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ELECTRON IMPACT EXCITATION EFFICIENCY CURVES FOR THE FORMATION OF NEUTRAL METASTABLE SPECIES*

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For some years now, a group at the Lawrence Radiation Laboratory at Berkeley has been engaged in making measurements of the excitation efficiency curves for the formation of neutral electronically metastable species.[1,2] Basically, an electron beam from an RPD gun has been crossed with an atomic or molecular beam. The metastable neutrals can be detected via their ability to eject electrons from a metal surface. In this work, the metal surface is the Cu-Be first dynode of an EMI type 9603 electron multiplier.

A difficulty encountered in making these measurements in this way is that U.V. photons produced in the collision chamber are also detected by the multiplier. However, the photons can be separated from the metastables by taking advantage of their flight time from the collision region to the detector. If excitation is effected by a short pulse of electrons, photons are observed to arrive at the detector during the pulse. The metastables arrive at later times.[2]

In attempting to extend the earlier work,[1,2] we have developed a method of making RPD measurements on the time-resolved species. The pulsing scheme used is shown in Fig. 1. A master clock pulse triggers an ~1 kHz pulse train from a time-based

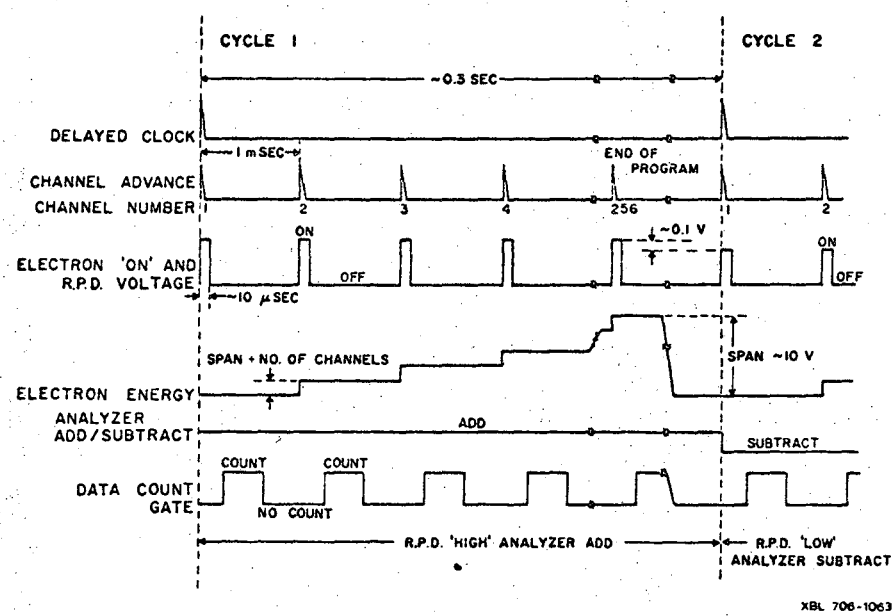

Fig. 1. Pulsing scheme for time-resolved RPD measurements.

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oscillator. These time-base oscillator pulses are used to trigger the channel advance of a Hewlett-Packard 5400 A multichannel analyzer used in the multiscale mode. An ∿10 μsec pulse, triggered by the time-base oscillator is applied to the RPD grid of a 5-electrode RPD gun. The voltage applied during the pulse is exactly that to allow a truncated electron distribution to pass through the collision chamber. The voltage of the collision chamber is set to give the desired initial electron energy. A data count gate is opened after a preset delay. The width and delay of the count gate is variable. This allows counts to be registered in the multichannel analyzer only during a specified time slot after the electron pulse. After ∿1 msec, a second time-base oscillator pulse advances the channel number and advances the electron energy (derived from the X-output of the multi channel analyzer) by one step. After scanning 256 channels in this fashion, the multichannel analyzer produces an end-of-program pulse which stops the sequence. On receipt of the second clock pulse, the entire sequence is repeated, except that the electron 'on' voltage is lowered by ∿0.1 V, and the analyzer is automatically reset to operate in the subtract mode. This produces an RPD scan of the time-resolved species. Multiple RPD scans are always accumulated in the analyzer.

Figure 2 shows an example of the application of this scheme to N_2. The upper

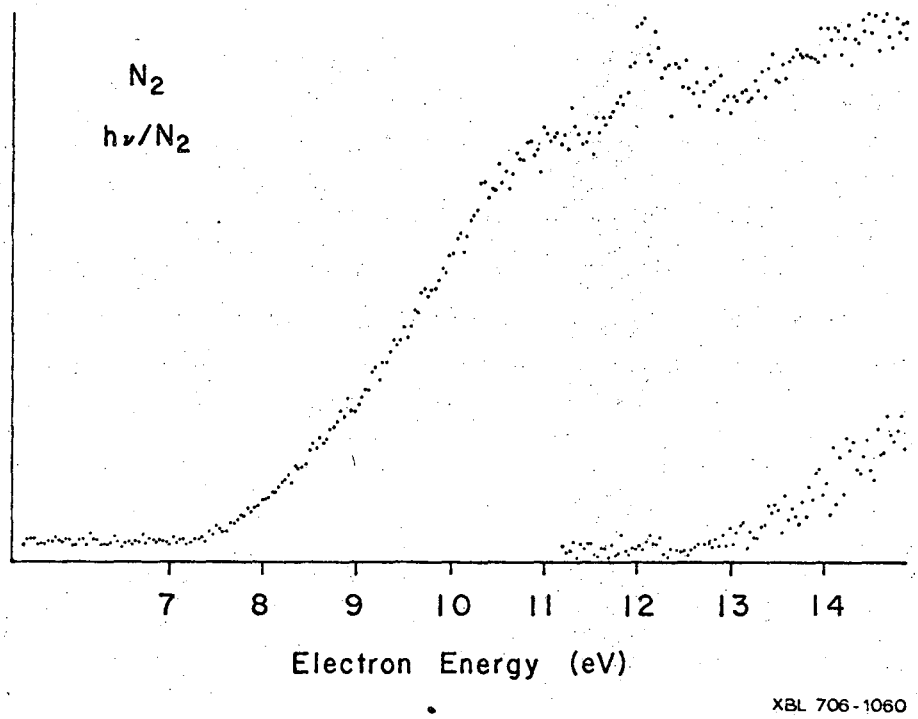

Fig. 2. Excitation efficiency curves for metastables and photons from N_2.

curve in Fig. 2 shows the formation of metastables in N_2. This species has been examined and discussed in detail by, e.g., Olmsted,[3] Lichten,[4] and Freund.[5] In the present study, the $E^3\Sigma_g^+$ state near 12 eV shows up clearly. The lower curve of Fig. 2 shows the photon signal observed in N_2. The appearance potential of the photons coupled with the knowledge

that they are sufficiently energetic to eject an electron from the multiplier strongly suggests that the Birge-Hopfield System is the source of the light.

In the studies of the rare gases Ne, Ar, and Kr, the metastable excitation efficiency curves agree very well with those of Olmsted, Newton, and Street.[1] In all cases, the photon appearance potential was equal, within experimental error, to that of the metastable. In Ar and Kr, a break in the photon curve was observed near the energy of the np^5nd configurations.

A time-of-flight survey of a variety of gases has revealed that there are species with a flight time shorter than that expected for the molecular metastable (but with a flight time longer than the fast photon signal) in O_2 and in CS_2. No excitation efficiency curves for the latter species are available.

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