Suzaku Observation of HESS J 1825-137; Discovery of an unusually extended X-ray pulsar wind nebula of PSR J1826-1334

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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 10r (~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. We made a direct comparison of the spectral energy distributions 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 ~5μG. 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 8.8×10^4 km/s.

1. Introduction; Previous observations

2. Observations & Imaging

- We observed the source and background region for ~50 ksec each. The galactic foregrounds are selected to be as small as possible between the regions considering the GRXE.
- The X-ray images of XIS are shown below. NXB was subtracted and vignetting was corrected. The star mark show the peak of the VHE γ-ray. A-D show the regions from which we obtained spectra. The circles show point-like sources we exclude for the analysis of radial profile and spectroscopy.
- Region B-C corresponds to the emission detected by XMM-Newton.

3. 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 γ-ray emission is shown by a vertical broken line.
- The intensity of the source is 5×10^4 photons/s/cm^2 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 productivity of non-X-ray background.

4. Spectroscopy

- We extracted spectra from spatially separated regions A-D and fitted them with absorbed power-law models. The best fit parameters are tabulated below. In the regions B-D, Γ is 2.0 in the range of 95% error. We merged the spectra of the regions B-D and tested an absorbed power-law model and thin thermal plasma model (APEC). The result is below. The one-solar-abundance thin thermal plasma is rejected. In the case of abundance-free thin thermal plasma, quite low abundance (zero in the 90% error) is required. It suggests the ambient gas is non-isothermal.

5. Discussion

- The extended emission is suggested as non-thermal. The re-emission is not shell-like characteristic of non-thermal SNR. It is thought to be a PWN.
- 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.
- Spectral energy distribution of the extended component from the X-ray to VHE γ-rays. Assuming the origin of the VHE γ-ray is IC with CMB, we plot the synchrotron radiation from the electrons responsible for VHE γ-ray toward the left for three different values of the magnetic field.

- 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 (8×10^17eV) electrons should be transported over 17pc within its synchrotron lifetime ~1.0 (100TeV)γ(8×10^17eV) kyr.

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

PSR J1826 (~17pc) is unusually large as a PWN.

• Suzaku XIS FOV

• Suzaku XIS X-ray image 3-9keV

• Suzaku XIS X-ray image 1-3keV

• Diffuse component extending farther than previous reported was found.