Temperature-Dependent Photoabsorption and Emission Studies of Atmospheric Gases, with Application to Planetary Atmospheres

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One of our recent laboratory efforts is concerned with the interaction of ultraviolet (UV) and extreme ultraviolet (EUV) photons with planetary, interplanetary, and cometary gases under various temperature conditions. The temperature-dependent measurements include absolute absorption cross sections and absolute cross sections for the production of fluorescence through photodissociation of molecules.

In recent years, we have obtained temperature-dependent absolute absorption cross sections of molecules at temperatures between 140 K and 400 K using a closed absorption cell and up to 650 K using a windowless high-temperature absorption cell. Our temperature-dependent photoabsorption cross sections for CO, C_2H_2, NH_3, H_2S, CS_2, and SO_2 have been applied in modeling optical albedos of Venus, Mars, Saturn, Jupiter, Titan, Io, and Jupiter after the collision of Comet Shoemaker-Levy 9. Future work in this area includes C_6H_6, which is of interest on Jupiter.

For higher temperature measurements, a windowless absorption cell allows us to measure absorption cross sections throughout the UV and EUV spectral region, free of troublesome out- gassing problems encountered while using high temperature closed cells. In a windowless absorption cell, however, accurate absolute pressure measurements are difficult to achieve. To resolve this difficulty, we directly calibrate the column density for given experimental flow and temperature conditions of the molecule of interest, and in specific wavelength regions where the absorption cross sections are known to be continuous and nearly constant with wavelength.

We also plan to extend our work on dissociative excitation processes for application to planetary atmospheres. A windowless high-temperature flow cell that is capable of achieving temperatures from 300 to 900 K has been used to determine fluorescence excitation functions of excited atomic and molecular species produced through photon excitation of atmospheric molecules such as N_2 (relevant to the atmospheres of the Earth, Titan, and Triton), CO, and CO_2 (Venus and Mars). Absolute fluorescence cross sections have been measured for the production of specific NI and NII EUV emissions resulting from photodissociation of N_2 at room temperature and 650 K. The dissociative photoionization excitation of N_2 has also been studied at several selected wavelengths shortward of 360 Å, using a coincidence technique to detect the NI 1200 Å fluorescence photon and the N^+ ion. The maximum quantum yields for these processes are of the order of 0.06. Thus, the neutral dissociative excitation processes can be competitive with dissociative ionization excitation for the multiple-electron transition states of N_2. The NI and NII results are important in the interpretation of the ultraviolet airglow emissions of the Earth, Titan, and Triton.

Typical results of both the photoabsorption and photon emission studies will be presented.