Suzaku Observation of HESS J 1825-137; Discovery of an unusually extended X-ray pulsar wind nebula of PSR J1826-1334 H. Uchiyama, H. Matsumoto, T. G. Tsuru, K. Koyama

We observed the brightest part of HESS J1825-137 with the Suzaku XIS, and found that diffuse X-ray emission extends at least up to 15' (~17 pc) from the pulsar PSR J1826-1334, which is farther than previously reported. We made spatially resolved spectra and studied the dependence of the emission properties on the distance from the pulsar. The spectra have no emission line, and they can be fitted with an absorbed power-law model. Thus the X-rays can be understood as synchrotron X-ray emission from a pulsar wind nebula. The photon indices are spatially constant at $\Gamma=2.0$, except for the neighborhood of the pulsar where $\Gamma=1.7$. We made a direct comparison of the spectral energy distribution between the Suzaku and H.E.S.S. results, and found that the distribution can be explained by high energy electrons of a single population in a magnetic field of $\sim 7\mu$ G. If electrons emitting the X-rays are accelerated only at the pulsar, these facts indicate that the electrons are transported over 17 pc within its synchrotron lifetime. This condition requires that the transportation has a velocity of at least 8.8×10³

1. Introduction; Previous observations B HESS J1825-137 PSR J1826-1334 (B1823-13) H.E.S.S TeV y excess map XMM MOS Pulsar 0.5-10keV PSR J1826-1334 -13. ~36nc PWN

Radio:Pulsar

•Spin-down luminosity ~ 2.8×10³⁶ erg s⁻¹ •Characteristic age 21.4 kyr (Clifton 1992) → characteristic of "Vela-like" Pulsar •Radio PWN and SNR have not been found. ·Distance ~4 kpc (by dispersion measure)

1arcmin~1.2pc@4kpc

Gaensler et al. 2003

X-rav[.]PWN •Diffuse emission extending mostly to the south has been found. (Gaensler 2003, Pavlov 2008) The diffuse component is ~5' in extent, but it was not clear whether the diffuse component is extended farther or not due to the high NXB background of XMM-Newton

•Diffuse component: $\Gamma \sim 2.3$ N_H~1.4×10²²/cm² L_x~3×10³³ erg s⁻¹

(Gaensler 2003)

12 100 80 -14. @4kpc RA J2000 (hours) VHE γ-ray:PWN

•H.E.S.S. detected widely extending VHE γray emission ~1°.(Aharonian 2006)

 $\cdot \gamma$ -ray spectra show a softening of Γ with the distance from the pulsar

 -L_{VHEγ} ~ 3×10³⁵ erg s⁻¹
 •There seems little X-ray emission coming from the y-ray peak which is separated from the pulsar by 10

We searched dim X-ray emission from the VHE γ-ray peak position with Suzaku. Due to the low-earth orbit, the NXB level of



Radial Profile & Background Evaluation





•Radial profile of the surface brightness in the 1.0-9.0 keV band. The NXB is subtracted and the vignetting is corrected. The vertical error bar of each data point is the 1σ error. The position of the peak of VHE v-ray emission is shown by a vertical broken line.

•The intensity of the source is 5.0×10^{-4} photons/s/arcmin² larger than that of the background outside 10'. We evaluated the fluctuations of unresolved point sources, Galactic ridge X-ray emission (GRXE), cosmic X-ray background (CXB) and the systematic error of oductivity of non X-ray background

Topicaded my of non-stray background.		
Excess of the source compared with the background	5.0 × 10 ⁻⁴	this work
(a)Fluctuation of unresolved point sources (95% error level)	<1.2 × 10 ⁻⁴	1
(b)Fluctuation of GRXE (95% error level)	<1.1 × 10 ⁻⁴	2,3
(c)Positional dependence of GRXE	9.8 × 10 ⁻⁵	3
(d)Fluctuation of CXB (95% error level)	<2.4 × 10 ⁻⁵	4,5
(e)Systematic error of of the reproductivity of NXB (95% level)	<1.6 × 10 ⁻⁵	5
Sum of (a) ~ (e)	<3.7 × 10 ⁻⁴	
 2XMM catalog 2. Yamauchi et al. 1996 3. Revnivtsev et a 	I. 2006, 4. Kushino et al. 2002 5.T	awa et al. 2008
The excess extending ~15' cannot	be explained	

error level of the fluctuation of the background is considered

5. Discussion

•The extended emission is suggested as non-thermal •The morphology is not shell-like characteristic of

Name	R_X^* (pc)	Morphology	VHE [†]	* Padius of the
Crab	1	torus	0	PWN
G21.5-0.9	2	spherical	0	measured in X.
Vela X	4	one-sided	0	rays if the
G327.1-11	7	spherical		morphology is
W44	2.5	bow-shock		not circular,
PSR B1957+20	0.2	bow-shock		the distance
3C58	7	ellipsoidal		from a pulsar
PSR J1747-2958	1.5	bow-shock		towards the X-
PSR B1509-58	6.5	bipolar	0	ray edge is
G0.9+0.1	8	one-sided	0	listed.
Kes75	0.3	bipolar	0	† Marked if
IC443	0.6	bow-shock		VHE y-ray has
PSR J1826-1334	217	one-sided	0	been detected.

•The X-ray diffuse emission newly detected covers the peak of the VHE γ -ray, so we can compare the intensities of them directly for the first time



 The photon indexes of the diffuse emission is constantly ~2.0 over 17pc without softening. •The smooth decay of the intensity with the distance from the pulsar shown in the radial profile suggests that the accelerator is the pulsar itself. These mean the high-energy (E~100TeV) electrons should be transported over 17pc within its synchrotron life time ~1.9(E/100TeV)-1(B/7uG)-2 kyr.

18:26:00

Right ascension (J2000)

25:36

To explain such a widely extended PWN, the transportation mechanism should have a velocity of at least 8800 km/s.



48

24

•We observed the source and background region for ~50 ksec each. The galactic

2. Observations & Imaging

25:36 18:26:00 Right ascension (J2000)

Spectroscopy

