SAS-2 GAMMA RAY OBSERVATIONS RELATED TO A GALACTIC HALO

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An examination of the intensity, energy spectrum, and spatial distribution of the diffuse γ radiation observed by SAS 2 away from the galactic plane in the energy range above 35 MeV has revealed no evidence supporting a cosmic ray halo surrounding the galaxy in the general shape of a sphere. The diffuse γ radiation does consist of two components. One component is related to the galactic disk on the basis of its correlation with the 21-cm measurements, the continuum radio emission, and galactic coordinates. Further its energy spectrum is similar to that in the plane, and its intensity distribution joins smoothly to the intense radiation from the plane. The other component appears isotropic, at least on a coarse scale, and has a steep energy spectrum. The degree of isotropy which has been established for the "isotropic" radiation and the steep energy spectrum, which distinguishes it from the galactic disk radiation, place strong constraints on galactic halo models for the origin of this component. Theoretical models involving a galactic halo have generally postulated a halo with dimensions of the order of the Galaxy and hence a radius, at least in the plane, of about 15 kpcs. Since the Sun is about 10 kpc from the galactic center, if such a halo exists and is responsible for the γ rays (through, for example, black body Compton radiation), a very marked anisotropy would be seen, with the γ ray intensity from the general direction of the galactic center being much larger than that from the same latitudes in the anticenter direction. In fact, no such anisotropy is seen; specifically the ratio of the average intensity in the $(300° < \ell < 60°, 20° < |b| < 40°)$ region to that in the $(100° < \ell < 250°, 20° < |b| < 40°)$ region was found to be 1.10 ± 0.19 compared to a calculated value for a model with a uniform cosmic ray sphere with a 15 kpc radius of 2.85. The ratio between the average γ-ray intensity from regions with $|b| < 60°$ to that from $20° < |b| < 40°$ is found to be 0.87 ± 0.09. If the region is assumed to be spherical, but with a larger radius and a uniform cosmic ray density, the upper limit (2σ) set for the anisotropy demands that the radius be at least 45 kpc. An extragalactic origin for the isotropic component currently appears to be a more plausible explanation.

W. B. Burton (ed.), The Large-Scale Characteristics of the Galaxy, 483–484.

DISCUSSION

Verschuur: Conditions in interstellar space at 5 kpc are clearly very different from those in the solar neighborhood. We can therefore question whether the emergence of intelligent life as we know it is even possible over much of the inner parts of the Galaxy. Much work is now being done on the influence of cosmic rays and interstellar gas and dust on planetary atmospheres. In order to make meaningful comments about the possibility of life in the inner parts of the Galaxy we need to have better data on cosmic ray and other high energy radiations as a function of R. Is such data likely to become available? What can we learn from the fact that the γ-ray emissivity is about 10 times greater at 5 kpc than at 10 kpc. Knowing better what the environmental conditions are like as a function of R might show that there is a limited volume of galactic space in which planets could exist with Earth-like conditions.

Stecker: The cosmic γ-ray fluxes even at 5 kpc would be quite insignificant in this context. The cosmic-ray intensity at 5 kpc would be about 2 to 3 times higher than in our vicinity and should not present any real problem to life as we know it on a planet similar to ours, although the genetic mutation rate and consequent evolution rate might be proportionately higher.

Lequeux: A nearly final reduction of the COS-B data for the galactic center shows no excess at $\ell \sim 0°$ in the longitude profile, contrary to what SAS-2 found. The discrepancy might be due to the presence of a transient γ-ray source at the time of the SAS-2 observation. From the COS-B data, taking a mass of interstellar matter of $7 \times 10^7\ M_\odot$ within $R < 300$ pc (rather a minimum), we find that the cosmic ray flux at the galactic center is not more than two times the flux close to the Sun (3σ limit).

Stecker: The result which you give is at variance with the result of the SAS-2 satellite experiment and with the results previously reported by the COS-B collaboration at the γ-ray symposium in Frascati in 1977. Both previous results show a peak in the γ-ray distribution at the galactic center.

Basu: Could your analyses of the γ-ray distribution in the halo be used to make an estimate of the mass of the halo?

Stecker: The cosmic-ray "halo" in the Galaxy, as I have tried to show, is basically a Population I-related phenomenon associated with recent star formation in the galactic disk. The stellar halo, on the other hand, is a Population II phenomenon. Thus, the answer to your question is no. Perhaps the term "halo" as applied to cosmic-rays is confusing.

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