The Temperature-Dependent Photoabsorption Cross Section Measurements Program at the Space Sciences Center, USC

C.Y. Robert Wu* D. L. Judge*

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Abstract

One of our recent laboratory efforts is concerned with the interaction of ultraviolet (UV) and extreme ultraviolet (EUV) photons with the atmosphere of the Earth, other planets, and cometary gases under various temperature and spectral resolution conditions. The cross section measurements in the temperature range from 140 K to 650 K with a spectral resolution from ultrahigh (0.0003 nm and 0.0008 nm), and high (0.008 nm), to medium (0.01 nm). A closed absorption cell was used to carry out measurements between 140 K and 400 K while a windowless high-temperature absorption cell was used for temperatures up to 650 K. The 6VOPE spectrometer available at the synchrotron radiation facility of the Photon Factory, KEK, Tsukuba, Japan, is used in the ultrahigh resolution studies, whereas the 4-m NIM spectrometer available at the Synchrotron Radiation Center, Madison, Wisconsin, is utilized in the high and medium resolution measurements.

Typical ultrahigh-resolution, high-temperature results on: (1) N_2 with a resolution of 0.0003 nm and 0.0008 nm in the 91.6 nm and the 83.4 nm regions at temperatures of 650, 555, 445, and 295 K and, (2) O_2 with a resolution of 0.0008 nm in the 83.4 nm, 91.6 nm, 108.5 nm regions at temperatures of 535 and 295 K will be presented. The data will contribute to a correct interpretation of the NII 91.6 nm, the OII 83.4 nm, and the NII 108.5 nm extreme ultraviolet airglow emissions of the Earth, by elucidating the effect of temperature on the atmospheric extinction due to absorption by N_2 and O_2.

We have also obtained temperature-dependent absolute absorption cross sections of molecules at temperatures between 140 K and 400 K for CO, C_2H_2, NH_3, PH_3, H_2S, OCS, CS_2, and SO_2. The data have been applied in modeling optical albedos of Venus, Mars, Saturn, Jupiter, Titan, Io, and Jupiter. We have also carried out low temperature cross section measurements on CH_4, C_2H_4, and C_2H_6 and have studied pressure-induced broadening effects on C_2H_2 in the presence of high pressure H_2

*Space Sciences Center and Department of Physics and Astronomy University of Southern California, Los Angels, California, 90089-1341

and N_2. Most recently the Cassini UVIS experiment detected CH_4, C_2H_2, C_2H_4, C_2H_6, C_4H_2, and HCN in the atmosphere of Titan using data from a stellar occultation by Titan [Shemansky et al., Science 308, 978 (2005)]. Our low- temperature CH_4, C_2H_2, C_2H_4, and C_2H_6 data have been applied to a model using Cassini UVIS observations. The observations cover an unprecedented range of altitudes from 450 km to 1600 km, allowing the first determination of the mesopause. However, there exists no previous high resolution and low temperature cross section data of HCN and C_4H_2. Therefore, we plan to carry out such measurements in our laboratory in the very near future. Typical low temperature data for a variety of atmospheric gases will be presented.