(from NASA news)

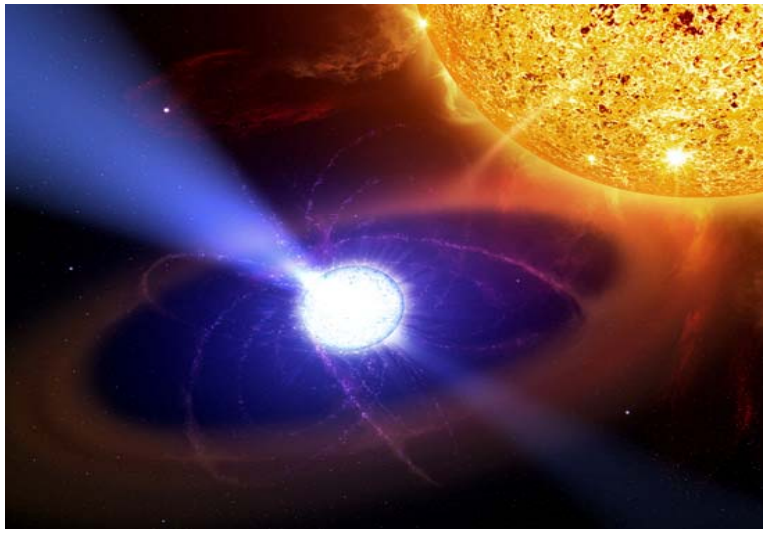
If it is true, white dwarfs may be a quiet but numerous acceleration site.
New steps of the research of Cosmic-rays of 100 years mystery.

【Summary】

Ultra high energy particles in the Universe: Cosmic rays
Although they are common in the Space, the origin is the long standing mystery of near 100 years.



Candidates in our Galaxy:
Neutron stars and Supernova remnants,
But number is small to account for all the cosmic rays.



Our Idea:
white dwarfs as particle acceleration site.
Discovery with Suzaku: Hard X-ray pulsation.

May be a white dwarf equivalent of pulsars, which have a potential to be a quiet but numerous particle-acceleration site.

Suzaku show a new possibility of cosmic ray site.
One step point to solve the mystery.