DARK MATTER DECAY AND THE HEATING AND IONISATION OF HI REGIONS

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I have proposed (Sciama 1989) that the heating and ionisation observed in HI regions from pulsar dispersion measure data and Hα emission is mainly produced by u-v photons emitted by decaying dark matter particles. If a particle P_1 of rest mass m_1 decays into a photon and a particle P_2 of rest mass m_2 one has:

$$P_1 \longrightarrow \gamma + P_2.$$

The energy E_γ of the photon in the rest-frame of P_1 is given by

$$E_\gamma = \frac{m_1^2 - m_2^2}{2m_1}. \qquad (c = 1)$$

If $m_2 \ll m_1$, we have the simple relation

$$E_\gamma \sim \frac{1}{2} m_1.$$

If the particles are neutrinos we know that their cosmological density will have the critical value if

$$\sum_i m_i \sim 100h^2 \ \text{eV},$$

where h is the Hubble constant in units of 100 km sec^{-1} Mpc^{-1} ($\frac{1}{2} < h < 1$) and the sum is over the three types of neutrino (τ, μ, e). Presumably P_1 is ν_τ. We notice immediately that if the neutrino density is critical and if m_{ν_τ} dominates, then $E_\gamma > 13.6$ eV unless h is almost exactly 1/2.

My proposal is speculative but was made because there is growing evidence that it is difficult to account for the observed ionisation using conventional astronomical sources. This is true near the sun (Reynolds 1990) and at heights $\sim$ 1 kpc above the galactic plane (Reynolds 1989). It is also true of the local interstellar medium (LISM) (Cox and Reynolds 1987), of NGC 891 at heights several kpc above its plane

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(Rand, Kulkarni, and Hester 1990), of the intergalactic medium at red shifts ~3-4 (Shapiro and Giroux 1987) and of Lyman α clouds at similar red shifts (Bajtlik, Duncan, Ostriker 1988). All these anomalies would be resolved at one stroke if the neutrino decay lifetime τ were given by

$$\tau \sim 1.5 \times 10^{23} \text{ sec.}$$

In a series of papers (Sciama 1989a-e, Salucci and Sciama 1990, Sciama and Salucci 1990) I have explored some of the consequences of this hypothesis. These consequences turn out to be rather remarkable. One can show that

(i) the rotation curve of the Galaxy can be derived from $n_e(r)$ as deduced from pulsar data.
(ii) $13.6 < E_\gamma < 14.5$ eV independently from (a) the observed upper limit on the extragalactic flux of ionising photons, (b) m_{ν_τ} derived from the Tremaine-Gunn phase space argument applied to our Galaxy, (c) the constraint that the decay photons must be unable to ionise nitrogen in the LISM.
(iii) the density of the universe is close to the critical value (and $m_{\nu_\tau} = 27.7 \pm 0.5$ eV).
(iv) the Hubble constant H must be 54.5 ± 1 km sec^{-1} Mpc^{-1},
(v) $n_e(r, z)$ for NGC 891 can be derived from its rotation curve via its dark matter and agrees with observation.
(vi) the distance of NGC 891 and H can be derived independently of our previous determination of H, with consistent results.

The hypothesis can be tested directly by searching for a line in the u-v background at $E_\gamma \sim 14$ eV. The predicted flux of this line is $\sim 2 \times 10^3$ cm^{-2} sec^{-1}. I am planning such a search in collaboration with S. Bowyer and R. Stalio.