PHOTODISSOCIATION OF NEUTRAL FREE RADICALS OF ASTROPHYSICAL INTEREST

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The necessity for understanding molecular formation and destruction processes occurring in astrophysical environments is well known. Accurate molecular data are of critical importance in formulating models of such diverse regions as interstellar clouds and planetary and stellar atmospheres. With this in mind we have devised an experimental method and constructed an apparatus for the determination of cross sections as well as the kinetics for photodissociation processes in chemically unstable neutral molecules. Similar experimental methods have been independently developed by de Bruijn and co-workers and by Chen et al. (1).

A schematic of our apparatus is shown in Figure 1. We produce the negative ion of the species of interest in a discharge ion source. The ions are extracted and electrostatically accelerated to velocities greater than 10^7 cm/sec. To insure beam purity they are mass analyzed using a magnetic sector which also deflects them onto the primary axis of the apparatus, where they are subsequently collimated. The beam from a pulsed laser is also directed along this axis. The energy of the photons in this beam is chosen to be just sufficient to induce photodetachment of the negative ions, and the intensity is chosen to be high enough to induce the photodetachment of a very large fraction of the ions in the beam. The remaining negative ions are electrostatically swept out of the beam, and the now neutral molecular beam is allowed to pass into the next section of the apparatus. Here ultraviolet light from a second pulsed laser crosses the neutral beam at right angles. Absorption of photons from this laser causes photodissociation of some of the molecules. Part of the energy of the absorbed photon is converted into kinetic energy of the photofragments. The fragments therefore move away from each other and also from the axis as they continue their flight along the beam line. If the collimation angles are small enough, some of the fragments will leave the cone of the parent molecular beam and form a "halo" (not necessarily circular) around it. Since they are moving at high velocity, they may be detected with secondary electron multiplying devices such as channelplates. If the detection system records the fragment impact positions and arrival times relative to the firing of the dissociation laser, then individual fragment kinetic energies can be deduced and angular distributions determined.

We have carried out experiments on the photodissociation of excited states of H_2^+ in order to assess the performance of the apparatus (see Figure 2). Light from a flashlamp-pumped (rhodamine 6G) dye laser was directed along the beam axis, and it induced dissociation from states of vibrational quantum number $v' = 7$ and above. H^+ fragments were directed onto a channel electron multiplier and H fragments were allowed to strike a channelplate electron multiplier fitted with a coarse annular multianode array. The data we have obtained are shown in Figure 3. Note that the channeltron preferentially detects H^+ ejected along the beam axis, while the channelplate preferentially detects H ejected perpendicular to the

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beam axis. The number of fragments ejected at a given angle to the axis (i.e., the angular distribution) is related to the laser beam polarization and to details of the initial and final quantum mechanical states (2). For this experiment large angles are expected (3) and observed.

Experiments on the astrophysically important free radical CH have been initiated. The C $^2\Sigma^+$ state can be excited from the X $^2\Pi$ ground state with 3140 Å light from a frequency doubled dye laser. It is inferred from spectroscopic evidence (4) that all vibrational-rotational substates of this electronic state predissociate, and this resonant process is considered to be the primary photodestruction mechanism for interstellar CH (5). We intend to study this predissociation by observing directly the H fragments. The apparatus can also be used to study the dissociation of CH through higher lying repulsive Σ and Π states and the dissociation of OH through predissociating substrates of the A $^2\Sigma^+$ state (6) and through the repulsive 1 $^2\Sigma^-$ state (7). This last process is expected to be a major loss mechanism for interstellar OH (7).

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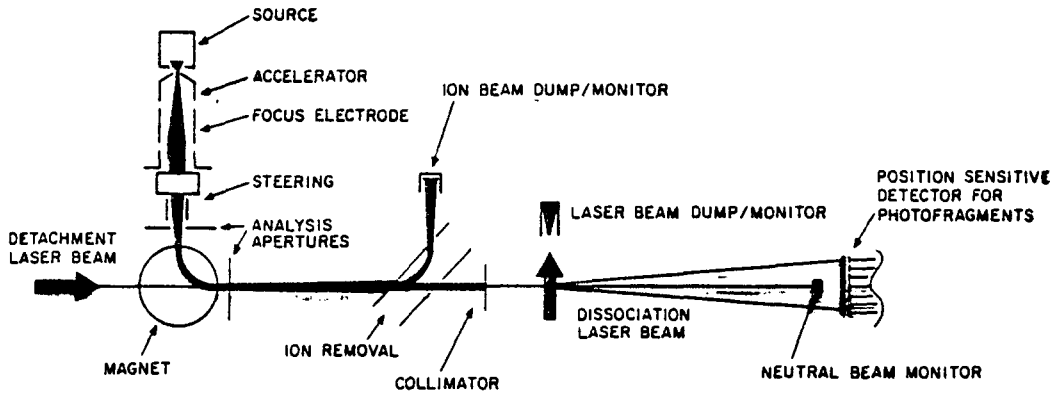

Figure 1. Schematic of Apparatus.

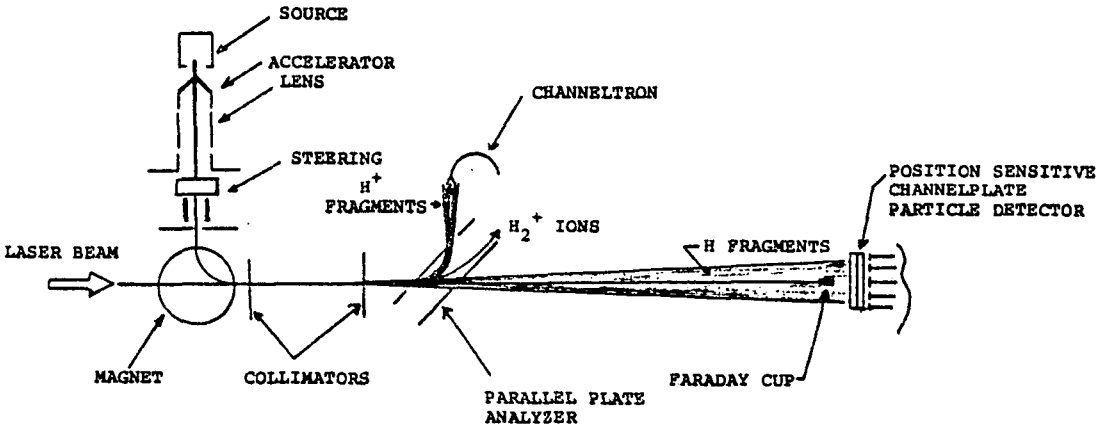

Figure 2. Schematic of Apparatus as Used for H_2^+ Photodissociation Experiment.

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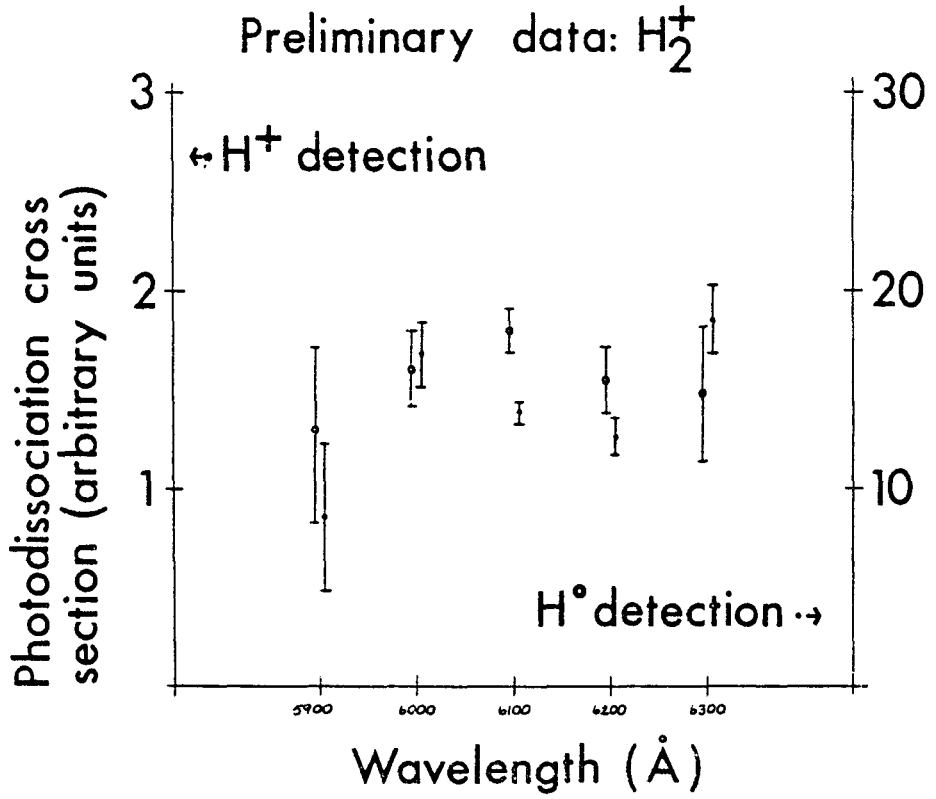

Figure 3. Preliminary Data for H_2^+ Photodissociaton Experiment

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