Transient Source for the Highest Energy Galactic Cosmic Rays

Executive Summary

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What is this contribution about?

The source of the highest energy Galactic CRs (dubbed "GCR-B" by Hillas – $10^{17.2-18.8}$ eV), is a longstanding puzzle. Here we constrain the source of GCBs from the Dipole Anisotropy. We isolate the GCB anisotropy by fitting the observed dipole data above 0.1 EeV as the sum of Galactic and Extragalactic components. The amplitude $\alpha_{\rm GCB} \approx 0.05$, and the direction probability is as shown in the plot to the right. (Only the RA phase is measured at lower energy, ergo the band, but almost any model would have the dipole direction be near the Galactic Plane.)

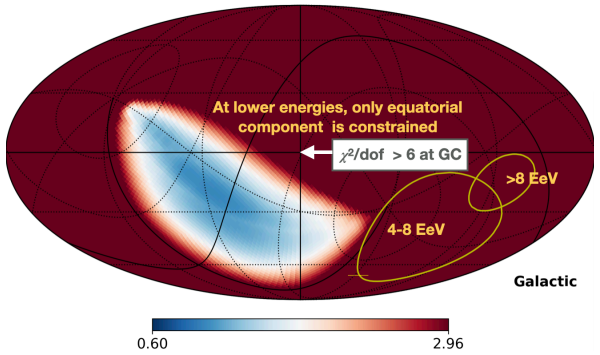

Figure 1: χ^2/dof of fit to observables, for GCB dipole anisotropy assumed to be in the given direction; scale saturates.

Why is it relevant/interesting?

The result disfavors acceleration in the Galactic wind termination shock, whose anisotropy should be small in magnitude (because the shock surface is so large) and toward or away from the GC by L-R symmetry. Thus a transient event is the most plausible source of these CRs. Using the approximate result for the anisotropy of a transient, $\alpha \approx r/(2ct)$, with r the distance and t the time since the event, allows the distance and time delay to be constrained.

What has been done?

The Galactic Catalog of 294 SNRs was searched, and one candidate stands out: SNR G65.3+5.7 at $\{r, t\} = \{0.8\text{kpc}, 22\text{kyr}\}$, yielding the observed α. The energy in high energy CRs produced by the event is calculated to be 10^{44-45} erg, comfortably within the energy budget of $\approx 10^{54}$ erg. The rate of such events in the Galaxy is estimated.

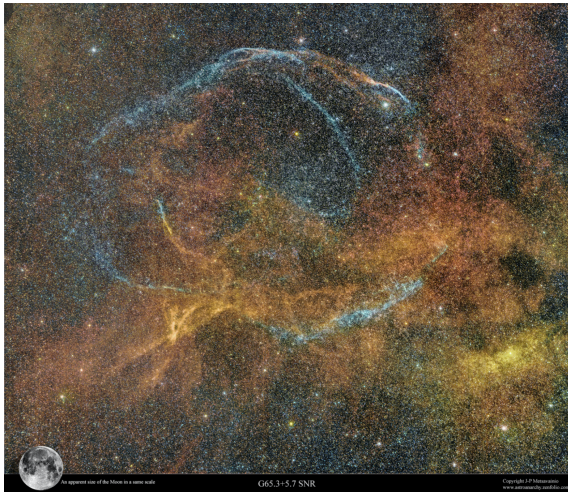

Figure 2: SNR G65.3+5.7, credit tbd.

What is the result?

The highest energy Galactic CRs observed today are consistent with having been produced by the converging shock flow of a core collapse SN in the wind of its massive binary companion, with SNR G65.3+5.7 and nearby PSRJ1931+30 plausibly being relics of that event. The chance such an event would have occurred in a space-time volume leading to the observed or higher flux and anisotropy is estimated to be $O(0.1-1)$.