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THE EXCITATION OF VACUUM ULTRAVIOLET RADIATION BY ELECTRON IMPACT ON CARBON MONOXIDE: SOME UNRESOLVED QUESTIONS NEAR THRESHOLD*

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In this note we discuss the excitation of vacuum ultraviolet [UV] radiation by electron impact on Carbon Monoxide. Recently Newton and Thomas reported[1] observing an interesting feature in the UV excitation function with a threshold of 7.4 eV and a sharp peak at 8.3 eV (see Figure 1). The measured work function of their surface detector was 5.1 eV, so that with a threshold of 7.4 eV the detected photons should have been largely confined to the wavelength region 1700 - 2400 Å. However, there is no spectroscopic evidence[2] in this region for the existence of excited CO states that would exhibit this remarkable resonance behavior under electron impact.

The intriquing questions raised by the observations of Newton and Thomas[1] prompted us to examine carefully the UV excitation function of CO using our time-of-flight [TOF] apparatus. The TOF techniques used in this experiment have been described in detail elsewhere.[3,4,5,6] Briefly, a pulsed electron beam was incident on a diffuse gas source [typical pressure 10^{-4} torr] and the resultant photons were detected at 90° to the beam direction with a Johnson CuBe electron multiplier. The multiplier was located 6.4 cm from the beam and detected[7] photons whose energy was greater than the work function of the CuBe surface (~ 5 eV). The pulse counting electronics were gated in order to reject any metastable molecules[4] or metastable fragments[8,9] reaching the detector. The electron gun was pulsed at a rate of 1 Khz with a beam pulse width of 10 μsec.

Our results are shown in Figure 1. Conspicuous by its absence is the resonant feature described by Newton and Thomas. To facillitate comparison of the data our energy scale was adjusted to achieve a best fit to the slope of the excitation function of Newton and Thomas in the

11 - 15 eV region where the agreement is very good. This adjustment amounted to a downward shift of our energy scale of 0.3 eV. Our excitation function was not current normalized but our electron beam current varied very slowly in this region and was constant to within 3%. The marked break in the excitation function in the 10 - 11 eV range is probably due to the excitation of several $^1\Sigma^+$ states in CO ($B^1\Sigma^+$, $C^1\Sigma^+$, $E_0{}^1\Sigma^+$) as pointed out by Newton and Thomas.[1]

The reason for the disparity between these two experiments at lower energies is not understood. At first we speculated that the work function of our surface detector might have been higher than expected thereby resulting in a lower efficiency for photon detection. However, based on the asymptotic behavior of the metastable detection efficiency of a CuBe surface[10] we would estimate the work function of our surface to be 5.0 $\pm$ 0.5 eV. Furthermore the excitation functions[1,4] for metastable CO molecules compare well, again indicating that our detection surfaces exhibited similar work functions. To determine if we were detecting the peaked feature but with a much smaller efficiency we expanded the vertical scale on the multi-channel scaler by a factor of 200 (see Figure 1). Again no trace of this peaked feature could be identified. On this expanded scale a threshold of 8 eV was clearly visible. We identify this threshold with the excitation of CO($A^1\Pi$) molecules.[11]

The experiments compared in this note differ in two respects: the nature of the source target and the distance of the detectors from the collision region. Newton and Thomas placed their detector at a distance of 10.7 cm and used a molecular beam source while our surface detector was at a distance of 6.4 cm and we used a diffuse gas source. We do not believe that either of these differences could account for the disparity.

We also note that Newton and Thomas used CP grade gas while we used research grade gas. The major contaminant in the CP grade CO gas is N_2(~ 0.4%). The threshold behavior of the UV photon excitation function for N_2 was therefore examined in our TOF apparatus. It did not display any resonant type behavior at threshold. So the pseudo-resonance signal reported by Newton and Thomas was not due to the major contaminant. The narrowness of the peak suggests that the signal might be due to magnetically trapped electrons. However, this notion can be discarded because the signal would not be pressure dependent and because the detector housing used by Newton and Thomas was biased to deflect charged particles.[12]

Newton and Thomas[1] have suggested that the photons are being emitted by an excited state of CO^- excited in a dielectronic attachment process. However, we can see no reason, based on the differences between the two experiments outlined above, why we should not also observe the same structure even if the emitting molecule is CO^-, and we are not aware of any spectroscopic data supporting this negative ion model. In view of these developments we believe that the resonance - like structure observed by Newton and Thomas[8] warrants further careful investigation.

FOOTNOTES AND REFERENCES

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FIGURE CAPTIONS

Figure 1. Ultraviolet photon excitation functions for electron impact on carbon monoxide.

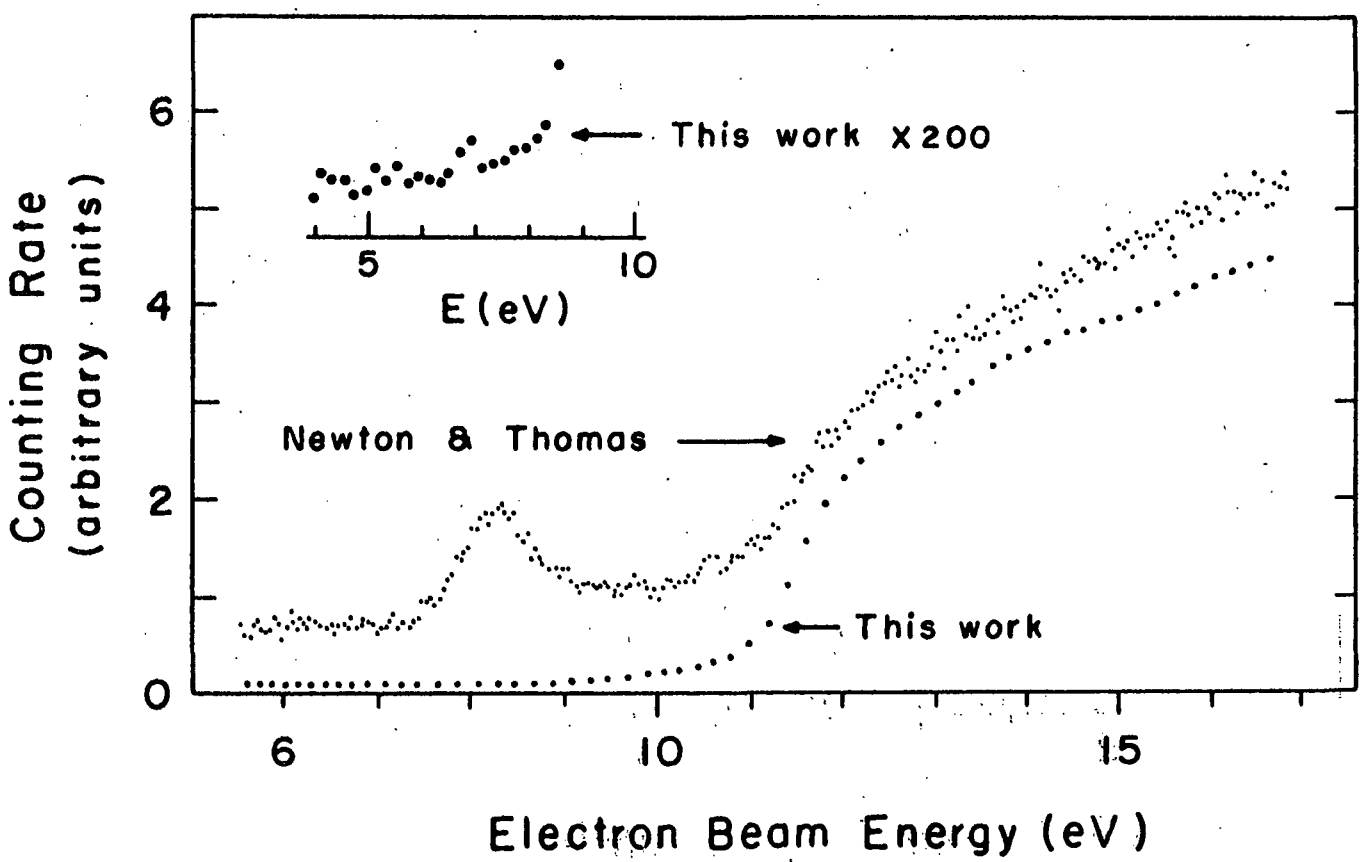
Counting Rate
(arbitrary units)
0
2
4
6
This work X200
5
10
E(eV)
Newton & Thomas
This work
6
10
15
Electron Beam Energy (eV)

Figure 1

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