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Origin of Galactic Cosmic Rays

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Supernova remnants (SNRs) are considered the dominant sources of Galactic Cosmic Rays. However, it remains to be shown how SNRs accelerate particles to very high energies and release them into the interstellar medium to form cosmic rays. The transport of cosmic rays in the Milky way galaxy also needs to be explored to address the observed characteristics of Galactic Cosmic rays. In this talk, I will review recent progresses on addressing these issues. In particular, we find that cosmic rays above ~100GeV are mostly accelerated in relatively young SNRs with an age of thousands of years, while the bulk of Galactic cosmic rays are accelerated in older SNRs with a relatively softer spectrum above 1GeV [1,2].

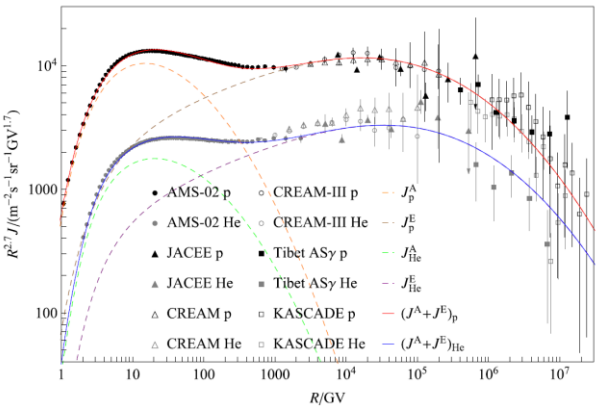

Figure 1. Fit to Cosmic ray proton and helium spectra based on a two stage time-dependent diffusive shock acceleration model for SNRs[1].

We also carried out detailed spectral fits to the broadband spectra of a sample of 34 SNRs [3]. It is shown that in general high-energy particle distribution in SNRs can be described with a broken power-law with a high-energy cutoff. The break energy and the spectral index decrease with the aging of SNRs. These results imply that although slow shocks are less efficient in producing very high energy particles, they can accelerate relatively lower energy relativistic particles efficiently so that the low-energy spectrum becomes harder due to higher compression ratio caused presumably by dominance of the gas pressure by relativistic particles in the downstream [2]. The high-energy cutoff of electrons are dictated by the acceleration and radiative loss processes in young SNRs and by the radiative process in intermediate age SNRS. In old SNRs, the high-energy cutoff of electrons and ions are dictated by an escape process.

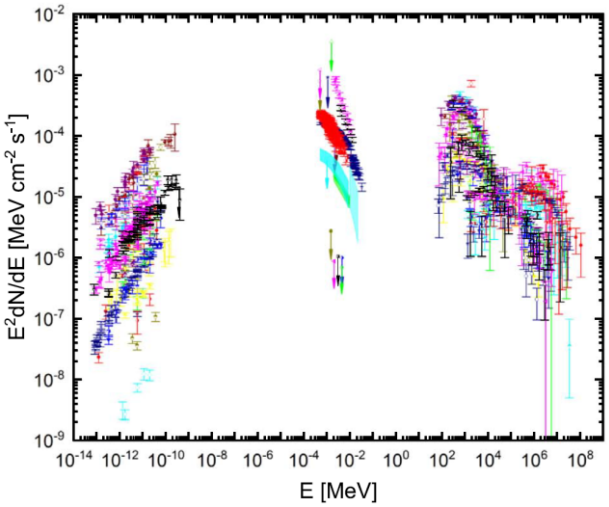

Figure 2. Broadband spectra of a sample of 34 SNRs normalized at 100GeV[3].

These results support the scenario that Galactic Cosmic Rays are mostly accelerated in SNRs. It remains to be shown how high-energy particles in SNRs escape into the interstellar medium. Future high resolution observations of SNRs near molecular clouds may address this issue.

References

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[3] Zeng, Houdun; Xin, Yuliang; Liu, Siming; Evolution of high-energy particle distribution in supernova remnants. ApJ, 874:50(2019)