Evidence for SNR Clustering?

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***Abstract*—It is commonly assumed, and with some justification, that cosmic rays (CR) of energy below 1PeV or so are accelerated in supernova remnants (SNR). Such remnants are clustered, and, furthermore, their outputs vary. Both characteristics have an effect on the CR distribution in the Galaxy.**

By examining the longitude distribution of secondary gamma rays in and near the Galactic Plane we have thrown some light on this problem.

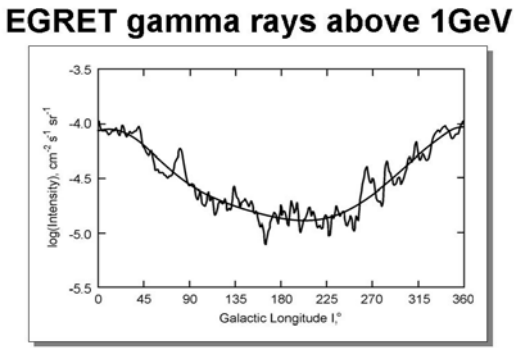
Our conclusion is that taking SNR clustering alone the degree of such clustering would need to be unreasonably high. Thus, we prefer an explanation in terms of a spread of SNR energies with perhaps modest clustering.

I. Introduction

The detailed examination of the origin of CR is bedeviled by the fact that the Galactic magnetic fields deflect the trajectories of the particles. Instead, recourse is usually made to an analysis of the secondary gamma rays coming from the interactions of CR with the interstellar gas. We have used this technique in an effort to say something more about the SNR commonly assumed to give rise to the particles below 1PeV or so. Two characteristics have been examined: the clustering of SNR and their spread in CR energy outputs.

Figure 1 shows the EGRET date [1] on gamma rays above 1GeV in the Galactic Plane (|b|<2˚). The spread in intensity about the smooth line is clearly due to two causes: the variable distribution of target gas and the variable CR intensity. It is the latter which is of prime concern.

Figure 1



Profile of intensity versus longitude for |b| < 2º. Points are averages over longitude bins Δl = 1º ; smooth line is the best fit of the profile by a 9-degree polynomial.

II. The Analysis

Our SNR clustering model assumes 10 SNR within 10^6 years at any one location. The model for SNR energetics has a fraction having a standard deviation of energy emitted in CR with $\delta(\log E) = 1.2$ [2] (denoted SSNR).

The standard deviations of gamma ray intensities about the best fit have been derived for different latitude ranges so that the CR properties can be derived as a function of median Galactocentric distance. The predictions have been made for 'normal' and 'anomalous' (our preferred situation) diffusion. Allowance has been made for the correlation of SNR and gas density. Calculations have been made for various 'fractions of clustered SNR' needed, δ, and the fraction of 'supersupernovae' (SSNR), in those with the possible high values for energy emitted.

III. The Results

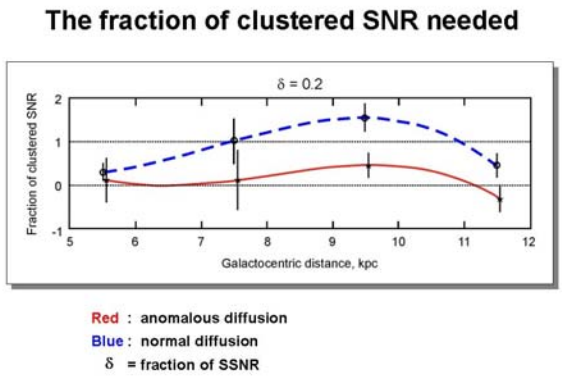
Figures 2, 3 and 4 summarize the results. The parameters are as indicated. With $\delta = 0$, ie all SNR are 'standard' it will be noted that for almost all the Galactocentric distances we need a fraction of clustered SNR greater than unity. This is, of course, literally impossible; to get agreement we would need a degree of SNR clustering greater than the already

considerable extent adopted.

With $\delta = 0.2$, ie 20% of the SNR are SSNR, the fraction of clustered SNR is usually allowable; indeed, with our preferred anomalous diffusion this fraction can be very small.

It is interesting to note that in our earlier work [3] we showed that there should be a transition from anomalous to normal diffusion with increasing Galactocentric radius. Inspection of the Figures shows that allowance for such a variation would have the result of flattening the dependence of fraction of clustered SNR on Galactocentric distance.

Figure 2



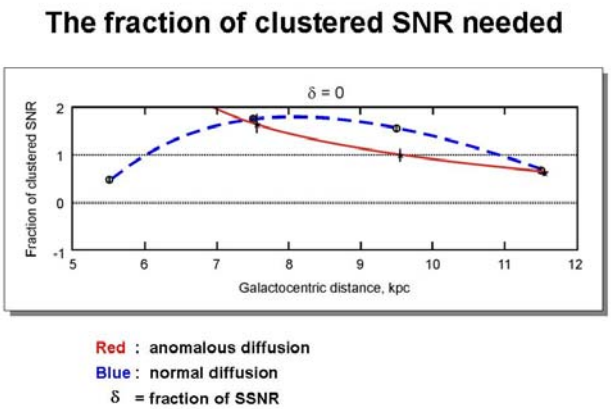


Figure 3

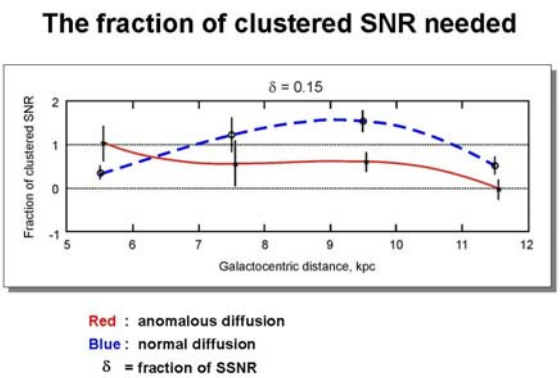


Figure 4

IV. CONCLUSIONS

In the absence of a prior knowledge as to what the fraction of clustered SNR or SSNR **should** be, it is not possible to define either. However, it does appear that SSNR **are** needed. 15% for the fraction seems not unreasonable from other considerations, coupled with modest clustering in the Inner Galaxy, where such a phenomenon is known to exist in any case.

ACKNOWLEDGMENT

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REFERENCES

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[2] Sveshnikova, L.G., 2003, Astron. Astrophys. **409**, 799

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