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Inefficient Cosmic-Ray Diffusion around Vela X: Constraints from H.E.S.S. Observations of Very High-energy Electrons

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Vela X is a nearby pulsar wind nebula (PWN) powered by a $\sim 10^4$ year old pulsar. Modeling of the spectral energy distribution of the Vela X PWN has shown that accelerated electrons have largely escaped from the confinement, which is likely due to the disruption of the initially confined PWN by the supernova remnant (SNR) reverse shock. The escaped electrons propagate to the earth and contribute to the measured local cosmic-ray (CR) electron spectrum. We find that the escaped CR electrons from Vela X would hugely exceed the measured flux by HESS at ~ 10 TeV if a standard diffusion coefficient for the interstellar medium (ISM) is used.

We propose that the diffusion may be highly inefficient in the vicinity of Vela X and find that a spatially-dependent diffusion can lead to CR flux consistent with the HESS constraint. Assuming a two-zone geometry for the diffusion region around Vela X, we find that the diffusion coefficient in an inner region of a few tens of pc should be $< 10^{28}\mathrm{cm}^2\mathrm{s}^{-1}$ for ~ 10 TeV CR electrons, which is about two orders of magnitude lower than the standard value for ISM.

Such an inefficient diffusion around Vela X resembles the case of the Geminga PWN, which suggests that inefficient diffusion regions may be common around PWNe with a wide range of ages.

Authors: HUANG, Zhi-Qiu (Nanjing University); Mr FANG, Kun (Key Laboratory of Particle Astrophysics, Institute of High Energy Physics, Chinese Academy of Sciences); Mr LIU, Ruo-Yu (Nanjing University); Prof. WANG, Xiang-Yu (Nanjing University)

Presenter: HUANG, Zhi-Qiu (Nanjing University)

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