【Grant-in-Aid for Scientific Research(S)】

Science and Engineering (Mathematical and physical sciences)

Title of Project： A Quest for Gamma-Ray Supernova Remnants by Probing the Interstellar Medium

Yasuo Fukui

(Nagoya University, Graduate School of Science, Professor)

Research Area：Astronomy

Keyword：Radio astronomy, Supernova remnant, Interstellar medium, Gamma-ray

【Purpose and Background of the Research】

The origin of the cosmic rays (CRs) is an important mystery in the Universe. The major component of CRs is protons which do not emit photons. The only possibility to confirm CR protons is to detect hadronic γ-rays which are created via neutral pion decay after p-p collisions. Recent progress in γ-ray observations has enabled us to image γ-ray distribution at 0.1 degree resolution. We have analyzed ISM protons in the most outstanding TeV γ-ray SNR (supernova remnant) RX J1713.7-3946 and found that the ISM protons show a good spatial correspondence with the γ-rays by analyzing both CO and HI. This result lends a new support for the hadronic origin of the γ-rays. Aiming at establishment of the origin of CRs, we will apply this method to the other SNRs and clarify the origin of γ-rays, the CR acceleration mechanism, and time-evolution in the CR acceleration.

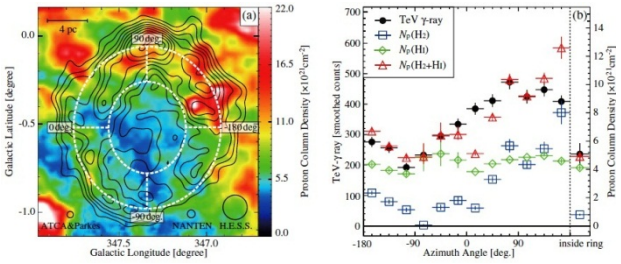

Figure 1. **Left:** Distribution of TeV-γ ray radiation (contours) superposed on column density of the ISM protons (Image). **Right**: Azimuthal distribution of column density of H_2, HI and the ISM protons, and TeV γ-ray smoothed counts per beam.

【Research Methods】

We choose 24 γ-ray SNRs in the present study and carry put the following three items;

1) <u>The total ISM protons</u>

The ISM protons are either atomic or molecular form. We use the CO 2.6mm dataset obtained by the NANTEN2 telescope in Chile and the HI 21cm dataset obtained by ATCA in Australia at angular resolutions of 2-3 arcmin. The CO intensity is converted into the H2 column density and the HI intensity is converted into the HI column density for a velocity range associated with the SNR. For the northern sky objects, we will use the 1.85m telescope of Osaka Prefecture University for CO and the Arecibo telescope and VLA for HI. Mopra 22m, NRO 45m, and ALMA telescopes will also be used to obtain high resolution CO data.

2) <u>Comparison with the γ-rays</u>

We first compare the distributions of γ-rays and X-rays with the CO distribution. CO distribution is generally clumpy, allowing us to identify associated gas reliably. The γ-ray data used include 100MeV to 10TeV or higher obtained by HESS, Fermi, and AGILE. We expect to find a good spatial correspondence between γ-rays and the ISM if the hadronic γ-rays are dominant.

3) <u>Comparison with numerical simulations</u>

The physical processes in the interaction between the SNR shock waves and the ISM are studied in detail via MHD numerical simulations (e.g., Inoue et al. 2012). The ISM distributions obtained in 1) and 2) will be used as inputs in these simulations. We derive constraints on magnetic field and the high-energy radiation in the SNRs and from the numerical simulations.

【Expected Research Achievements and Scientific Significance】

The present study will allow us to better understand the origin of CRs in the Galaxy where the highest energy of CRs is $10^{15.5}$eV from a unique approach to compare the distributions of the ISM protons and γ-rays. The study will also provide important inputs to the new generation telescopes including CTA.

【Publications Relevant to the Project】

・"A Detailed Study of the Molecular and Atomic Gas Toward the γ-ray SNR RX J1713.7-3946: Spatial TeV γ-ray and ISM Gas Correspondence", Fukui, Y. et al., ApJ, 746, id. 82,2012

【Term of Project】 FY2012-2016

【Budget Allocation】 163,700 Thousands Yen

【Homepage Address and Other Contact Information】

http://www.a.phys.nagoya-u.ac.jp/ae/