Chemical simulation for ionic oxygen isotope ratio in the terrestrial thermosphere

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Recent measurement of lunar soils indicates that oxygen isotope ratio in the metallic particles is highly mass-independently fractionated (MIF) as Delta^{17}O ~25 permils (Ireland et al., 2006). Ozima et al. (2007) suggested that the MIF oxygen is transported from terrestrial atmosphere by Earth Wind (EW). The recent observation of GEOTAIL satellite shows that escaping oxygen ions in the EW is consistent with the amount of the oxygen implanted in lunar metals. The SELENE satellite vigorously starts to make a mass-spectroscopic measurement around the lunar rarefied atmosphere. In this circumstance, if the MIF dependence of atomic oxygen is generated in a certain region of the present Earth, this would give a robust support for the above EW-oxygen hypothesis; the most possible one is the thermosphere, F-region around 200-300 km, where the oxygen starts to escape. However, current information on the isotopic composition of O either by measurements or theoretical calculation is limited to less than 100 km, and is not useful in accessing the isotopic characteristics of EW-O. We make a 1d ion-neutral chemical simulation for thermospheric oxygen and nitrogen processes and try to evaluate the MIF dependence of atomic oxygen ion.

We give below an outline of our chemical model and simulation. We solve 21 sets of photochemical equations for several ionic and neutral species including oxygen isotopes and electron, about 60 reactions being considered with referring to the JPL94 data compilation. The calculation domain is set to be the altitude range of 100-800 km. It includes the molecular diffusion and several photoionization processes, of which data taken from the EUVAC model. Solving the equation for major species N_2, O_2, and O, we require the perfect mass conservation when the diffusion is disregarded. We take the MSIS-E90 model data for initial values of density and temperature at the latitude of 75 degree where the ion outflow predominantly occurs. Inspired by the insightful interpretation of MIF in ozone layer by Gao and Marcus (2001), we examined dependence of the isotopic composition of O^+ on the isotopic effect of reaction rates especially for charge exchange as $O^+ + O_2$ to $O_2^+ + O$. This reaction is likely to be important in the F-region chemistry, such as the balance between atomic and molecular oxygens, from the test calculation with and without diffusion term. The present result shows that the Delta$^{17}O^+$ values around 300 km amounts to over 20 permils, provided that the reduction in rate coefficients by the isotopic effect is about 10 % than the standard one. It is found that O^+ shows a high MIF even when the associated reaction coefficients have a MF dependence. In this talk, we report the result of this first attempt focusing on isotopic composition of O^+, and discuss characteristic of this chemical reaction system.