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LIFETIME OF CO(a3II) FOLLOWING ELECTRON IMPACT DISSOCIATION OF CO2

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Lifetime of  $\text{CO}(\underline{a}^3\Pi)$  Following  
Electron Impact Dissociation of  $\text{CO}_2$  †

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March 1972

The same time-of-flight technique previously employed to measure the lifetime<sup>1</sup> of the  $\underline{a}^3\Pi$  metastable state of CO produced by electron bombardment of a molecular beam of ground state CO has been used to investigate, for several electron bombardment energies, the lifetime of  $\text{CO}(\underline{a}^3\Pi)$  following electron impact dissociation<sup>2,3</sup> of  $\text{CO}_2$ . Knowledge of the lifetime and velocity distribution of  $\text{CO}(\underline{a}^3\Pi)$  following its dissociative excitation is of interest not only because of the observation<sup>4</sup> of CO Cameron band emission in the Martian upper atmosphere by Mariner 6 and 7, but also in connection with measurement<sup>5</sup> of the dissociative excitation cross section for production of  $\text{CO}(\underline{a}^3\Pi)$  by electron impact on  $\text{CO}_2$ .

A complete description of our apparatus, data-collection scheme, data analysis, and time-of-flight theory has been given previously.<sup>6</sup>

The experiment is based on the time-of-flight technique where an atom or molecule is assumed to leave the metastable state only by radiative decay as it drifts over a 5-m path between two fixed detectors.

Neutral, ground-state  $\text{CO}_2$  molecules effuse from a source slit and are immediately excited by a pulse of magnetically focused electrons. The metastable  $\text{CO}(\underline{a}^3\Pi)$  molecules resulting from the dissociation<sup>2,3</sup> of the excited  $\text{CO}_2$  molecules are then collimated while passing through three buffer chambers and finally detected at both ends of the 5-m drift region.

The data-taking and timing aspects of the experiment are controlled by an on-line PDP-8 computer. An example of the data collected is shown in Fig. 1. The electron gun is pulsed on only during channel 0 and counts are then collected simultaneously at both detectors into 199 channels, not all of which are shown. The 20-V distribution, representing 48 hr of data collection, contains about 3000 counts at the peak, while in contrast the 200-V distribution has about 27 000 peak counts and was collected in only 4 hr.

Taking the ratio  $R$  of detector-2 counts to detector-1 counts for metastable  $\text{CO}$  molecules of the same velocity gives a decay plot of  $\ln R$  vs time of flight  $t$ , as shown in Fig. 2. If only one component were present, as in our previous discussion<sup>6</sup> of the time-of-flight technique,  $\ln R$  vs  $t$  would be a straight line, and the lifetime  $\tau$  of the metastable state would be obtained from the slope =  $-1/\tau$  of this straight line. But since several vibrational and rotational levels of  $\text{CO}(\underline{a}^3\Pi)$  are

metastable and have different radiative lifetimes,<sup>1,7</sup> the decay plots of Fig. 2 have curvature, as expected for the decay of a multicomponent metastable beam. Only an average lifetime  $\bar{\tau}$  of CO(a<sup>3</sup>Π) can be obtained from the "average" slope of the decay plot for each electron bombardment voltage, since, unlike our earlier lifetime measurement<sup>1</sup> of CO(a<sup>3</sup>Π) produced by direct electron excitation of CO, the relative populations of the various CO(a<sup>3</sup>Π) rotational levels are unknown for dissociative excitation of CO<sub>2</sub>. In fact, the change in average lifetime at about 35 V apparent in Fig. 2 implies a corresponding change in the relative populations of the CO(a<sup>3</sup>Π) levels.

The author would like to thank Dr. W. C. Wells for suggesting these measurements.

#### References

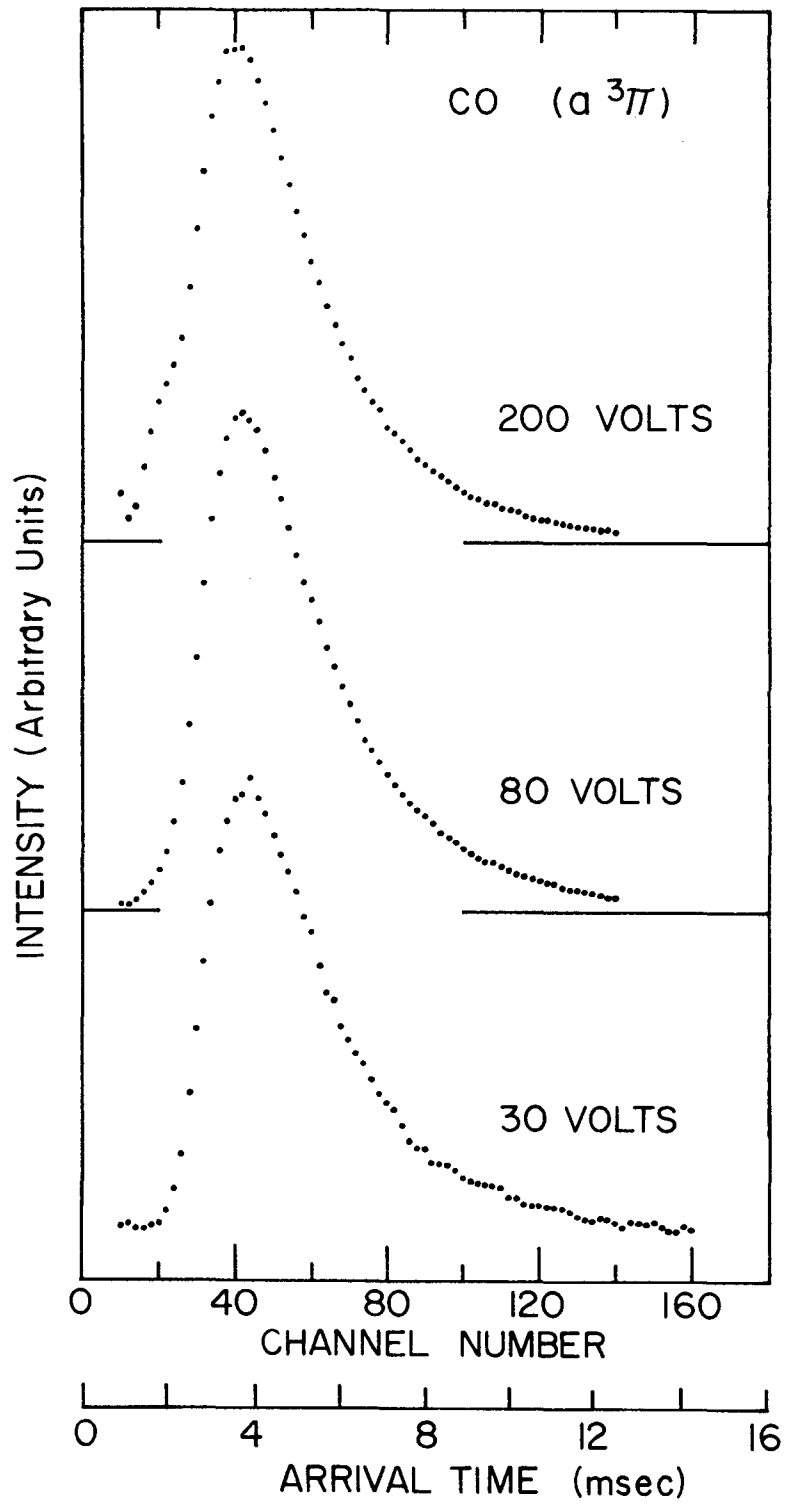
† Work supported by USAEC.

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Figure Captions

Fig. 1.  $\text{CO}(\underline{a}^3\Pi)$  time-of-flight distributions taken at detector 2, 6.62 m from the electron gun used to bombard the  $\text{CO}_2$  molecular beam. The shoulder on the distribution for an electron bombardment energy of 200 eV first appears at about 120 eV and is a new feature not reported in refs. 2 or 3.

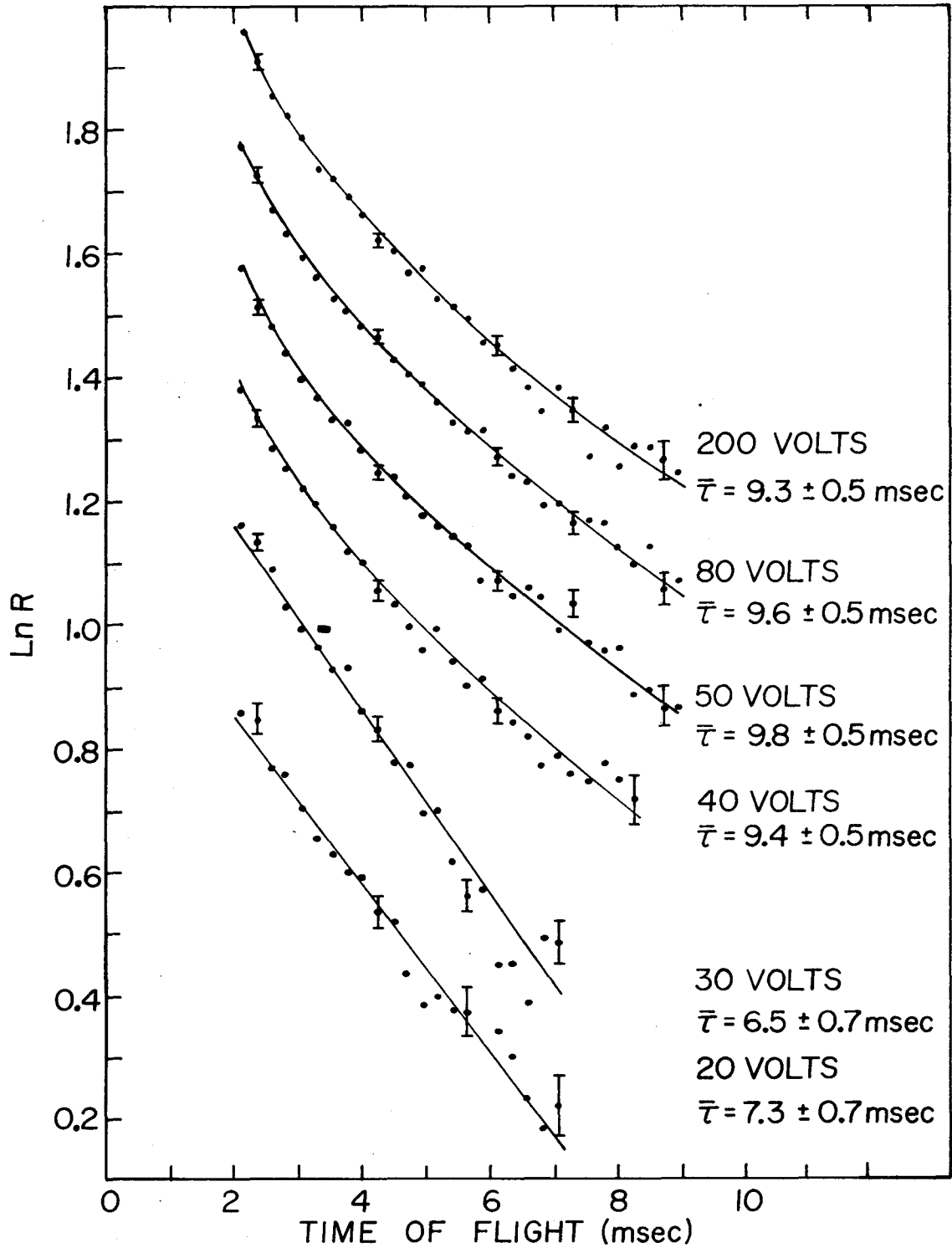
Fig. 2. Decay plots. The ratio of detector-2 to detector-1 metastable CO distributions versus time of flight between detectors is plotted on a logarithmic plot for several electron bombardment voltages. The average lifetime  $\bar{\tau}$  of  $\text{CO}(\underline{a}^3\Pi)$  at each voltage represents  $-1/\text{average slope of the decay plot}$ ; the solid curves are only for comparison purposes.



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Fig. 1





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Fig. 2

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