IONIZATION IN THE INTERSTELLAR HI REGION BY LOW ENERGY COSMIC RAY ELECTRONS

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Recent observations of the pulsar dispersion measures show a large scale height and relatively high density for the diffuse, ionized gas in HI regions. The maintenance of the ionization requires a pervasive ionizing agent. This agent could hardly be the UV photons from O stars or the extragalactic background UV photons due to their large optical depth; nor could it be the soft X–rays from the hot, ionized gas due to a low flux indicated by observations. Studies of the Galactic diffuse low energy γ–rays provides a clue to this problem. The extraordinarily high intensity of MeV electrons, which is derived from the γ–ray flux, could account for the ionization. In this scenario the electrons do both ionization and heating in HI regions, accordingly the atomic hydrogen gas is *warm* ($\sim 10^4$ K). The ionized gas density has a radial gradient with a scale length 4 kpc, there being more ionized gas in the inner Galaxy, due to a gradient in the electron intensity.

The MeV cosmic ray electrons are usually referred to as the 'seed' population, to distinguish them from the high energy population of cosmic rays in the common sense. The generation mechanism of these low energy electrons, in view of their excess over a single power–law injection spectrum extrapolated from the high part, is thought to be different from the standard diffusive shock accleration by young supernova remnants. A likely mechanism is the low–frequency turbulence due to the modified two stream instability in a magnetized plasma, such as it works for particle acceleration in solar flares and the Earth's bow shock. Here, we suggest that this mechanism may be operated effectively by interstellar shocks which are initiated by massive stars and old supernova remnants. Also, unlike the high energy electrons, these low energy electrons propagate slowly, thus they are relatively 'local' and have a large radial gradient, say, 4 kpc for the scale length, a value comparable to the stellar scale length. The diffusion coefficient, we suggest, should lie in the range $10^{27} \sim 10^{28}$ cm^2 s^{-1} and the electrons are able to travel a few hundred pc before losing most of their energy. Nevertheless, they could be convected into the halo by the galactic wind and ionize the gas there. The total energy input for these electrons is estimated to be $\sim 10^{41}$ erg s^{-1} and the ambient energy density is 0.05 eV cm $^{-3}$.

It can be remarked, finally, that it is unnecessary to postulate the decay products of dark matter particles as the source of the observed ionization. It is also unnecessary to invoke the diffuse ionized gas being *cool* as the interpretation of the inclination dependence of radio power at low frequency (57.5 MHz) observed in external spiral galaxies. This effect, we think, is caused by the spectral flattening of GeV cosmic ray electrons and by the absorption of HII regions.

H. Bloemen (ed.), The Interstellar Disk-Halo Connection in Galaxies, 197.