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Isotope Effect of Photo-dissociation of O2 and its Application to the Earth Wind Hypothesis

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Oxygen has three stable isotopes, whose mass numbers are 16, 17, and 18. It was well known that the isotopic ratios are mass dependently fractionated in most chemical and physical processes. Since the first discovery of mass independently fractionated (MIF) oxygen isotopes, there have been a number of studies for analysis MIF and its origins. From isotope analysis of meteorites, it is well established that the oxygen isotope anomaly $D^{17}O$ (= $d^{17}O$ - 0.52 $d^{18}O$, $d^{i}O = 10^{3}[(^{i}O/^{16}O)_{Sample}/(^{i}O/^{16}O)_{SMOW}-1]$) of minerals ranges from -40 to 90 permil and that of bulk meteorites ranges from -5 to 1 permil. Important questions are what is the mean isotopic composition of the solar system and how to make MIF. To explain the differences between the oxygen isotopic ratios of CAIs and those of planetary objects,there are roughly two models; (i) The CO self-shielding models proposed that photo-dissociation of CO would make MIF O-atoms. In these models, the isotopic ratios of CAIs are the same as that of the Sun, and after condensation of CAIs, the nebular gas became isotopically heavier with time to make MIF objects. (ii) Chemical fractionation model proposed that the three body reactions on solid surface make MIF. The life times of vibrationally excited dioxide on the surface are different between symmetric and asymmetric molecules. A symmetric molecule which has shorter life time has a tendency toward formation of CAIs. In contrast, an asymmetric molecule has a tendency toward evaporation again. Both models require tests. Especially the CO self-shielding models proposed so far were phenomenological without rigorous treatment of the dissociation process of CO. Another approach to the oxygen MIF problem is to observe Solar oxygen isotopic compositions. We have only indirect measurements because it is not possible to reach and sample the Sun. First is the observations of solar wind compositions (Genesis mission and Lunar soil observation) and second is the observation using infrared spectroscopy of the Sun. These methods have a problem whether or not the observed isotopic ratios is equal to the solar isotopic ratio. In addition, the lunar soil observation has another problem. There is a hypothesis that the origin of oxygen implanted in the lunar soil may have been transported from the Earth (the Earth Wind hypothesis). The purpose of this study is to test this hypothesis.

I calculate the photo-dissociation cross sections of O_2isotopomers using the first principle calculation to estimate the isotope effect of Photo-dissociation of O_2. I sum the principal quantum number n up to 15 and the every 6^{th}azimuthal quantum number l from 0 up to 96. Calculated dissociation cross sections for $^{16}O_2$agree well with measurements. Assuming the Boltzmann distribution at 1000 K, the photo-dissociation yields $d^{17}O$ = 16.3 permil at the altitude of 300 km. This oxygen isotopic ratio is the same order as the implanted oxygen in the lunar soil. This isotopic composition is not plotted on the slope one line in the oxygen three isotope plot. This is because the cross sections for $^{17}O^{16}O$ are not equal to that for $^{18}O^{16}O$.

Keywords: Oxygen isotopic ratio, Photo-dissociation, First principle calculation