LOW-INTENSITY H-BETA EMISSION FROM THE INTERSTELLAR MEDIUM

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Pulsar pulse dispersions and low-frequency absorption of galactic and extra-galactic radio sources strongly suggest that the interstellar medium is much more ionized than previously assumed.

It used to be assumed that the interstellar medium consisted mostly of large regions of neutral hydrogen gas and that any free electrons within this neutral hydrogen medium would be the result of the ionization of carbon, silicon, and iron atoms by ultraviolet starlight with photon energies less than 2.18 aJ (13.6 eV).

But this model falls short of producing the observed number of interstellar electrons by nearly a factor of 100. Therefore, one is forced to conclude that the interstellar hydrogen is also being ionized by some process, and there are now many people working on various possible ionization and heating mechanisms for the interstellar hydrogen.

Experimentally a great deal of information can possibly be learned about the ionization and heating processes acting upon the interstellar hydrogen by studying the very faint hydrogen recombination radiations that would result. A search for the resulting H-beta line was recently made using a spectrometer at the Coude focus of Goddard's 36-in. telescope. This work was done in collaboration with Fred Roesler and Frank Scherb at the University of Wisconsin and Elihu Boldt at Goddard.

The search was confined to directions near pulsars because of the additional information provided by the dispersion measure which gives the total number of electrons along the line of sight to the pulsar. Of the four directions in which observations were made, an emission line appears to be present in at least two and possibly three directions.

Figure 1 shows the data obtained from a low galactic latitude direction near the Crab Nebula pulsar. The observing direction was about 9 arcmin off the Crab with the field of view of about 1.5 arcmin. The number of counts has been plotted versus the local standard of rest velocity and local standard wavelength of H-beta.

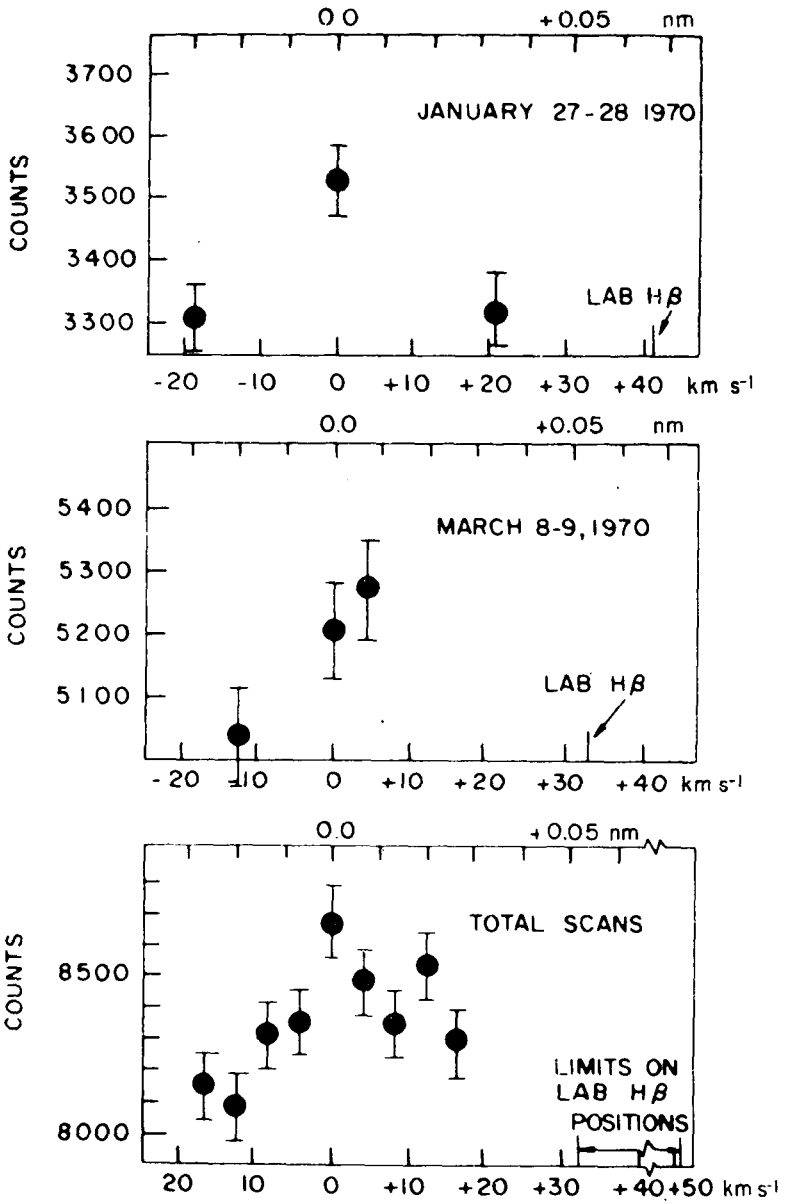

Figure 1—Data from a low galactic latitude direction near the Crab Nebula pulsar, PSR 0532 direction.

The resolving width of the spectrometer is about 8 km s^{-1} or 0.014 nm. The top two graphs consist of just the three data points, each to confirm the presence of an emission feature; the bottom graph shows an attempt to measure the line profile and represents the total accumulating time of 1 hr per data point. This feature coincides in position and approximate width with the velocity distribution of the neutral hydrogen in this direction as determined from 21-cm data.

The data from a high galactic latitude direction is shown in Figure 2; the galactic latitude is +50° for this pulsar. The neutral hydrogen in this direction is also peaked at 0 km s^{-1}, as this emission feature appears to be.

If these features are galactic H-beta, then there are two main conclusions that can be deduced from the data. First, the data can be combined with galactic radio absorption measurements and pulsar dispersion measures to set a lower limit of 1000 K for the electron temperatures of the emitting regions and upper limit of 1 electron cm^{-3} for the densities.

Secondly, the average recombination rate of hydrogen along the line of sight must be greater than or about equal to 10^{-14} per hydrogen atom per second. Assuming steady-state conditions, this would also be the value of the average ionization rate for hydrogen and is a factor of 3 to 10 times higher than what people working on steady-state ionization models had been assuming.

These observations are continuing with a spectrometer of much larger area, and preliminary results of the data obtained last month (October 1971) at 13 additional directions seem to confirm these general conclusions.

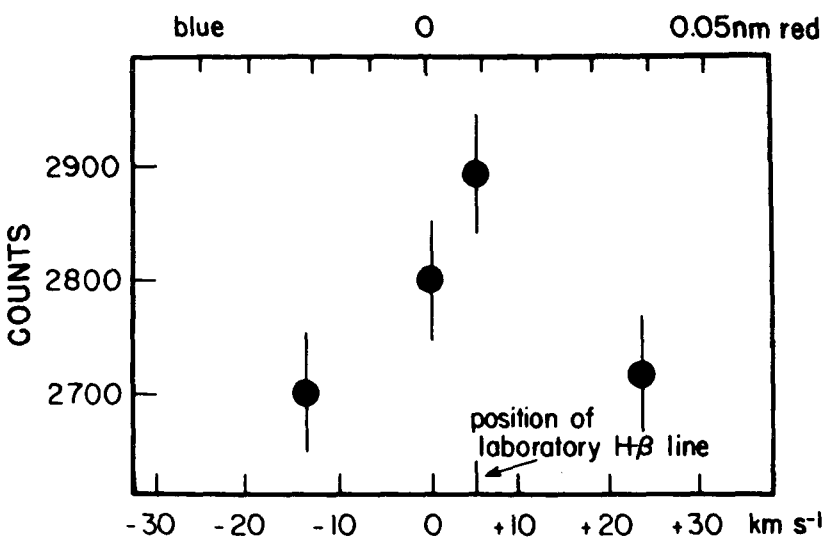

Figure 2–Data from a high galactic latitude direction, PSR 1508.