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Photon and Positive Ion Production from Collisions of
Superthermal Hydrogen Atoms with Lithium Atoms and Molecules*

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* Supported by the United States Department of Energy [Contract No. EY-76-S-02-2326.*001].

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~~We wish to report~~ ^{is reported} photon and positive ion production from superthermal collisions of hydrogen atoms with lithium atoms and molecules. These are the first results in the difficult ~~to~~ 10 eV collision regime obtained with our recently developed high intensity plasma-arc source of H atoms.¹ These superthermal H atoms (~5 eV average kinetic energy but not velocity selected in these experiments) have been collided with an intense supersonic lithium beam (~10% Li₂; Li₃ undetectable) with cold internal degrees of freedom (T_{vib} = 195°K, T_{rot} = 70°K).² The other aspects of the apparatus have been given previously.^{1,2} ~~We have detected~~ ^{is reported} low resolution photon and positive ion production in the collision chamber scattering center (Position I) indicated in Reference 1 and also ~~medium resolution; Figure 1~~ ^{is reported} photon production in the magnet chamber between the skimmer and the magnet. (Position II) ~~were~~ ^{is reported} detected.

Figure 1. Visible spectrum (6 Å resolution; uncorrected for photomultiplier and spectrometer wavelength dependence) resulting from collision of super-thermal (~5 eV) H atoms with a Li/Li₂ crossed beam. In the absence of the Li/Li₂ beam, a smooth background with only the Balmer lines of hydrogen is observed. Features not assigned to atomic lines are thought to be molecular on the basis of their width and their intensity dependence on resolution. In the 4600 - 5400 Å region, numerous features corresponding to ⁷Li₂ (B ¹Π_u + X ¹Σ_g⁺) are observed. In the 6600 - 7000 Å region, four weak but definite features corresponding to ⁷Li₂ (A ¹Σ_u⁺ + X ¹Σ_g⁺) have been observed, but cannot be seen clearly in this spectrum. Other features apparently do not correspond to a known spectrum.

In our initial (Position I) experiments, we looked primarily for total photon and positive ion production. There are many accessible photon and ion production channels (for 5 eV H atoms, excited states of Li, Li₂ and LiH; and Li⁺, Li₂⁺, LiH⁺, H⁺, Li⁻, LiH⁻, Li₂⁻ ions; further possibilities arise from collisions with Li₃, Li₄, etc. and from the high energy tail of the H atom kinetic energy distribution). On this basis, we designed our apparatus expecting a total photon production cross section of $\sim 10^{-16}$ cm². Given our H atom¹ and Li₂ molecule² fluxes ($\sim 1 \times 10^{20}$ atoms/sr-sec and $\sim 4 \times 10^{18}$ molecules/sr-sec), however, we observe much smaller photon and positive ion production cross sections of $\sim 10^{-19}$ cm⁻¹ and $\sim 10^{-20}$ cm², respectively. We have observed with calibrated filters that $75 \pm 6\%$ of the photons are produced in the narrow region near the Li (2s - 2p) resonance lines. With regard to ions, $7 \pm 2\%$ of the positive ions were Li₂⁺, the remainder Li⁺; all other positive ions were undetectable ($< 0.002\%$ of the total). Possible spurious causes of photon and ion production (e.g. H (2s) or Cu from the Cu nozzle in the H atom beam; background O₂ and N₂; photons, electrons or ions from the plasma-arc) have been examined and discounted.

Because the photon production was only $\sim 10^{-3}$ of what we designed for, we repeated these non-velocity-selected experiments in Position II, just in front of the velocity-selection magnet, where by geometric factors the photon signal should be $\sim 10^4$ times that at Position I. This ten thousand-fold enhancement of photon signal with only a tenfold increase in background allowed us to obtain medium resolution spectra (1.4 to 6 Å in various runs) such as given in Figure 1. It should be noted that it was necessary to install a grid to suppress electron impact excitation of Li₂ ($B^1\Pi_u \rightarrow X^1\Sigma_g^+$) emission (similar to the photon excited spectrum previously reported²), the electrons arising from the plasma-arc.

The primary purpose of this communication is to present this spectrum, consisting of a variety of atomic lines (narrow and assigned) and a variety

of molecular bands (broader and for the most part unassigned). The molecular and atomic lines could also be readily distinguished by varying the slit width (resolution). We believe this includes a previously unobserved molecular spectrum, presumably due to $H + Li_2$ collisions; a reasonable possibility is Li_2^+ , which should have emission bands in the 4000 - 6700 Å region.³ We shall continue to seek the origin of these spectra and to obtain velocity-selected results for these collisions.

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