FURTHER TESTING OF “SELF-SHIELDING” MODEL FOR THE OXYGEN ISOTOPE EVOLUTION IN THE EARLY SOLAR NEBULA — ISOTOPE COMPOSITION OF ATOMIC OXYGEN FROM CO PRE-DISSOCIATION. Xiaoyu Shi¹, Qing-Zhu Yin², Cheuk-Yiu Ng³¹Department of Chemistry, University of California at Davis, One Shields Avenue, Davis, CA 95616, USA (xxyshi@ucdavis.edu; cyng@ucdavis.edu), ²Department of Geology, University of California at Davis, One Shields Avenue, Davis, CA 95616, USA (qyin@ucdavis.edu).

Introduction: Inner solar system materials have distinct oxygen isotopic compositions, suggesting a large scale mixing between ¹⁶O-rich and ¹⁸O-poor reservoirs. Exactly how these reservoirs were first developed in the solar nebula has remained elusive ever since the discovery of the oxygen isotope anomalies in 1973 (1). Recently, building on earlier suggestions (2, 3) and well known astronomical observations (e.g. 4), an intriguing model known as carbon monoxide (CO) “self-shielding” was invoked (5-7) to explain the observed oxygen isotope anomalies in the early Solar System materials. The model is important in that the proposed mechanism and reaction pathways involve all major oxides in the early solar nebula (CO ~50%, H₂O ~33% and the rest as solid oxides of other elements ~17%) (8). According to the model, oxygen isotope anomalies were produced with CO, stored in H₂O, and reacted with dust, and discovered in meteorites today (5-7). The model has recently garnered observational support (9-12).

To experimentally verify the self-shielding model, we have started investigating the photopredissociation behavior of excited state E'Π v=1 around 105.17 nm (13) of carbon monoxide (CO), by comparing the absorption efficiencies of ¹²C¹⁶O, ¹²C¹⁷O, and ¹²C¹⁸O in their excited states respectively. According to (14), the integrated cross section of absorption and predissociation is close to unity. Therefore the absorption efficiencies ratios of isotopologues are analogous to the ratios of the products of the predissociation of ¹⁶O, ¹⁷O, ¹⁸O. We have previously reported our finding at the 2011 LPSC meeting regarding the excited state of CO before predissociation (15). Here we further report the shielding effects and document its isotopic composition on CO’s predissociation products: atomic ¹⁶O, ¹⁷O and ¹⁸O. To our knowledge, no direct isotopic measurement of photodissociation products for the specified vacuum ultraviolet (VUV) region have been reported for minor isotopes such as ¹⁸O.

Experiment: The experimental setup consists of two VUV laser systems, and a time of flight (TOF) spectrometer (Fig. 1). The ultra-high resolution VUV-1 is shielded (absorbed) by CO with natural composition at different number densities. The attenuated VUV-1 laser excites CO isotopologues in supersonic molecular beam to rovibrational states undergoing predissociation. To enhance time-of-flight mass spectrometer detection (TOF), isotopically labeled, ¹⁰O- and ¹⁸O-enriched CO gas was used in the molecular beam chamber, while the “shielding” was done with a natural composition. Subsequently, with a 300 ns delay, the second VUV-2 laser probes (ionizes) the atomic oxygen from CO predissociation. As VUV-1 scans across the wavelength region of interest with high resolution, absorption and dissociation spectra of CO and O are taken respectively in real time.

Results and Analysis: Fig. 2 shows the TOF mass spectra of atomic ¹⁶O and ¹⁷O as products of VUV-1 dissociation-VUV-2-ionization. The Q branches in state E'Π v=1 of ¹²C¹⁶O, ¹²C¹⁷O, and ¹²C¹⁸O are separated by more than 20 cm⁻¹ from each other. Information on the predissociation behavior is obtained by directly detecting the atomic oxygen isotopes generated by CO predissociation. We scanned the VUV-1 from 95082.0 to 95083.6, from 95055.8 to 95056.2, from 95031.65 to 95032.3 cm⁻¹, respectively,
to excite CO to Q branches in state $E'II \nu=1$. The VUV-2 is fixed to a strong autoionization line of atomic O (3P) at 92.95 nm to ionize atomic oxygen. By measuring oxygen intensity as a function of the photon energy of VUV-1 we obtain the rovibrational spectra of oxygen for the Q branches of $^{12}$C$^{16}$O, $^{12}$C$^{17}$O, and $^{12}$C$^{18}$O, shown in Figure 3.

The temperature of the CO molecule beam was at 160K. Each of the data points represents a different shielding depth. The slope = 1.003 obtained by least square linear fitting agrees with the prediction of self-shielding theory. Our result is at odds with a similar experiment for the same band by (16) using broadband synchrotron VUV light source at Advanced Light Source (ALS) at Lawrence Berkeley National Laboratory. The discrepancy remains to be resolved by taking into account the details outlined in (17,18,19).

**References:**