Short Communication

A search for H_3^* emission from electron-pulse-irradiated hydrogen gas

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No H_3^* emission was detected when hydrogen gas was irradiated by a 0.53 MeV pulsed electron beam at pressures which lead to the production of H_3^* in a hollow cathode discharge. The intensity of any such emission must be considerably less than 0.1% of the intensity of the Balmer α emission observed from the system.

1. *Introduction*

Herzberg and coworkers [1 - 4] have reported line emissions from H_3^* in the 708 - 736 nm and 557 - 565 nm wavelength regions when hydrogen gas is excited in a hollow cathode electrical discharge. The emission apparently arises [1, 4] from Rydberg states of H_3 formed by recombination of electrons with H_3^+ which is commonly found in electrical discharges through hydrogen. Although the conditions in a hollow cathode discharge appear to favour the formation of H_3^* particularly, there is little understanding of why this should be so.

High energy electron beams provide a convenient means of producing a wide range of excited species owing to the broad range of electron energies available in the degradation spectrum and the possibility of exciting spin-forbidden transitions by the mechanism of electron exchange. It therefore seemed desirable to determine whether H_3^* emission lines are produced when hydrogen gas at its usual [1 - 4] pressure of about 1 Torr is bombarded with high energy electrons. The latter were provided as narrow (3 ns) pulses to enable time-resolved studies of any H_3^* emissions to be carried out.

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2. *Materials and methods*

The electron beam was provided by a Febetron 706 pulsed electron accelerator (located at the Lucas Heights Research Laboratories, New South Wales, and operated by the Australian Institute of Nuclear Science and Engineering) equipped with a type 5515 tube. The electron pulses were approximately triangular in shape and had the following characteristics [5]: peak beam current, about 5000 A; mean electron energy, 0.53 MeV; pulse duration, 3 ns (full width at half-maximum); reproducibility of charge per electron pulse, ±5%. The irradiation cell and detection system were as described previously [5] except that a Hamamatsu R928 photomultiplier tube and a Bausch and Lomb high intensity monochromator were used.

All measurements were carried out at 293 ± 2 K with hydrogen gas (manufacturer's specification, 99.999% pure) flowing continuously through the irradiation cell in which it had a mean residence time of 30 - 45 s. The helium gas added in some experiments had a purity of 99.99%. The period between successive irradiation pulses was at least 1 min. The pressure inside the irradiation cell was monitored with an MKS Baratron type 315 absolute capacitance manometer and was maintained at 1.30 Torr.

3. *Results and discussion*

Emission spectra (400 - 720 nm) were obtained by plotting the maximum intensities (uncorrected) from oscilloscope traces of intensity *versus* time as measured from the commencement of a Febetron pulse. A weak

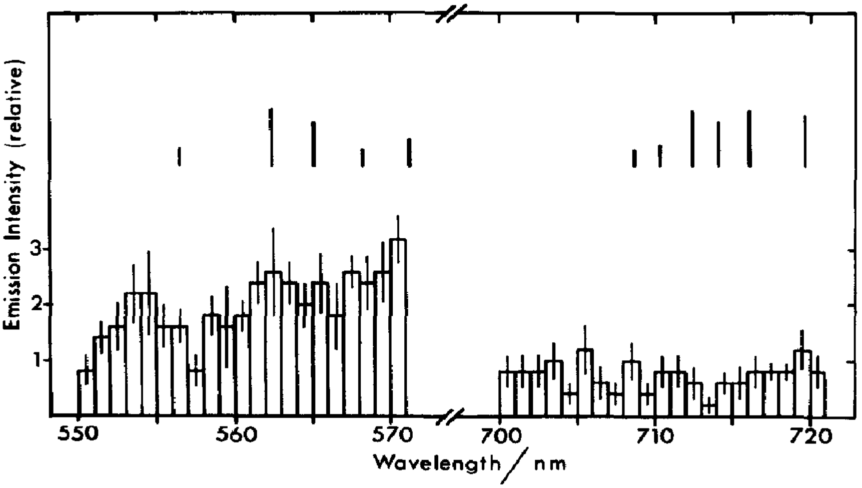

Fig. 1. Emission spectra of electron-pulse-irradiated hydrogen (1.30 Torr) in the H_3^* emission regions. The positions of the most pronounced H_3^* band maxima observed by Herzberg and coworkers [1 - 3] are shown as vertical marker lines with lengths proportional to the reported intensities. Each experimental point is the mean of five replicate determinations and the vertical error bars represent the 50% confidence intervals associated with these means. Horizontal error bars represent the monochromator bandpass of 1 nm. The intensity of the Hα emission was about 1000 on the vertical scale used.

emission was observed between the prominent Balmer α, β, γ and δ emission lines from atomic hydrogen. This weak emission was 0.1% - 0.2% as intense as the Balmer α line and the relevant portions of the former are examined in Fig. 1 for the presence of the characteristic [1 - 4] emissions from H_3^*. Each experimental point is the mean of five replicate determinations and the error bars represent the 50% confidence intervals associated with these means. The positions of the prominent H_3^* emission wavelengths are also shown and the lengths of these reference markers represent the relative intensities of the reported [2, 3] band maxima.

Figure 1 shows no evidence of emission from H_3^*. Any such emission is evidently below the level of the continuum emission observed throughout these regions, the latter presumably arising from the closely packed lines emitted [6] by excited H_2. In addition, there was no evidence of any H_3^* emission when the experiment was repeated under the same conditions with 10 mol.% He in the hydrogen. The intensities of any H_3^* luminescences emitted by these systems must be considerably less than 0.1% of the intensities of the observed Balmer α emissions.

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