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POSSIBLE ORIGIN OF HIGH-ENERGY COSMIC GAMMA RAYS?

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The intensity of the new microwave radiation observed by Shivanandan, Houck, and Harwit is adequate to produce, by Compton scattering on cosmic-ray electrons, the flux and distribution of ~100-MeV γ rays reported by Clark, Garmire, and Kraushaar.

Recently Clark, Garmire, and Kraushaar[1] have reported a definite flux of high-energy (~100-MeV) extraterrestrial gamma radiation. This radiation has been detected from a band in the sky coincident with the galactic plane and the intensity has a broad maximum towards the galactic center. In addition there also seems to be evidence for an isotropic component which is believed to originate outside the galaxy. In this note we shall briefly discuss a possible new source of this radiation.

As pointed out by Clark, Garmire, and Kraushaar,[1] the expected intensity of the radiation arising from the decay of neutral pions produced in collisions of cosmic-ray nucleons with interstellar matter is smaller, by a factor of ~25, than the observed intensity in the direction of the galactic center. In this calculation they have made the valid assumption that the mean interstellar flux of high-energy cosmic-ray nuclei is the same as that observed at the top of the earth's atmosphere during solar minimum. According to the present ideas of cosmic-ray modulation the interstellar flux at energies above ~1 GeV/nucleon, where pion production becomes significant, cannot be more than a factor of 2 higher than the solar-minimum flux; therefore, nuclear collisions may not provide more than about $\frac{1}{10}$ of the observed flux of gamma rays. On the other hand, as shown below, the high-energy electron component of cosmic rays may well provide a source of these hard quanta if the high-intensity microwave radiation in the wavelength interval of 0.04-0.13 cm observed by Shivanandan, Houck, and Harwit[2] is confirmed. The intensity of the new microwave radiation is 5×10^{-9} W cm^{-2} sr^{-1}, which corresponds to an energy density of 13 eV/cm^3 with a maximum photon energy of 3×10^{-3} eV. Since this radiation seems to be fairly isotropic one may assume that it pervades a spherical volume which at least envelops the whole galaxy.

The differential spectrum of cosmic-ray electrons as observed by Anand, Daniel, and Stephens[3] is

$$F(E_e)=905/E_e^{2.64}\ \mathrm{cm}^{-2}\ \mathrm{sec}^{-1}\ \mathrm{sr}^{-1}\ \mathrm{MeV}^{-1}. \quad (1)$$

The differential intensity of the scattered photons arising from the inverse Compton effect is given by

$$f(E_\gamma) = \frac{905}{[(E_\gamma m^2/\epsilon)^{1/2}]^{2.64}} \tfrac{1}{2}m(E_\gamma \epsilon)^{-1/2} \times N\sigma_T L \text{ cm}^{-2} \text{ sec}^{-1} \text{ sr}^{-1} \text{ MeV}^{-1}, \quad (2)$$

where m is the mass of the electron in MeV, ϵ is the mean energy and N the number density of the microwave photons, σ_T the Thomson cross section (6.65×10^{-25} cm^2), and L the effective distance in the direction under consideration. The integral intensity of γ rays then becomes

$$I_\gamma(E) \simeq 3\times10^{-2}E^{0.82} \text{ cm}^{-2} \text{ sec}^{-1} \text{ sr}^{-1}. \quad (3)$$

Taking $L = 7\times10^{22}$ cm towards the galactic center, the expected intensity is $\sim5\times10^{-4}$ cm^{-2} sec^{-1} sr^{-1}. The area-solid-angle product for the detector used by Clark, Garmire, and Kraushaar[1] is given as 0.5 cm^2 sr. Assuming that the gamma-ray flux is approximately isotropic over the 15° opening angle of the telescope we expect a counting rate of $\sim2.5\times10^{-4}$ sec^{-1}, as compared with the observed counting rate in this direction of $\sim4\times10^{-4}$ sec^{-1} given[4] in Fig. 3 of Clark, Garmire, and Kraushaar.[1]

It has been pointed out by Hayakawa[5] that with changing galactic longitude the gamma-ray intensity varies in the same way as the intensity of the 21-cm hydrogen line, thus indicating a correlation of this radiation with matter in the galaxy. If the interpretation given here for the origin of the high-energy gamma rays is correct, then their intensity distribution would reflect the cosmic-ray electron densities in various regions of the galaxy. It is perhaps reasonable that cosmic-ray electron density should be correlated with matter density and also with magnetic field strength.

Regarding the possible isotropic component of these hard quanta, it is to be pointed out that a cosmic-ray halo with a diameter of $\sim10^{23}$ cm could very well reproduce the observed variation of gamma-ray intensity with galactic latitude. Therefore, one has to wait for the accumulation of more data before the existence of an extragalactic component can be well established.

We would like to point out that a microwave radiation of the intensity reported by Shivanandan, Houck, and Harwit[2] would produce, through inverse Comtpon effect, a flux of 100-MeV gamma rays from the Crab nebula, which is smaller, by a factor of ~10, than the limit of $\sim5\times10^{-5}$ cm^{-2} sec^{-1} reported by Clark, Garmire, and Kraushaar.[1]

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A KINEMATIC-AMBIGUITY-FREE TEST FOR A_1 AND B MESONS*

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The photoproduction reaction channel $\gamma n \to p\pi^+\pi^-\pi^-$ is suggested as a means to test whether the A_1 and the B mesons are genuine resonances or kinematic effects. Implications for the duality principle are discussed.

There is at present an increasing number of meson and baryon resonances whose existence is clouded by the fact that they may also be interpreted as arising from some kinematic effect rather than being true resonances. The most studied yet persistently bewildering one in this category is the A_1 meson, a $\rho\pi$ enhancement at about 1080 MeV, with a width around 100 MeV and $IJ^{PG} = 11^{+-}$. It has long been pointed out[1] that this enhancement could also be due to a Drell-Hiida-Deck-type kinematic effect (hereafter referred to as the Deck effect). A recent multiperipheral Regge calculation by Berger[2] in the same spirit also fits the experimental data