Mr. S.A. Haines 23 July, 1979

I am enclosing the write-up on triatomic hydrogen that you requested for "Research News".

G. Herzberg

Enc:

TRIATOMIC HYDROGEN

In the Spectroscopy Laboratory of the Herzberg Institute recently a new spectrum has been observed which has been assigned unambiguously to triatomic hydrogen or deuterium. The ion of triatomic hydrogen, H_3^+, has been known as a very stable system since the earliest work on mass spectrometry by J.J. Thomson but neutral H_3 has always been assumed to be unstable; however this is only true for the ground state of this system. If an electron is added to the H_3^+ ion in a sufficiently excited orbital (Rydberg orbital) one would expect to find excited states of H_3 with a stability similar to that of H_3^+. Transitions between such Rydberg states have now been found in a hollow cathode discharge through hydrogen and deuterium. The first spectra obtained were fairly diffuse but it was nevertheless possible to show that these spectra must be due to neutral H_3 or D_3. Later much sharper spectra were obtained corresponding to different electronic transitions and precise values for the H-H distance have been derived (0.870 Å). A spectrum of the H_3^+ molecule has not yet been observed but the theoretical structure, with the H nuclei arranged in an equilateral triangle, is well brought out in the new spectra of H_3 and D_3. The diffuseness of most of the lines of H_3 and D_3 is due to the fact that the lower states of the transition are subject to radiationless decay (called predissociation) into the unstable ground state.

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It is surprising that the spectrum of triatomic hydrogen has not been observed earlier. It appears much stronger and less diffuse in deuterium than in ordinary hydrogen. Preparations are being made to study, jointly with the Los Alamos Scientific Laboratory, the spectrum of triatomic tritium which is expected to be sharper.