CAN GALACTIC γ-RAY BACKGROUND BE DUE TO SUPERPOSITION OF γ-RAYS FROM MILLISECOND PULSARS?

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The SAS 2 and COS B observations have established the existence of diffuse γ-rays in our Galaxy in various energy ranges. The diffuse radiation is attributed to the interaction of cosmic ray nuclei and electrons with the particles of interstellar atomic and molecular gas (via the decay of pions and bremsstrahlung, respectively). Inverse Compton scattering of interstellar photons by the high energy electrons of cosmic rays may also be contributing to this background. In addition some contribution may come from discrete sources of γ-rays.

We investigate if the whole of the diffuse γ-radiation in the energy range 300–5000 Mev be due to discrete sources. The discrete sources we have in mind are the millisecond pulsars which are found in large numbers in the Galaxy. Most millisecond pulsars have magnetic fields between 3 to 4 orders of magnitude smaller than that of canonical pulsars. But by virtue of their rotational velocities the charged particles in their magnetospheres could be accelerated to energies with Lorentz factor as high as

$$\gamma_e = 1.23x10^7 R_6^{3/4} P_{ms}^{-1/4} B_8^{1/4}. \qquad (1)$$

The critical energy of the curvature radiation photon becomes

$$E_c = 1.7x10^{-2} P_{ms}^{-1/4} R_6^{18/8} B_8^{3/4}. \text{ ergs} \qquad (2)$$

The luminosity of a millisecond pulsar between energies E_1 and E_2 can be shown to be

$$\dot{N}_\gamma = 9.7x10^{36} B_8^{5/4} P_{ms}^{-9/4} R_6^{15/4} \int_{E_1}^{E_2} \frac{F(E)}{E} dE \text{ photons/sec} \qquad (3)$$

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For an estimate of the total contribution from all millisecond pulsars in the disk and the globular clusters of the Galaxy we require their period and space distributions. For the millisecond pulsars in the disk we have taken distributions already derived in the literature. For the millisecond pulsars in the globular clusters we have modeled their space distribution after the distribution of globular clusters themselves. Their period distribution was taken from literature. The integrated flux of γ-rays was calculated from the expression given in terms of the galacto-centric coordinates,

$$F_\gamma = \int\int\int q\phi(R, z, \theta)\, dR\, dz\, d\theta \tag{4}$$

where $\phi(R, z, \theta)$ is the space distribution of pulsars and q is given by

$$q = \frac{1}{4\pi}\int_{P_{min}}^{P_{max}} \dot{N}_\gamma \rho_P(P)\, dP \text{ photon/sec/sr} \tag{5}$$

The expression for the flux is transformed to galactic longitude and latitude and is evaluated for the energy range 300–5000 Mev. It is found that γ-rays from millisecond pulsars alone do not agree with the observations. However, in combination with those from the interaction of cosmic rays with the interstellar gas they could explain the observed flux quite satisfactorily. But for this the millisecond pulsars in the disk of the Galaxy must be $< 5x10^3$ and those in the globular clusters must not be > 200 per globular cluster. These constraints seem reasonable in view of some observations and can be a guide to the future pulsar surveys. (For detailed discussion, see Bhatia et al., 1997, Ap. J. **476**, 238.)