NUCLEOSYNTHESIS AND GALACTIC CHEMICAL EVOLUTION OF THE ISOTOPES OF OXYGEN.

B. S. Meyer, Department of Physics and Astronomy, Clemson University, Clemson, SC 29634-0978, USA (mbradle@clemson.edu).

Introduction: The stable isotopes of oxygen are important diagnostics of stellar nucleosynthesis and Galactic chemical evolution. This is primarily due to the fact that ^{16}O is a principal product of stellar evolution and is therefore very abundant in the Galaxy. It is also due to the fact that ^{16}O is a primary isotope while ^{17}O and ^{18}O are secondary isotopes.

Nucleosynthesis: ^{16}O is primarily produced at the end of helium burning in stars. ^{12}C produced by the triple-alpha reaction captures another ^{4}He to produce ^{16}O. This means that the interplay of the triple-alpha reaction and $^{12}C(alpha,gamma)^{16}O$ determines the ratio of ^{12}C to ^{16}O in the star after helium burning, which, in turn, governs the subsequent stellar evolution (e.g., [1]). Experimental determination of the $^{12}C(alpha,gamma)^{16}O$ reaction rate is difficult and is the subject of intense study (e.g., [2]). ^{16}O abundance is increased further during neon burning. Because ^{16}O can be produced by stars initially composed only of hydrogen, it is a primary isotope. It is worth noting that ^{16}O is, in fact, one of the dominant products of massive stars. For example, one may consider a model of a star 25 times the mass of the Sun [3]. This model began with about 0.23 solar masses of ^{16}O but ejected 3.24 solar masses of that isotope.

By contrast, ^{17}O and ^{18}O are secondary isotopes, which means their production requires pre-existing seed nuclei. ^{17}O is dominantly produced by CNO burning of hydrogen into helium and is thus a prevalent isotope in hydrogen burning shells in stars. ^{18}O is primarily made when abundant ^{14}N, left over from CNO burning, captures ^{4}He. This means ^{18}O is abundant in helium-rich zones in stars. Because ^{16}O and ^{18}O production requires helium burning while ^{17}O only requires hydrogen burning, low-mass stars may contribute more significantly to the synthesis of ^{17}O than to ^{16}O or ^{18}O.

Galactic Chemical Evolution: Since ^{16}O is a primary isotope, it was produced in the first generation of stars. Observations of very metal-poor stars show the rise of oxygen with metallicity in the early Galaxy (e.g., [4]). The primary nature of the nucleosynthesis of ^{16}O means that this rise is roughly linear in time. By contrast, the secondary nucleosynthesis of ^{17}O and ^{18}O means that the abundance of these isotopes in the Galaxy will rise roughly quadratically with time in a chemical evolution model (e.g., [5]). Such evolution is evident in Figure 1, which shows the evolution of the mass fraction of the oxygen isotopes in the interstellar medium from a standard Galactic chemical evolution model. The figure was generated with the Clemson University online Galactic Chemical Evolution code available at the web site

http://nucleo.ces.clemson.edu/home/online_tools

Interested readers are invited to explore the details of stellar yields and Galactic chemical evolution of the oxygen isotopes with this tool.

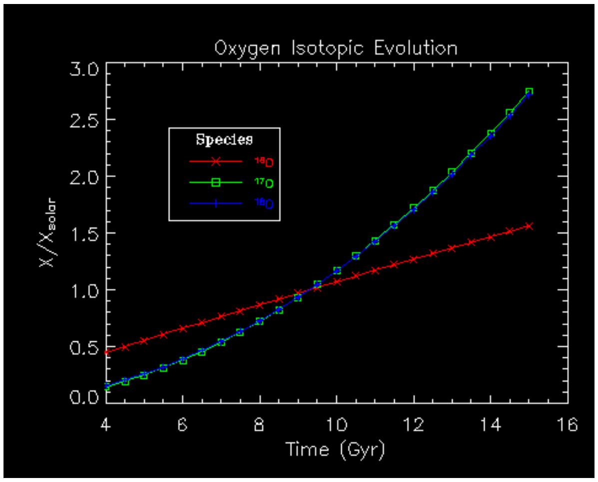

Figure 1: Chemical evolution of the mass fractions of the oxygen isotopes relative to their solar values in the interstellar medium in a standard chemical evolution model. The ^{16}O mass fraction rises linearly with time because it is a primary isotope. ^{17}O and ^{18}O rise quadratically with time because they are secondary isotopes. This figure was generated with the Clemson University online Galactic Chemical Evolution code.

References: [1] El Eid M. F. et al. (2004) *Astrophys. J.*, *611*, 452-465. [2] Kunz R. et al. (2002) *Astrophys. J., 567,* 643-650. Meyer B. S. et al. (1995) *Meteoritics, 30*, 325-334. [4] Israelian G. et al. (2001) *Astrophys. J, 551*, 833-851. [5] Clayton D. D. (1988) *Astrophys. J., 334,* 191-195.