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We have examined the alternative hypotheses of galactic and extragalactic origin of the observed cosmic γ-ray flux between 1 and 6 MeV in the light of the most recent spectral information on cosmic γ-rays at above 1 MeV. We conclude the galactic-origin hypothesis is extremely remote and that the 1-6 MeV flux is of extragalactic origin. It should thus provide a strong background upon which sources in this energy region will be superimposed. This necessitates the use of high-resolution γ-ray telescopes in order to study possible discrete sources in the 1-15 MeV energy region.

Within the last two years, measurements have been made of the flux of cosmic γ-rays above 1 MeV energy. The nature and extent of these measurements as of early 1970 have been presented in a recent review article by Fazio[1]. The work up to that time, most particularly the work of Clark, et al.[2], established the existence of a detectable flux of γ-rays of cosmic, and especially galactic, origin. Since that time, new results reported on by three experimental γ-ray astronomy groups have provided significant new which would indicate that even at the galactic center pion-decay supplies most of the γ-ray flux. A two-component model of the galactic center spectrum consistent with the observations of Kniffen and Fichtel[7] is shown in Figure 1. By inference, γ-rays from the galactic disk can be attributed to an essentially pure pion-decay origin. (See reference 10)

We may well ask if the γ-ray flux reported by Vette, et al.[5] may also have an origin in the galactic disk. This possibility was indeed suggested in one paper[11] which postulated a galactic electron-bremsstrahlung origin for almost all of the cosmic γ-rays observed at energies above 1 MeV. This paper, however, was written before the hardness of the galactic γ-ray spectrum at 100 MeV was well established and we must now take this fact into consideration. While it is true that the data obtained by Vette, et al. was of a nondirectional nature, thus allowing the possibility of galactic origin, we will attempt to show here that because of the nature and intensity of the flux observed in the 1-6 MeV energy range, such a possibility is extremely remote.

In order to show this, let us construct a spectrum of cosmic γ-rays for the galactic disk under the assumption that the 1-6 MeV γ-rays are produced there. Such a spectrum is shown in integral form in Figure 2. This spectrum was constructed using the additional assumptions that (a) the point at 100 MeV represents the revised average γ-ray flux from the galactic disk as reported by Clark, et al., and (b) the upper limit at 50 MeV is given by equation (1), this being a conservative upper limit, particularly for the galactic disk. Also shown in Figure 2 are curves corresponding to the theoretical (calculated) γ-ray spectrum from pion-decay[12], a theoretical

Compton γ-ray spectrum with a differential index $\Gamma = 2$ [i.e., one representing a spectrum of the from $I(E_\gamma)\, dE_\gamma \propto E_\gamma^{-\Gamma} dE_\gamma$], the photon spectrum of Vette, et al. interpreted as a galactic line flux and with an approximate average index, Γ, and a spectrum between 6 and 50 MeV representing the flattest power-law spectrum consistent with the upper limit given at 50 MeV.

A glance at figure 2 immediately shows that a Compton-type spectrum is not only too soft to explain the data between 50 and 100 MeV, but is also too hard and of too low an intensity to explain the break between 6 and 50 MeV consistent with a galactic origin for the 1-6 MeV flux. One should also note that bremsstrahlung radiation from cosmic-ray electrons, as observed in the vicinity of the solar system (taking modulation into account)[13], cannot account for the 1-6 MeV flux. In order to force a bremsstrahlung model to work, one would have to devise a means for filling the galaxy with 1-10 MeV electrons of $\sim 10^4$ times the intensity of those which appear to be present in the solar neighborhood, with a much flatter spectrum below 6 MeV than has been observed by Simnett and McDonald at these energies[13] and with an extremely sharp break of at least 3.3 powers in the spectral index between 6 and 50 MeV. Such an ad hoc hypothesis seems extremely remote.

Other suggested explanations of the 1-6 MeV γ-ray flux have been discussed by Vette et al.[5] They showed that the galactic source model also seemed highly unlikely. In their discussion of various extragalactic models, they pointed out that these models which produce isotropic γ-ray fluxes can account much more easily for the observed γ-ray intensity.

Of the extragalactic models, the cosmological model proposed by Stecker[14-17], suggesting that this flux originated at a very early epoch in the history of the universe, provided a natural quantitative fit to the spectral data in this energy range when added to an extrapolation of the X-ray spectrum below 1 MeV. It thus appears highly probable that the cosmic γ-ray flux between 1 and 6 MeV is of extragalactic origin and is highly isotropic. It can thus be expected to provide a large background upon which sources in this energy range will be superimposed. This would necessitate the use of high-resolution γ-ray telescopes in order to best study possible discrete sources in this energy range.

Unfortunately, only very crude directional instruments can presently be constructed for studies of 1-15 MeV γ-rays. Even the large γ-ray source survey experiments that are expected to be flown in the mid-1970's have resolutions of ~ 0.1 sterradians and background count rates of $\sim 3 \times 10^{-3}$ counts per cm^2-sec-MeV . Although in principle it is possible to extract weak sources from such a large background by observing over long periods of time, in practice, systematic effects rather than statistics limit the precision with which fluxes can be measured. Detectors capable of much higher angular resolution to cut down on the effect of the background flux are clearly desirable.

The above discussion of the implications of the results of Vette, et al.[5] highlights the importance of confirming their results. It should be pointed out that the application of a simple asymmetric detector system, employing a multichannel analyzer flown on a small spinning satellite, can provide considerably improved data on the energy spectrum and isotropy of this flux.

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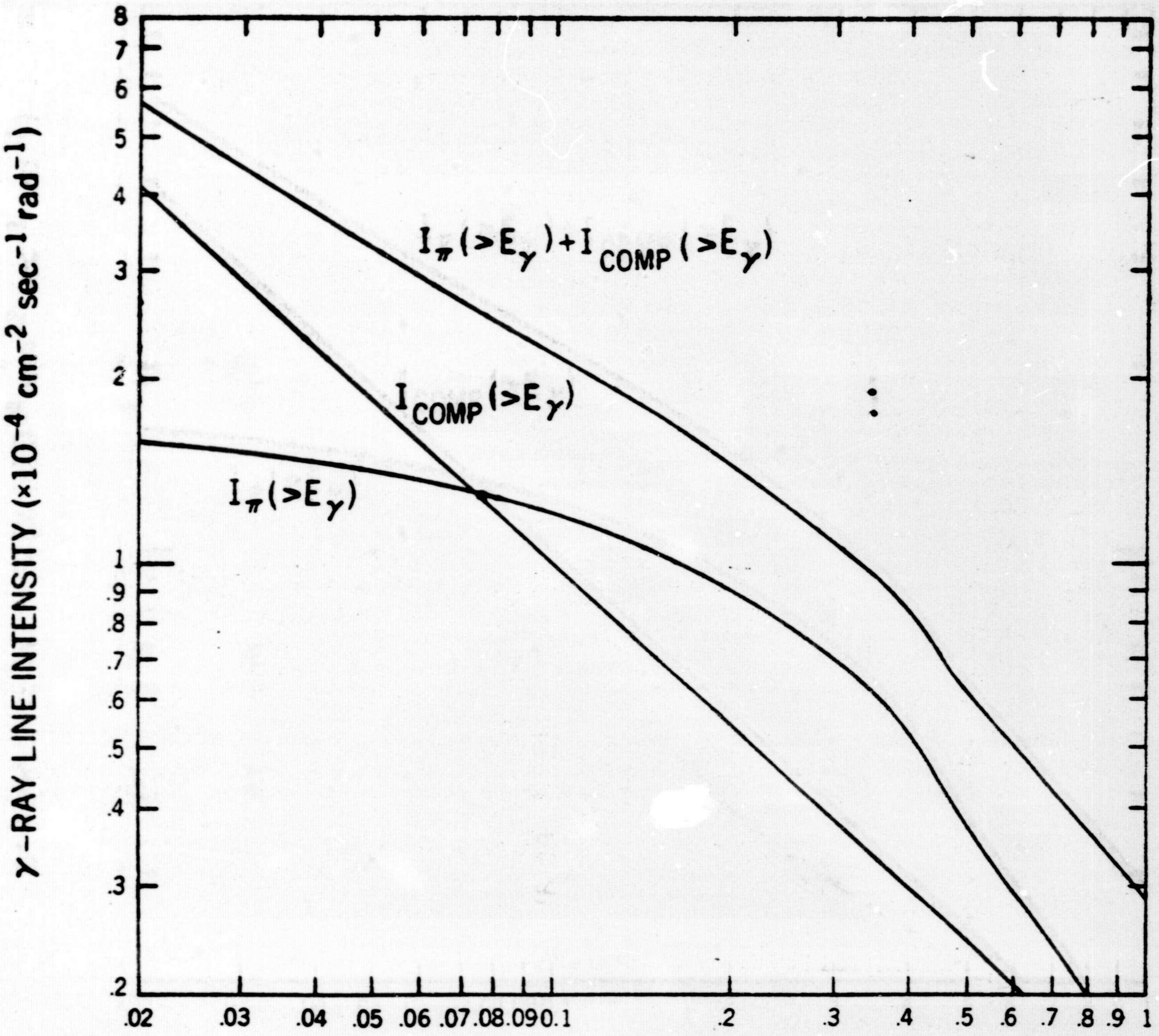
Figure Captions

Figure 1: A Two-Component Spectrum Model for the Galactic Center Region (based on the discussion of Stecher and Stecker[10]).

Figure 2: A Hypothetical Intergral γ-ray Spectrum for the Galactic Disk Under the Disk-Origin Assumption for the 1-6 MeV γ-ray Flux.



γ-RAY LINE INTENSITY ($\times10^{-4}$ cm^{-2} sec^{-1} rad^{-1})
$I_\pi(>E_\gamma)+I_{COMP}(>E_\gamma)$
$I_{COMP}(>E_\gamma)$
$I_\pi(>E_\gamma)$
E_γ (GeV)
8
7
6
5
4
3
2
1
.9
.8
.7
.6
.5
.4
.3
.2
.02
.03
.04
.05
.06
.07
.08
.09
0.1
.2
.3
.4
.5
.6
.7
.8
.9
1