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CALCULATING CHEMICAL EVOLUTION ON THE WEB. B. S. Meyer, J. E. Denny, D. D. Clayton, *Department of Physics and Astronomy, Clemson University, Clemson, SC 29634-0978 (brad@photon.phys.clemson.edu, jdenny@clemson.edu, clayton@gamma.phys.clemson.edu).*

Introduction. We have constructed a web site that may be of interest to cosmochemists seeking to understand the evolution of isotopes in the Galaxy. The URL is <http://photon.phys.clemson.edu/gce.html>. It is fully interactive and uses IDL on the Net (ION) to construct tables and graphs dynamically. The resulting tables may be downloaded as text files while the graphs may be downloaded as gif or postscript files. The present abstract presents a brief tutorial on using the “GCE tool” on this site and illustrates some of its capabilities. Questions or comments should be addressed to either of the first two authors.

Supernova II Ejecta Tool. In exploring the evolution of an isotope in the Galaxy, the first task is to understand its production in stars. The Clemson chemical evolution web site currently employs yields from the massive star models of Woosley and Weaver (1). On the web site, one selects a set of models ranging in metallicity from zero to twice solar metallicity and ranging in initial stellar mass from 12 to 40 solar masses. One may then call the separate “supernova ejecta tool” to explore the ejected mass (at any time after the supernova explosion) for the listed set of nuclei. Figure 1 shows that tool’s plot of the ejected mass of ^{16}O from a range of metallicities and stellar masses. The ejected masses do not vary much with metallicity, a result in line with our expectation for a primary isotope.

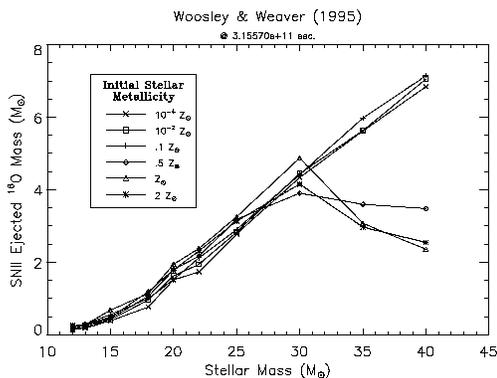


Figure 1: Mass of ^{16}O ejected from stars of different initial masses and metallicities.

Initial Mass Function. After choosing the set of stellar models, the user must then choose an initial mass function (IMF). This is the function $\phi(m)$ that gives the

number of stars in the stellar mass range m to $m + dm$ that forms in each new generation of stars. The function $m\phi(m)$ then gives the amount of mass that goes into stars in the mass range m to $m + dm$. The user may freely choose the form of the IMF. It may be piecewise (up to four separate pieces). The IMF program ensures that the chosen function is continuous and properly normalized. The IMF of B. Pagel is chosen as the default (2)—see Figure 2. The well-known IMF of Salpeter is a separate option (3).

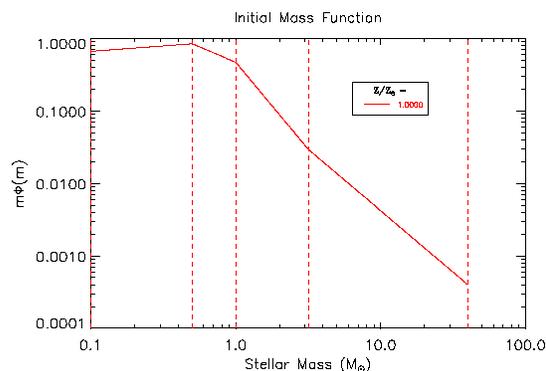


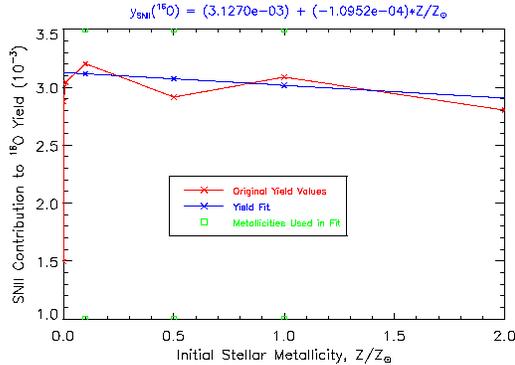
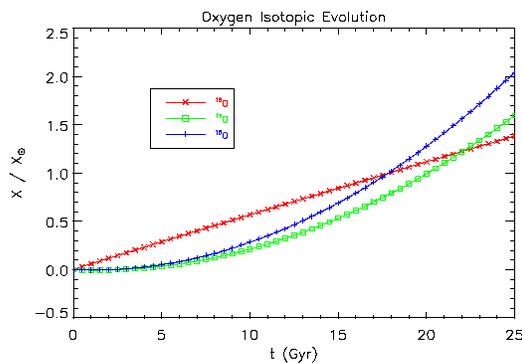
Figure 2: Piecewise, continuous initial mass function generated by the IMF function.

Stellar Remnant Mass. The next step is to choose the mass of the remnant white dwarf, neutron star, or black hole left behind at the end of the star’s life as a function of the star’s initial mass. For the default, we have chosen stars below $1.1 M_{\odot}$ to have a remnant mass equal to the initial stellar mass. This is not necessary. We do it here because the chemical evolution model we currently use employs the instantaneous recycling approximation. Thus, the lifetime of stars in our model is taken to be zero. Our choice crudely accounts for the fact that low-mass stars evolve slowly and have not yet formed remnants.

Yields. After the user specifies the stellar models, the IMF, and the remnant mass function, the web site automatically calls a program that computes the stellar yields for each isotope. The yield, in our terminology, is the mass of the isotope ejected from a generation of stars divided by the mass that generation leaves behind in remnants. The program also makes a linear fit to the yield for the analytical chemical evolution model. The

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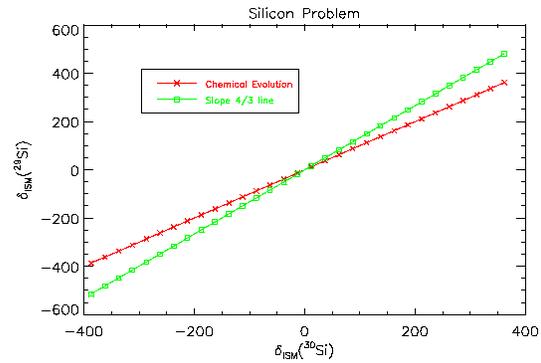
user may create a plot of the yield of any isotope (for example, the ^{16}O yield shown in Figure 3), create a table of the yields and fits to the yields, see the yield of the isotope fit as purely a primary or secondary isotope, or view the IMF-integrated ejected mass in the isotope from a generation of stars.

Figure 3: Yield of ^{16}O .Figure 4: Mass fractions of $^{16,17,18}\text{O}$ in the ISM relative to their solar values in an analytic chemical evolution model.

Chemical Evolution. With the yields available in fitted form, the user may compute a chemical evolution model. The web site currently uses a family of analytic models developed by Clayton (4). Parameters for these models are Δ , a free-fall timescale, k , a parameter determining the nature of the infall, ω , the rate at which interstellar gas mass goes into stars, and M_{G0} , the initial mass of the Galactic disk. With these parameters chosen, the user may then evaluate t_{\odot} , the time at

which the disk reaches solar metallicity, and the contribution of Type Ia (thermonuclear) supernovae based on the Galactic ^{56}Fe mass fraction. One may then plot the evolution of any of the isotopes. For example, Figure 4 shows the evolution of the isotopes of oxygen versus time for the default set of parameters. For this model, ^{16}O reaches its solar value at 17.8 Gyr, and ^{17}O and ^{18}O reach solar somewhat thereafter. The straight-line nature of the ^{16}O curve shows that this isotope is primary. ^{17}O and ^{18}O are secondary isotopes; hence, their curves are quadratic.

Application to Presolar Grains. As an application to cosmochemistry, we compute, from the analytic chemical evolution model and with the default parameters, the evolution of the ISM-normalized deviations of ^{29}Si and ^{30}Si . This is shown in Figure 5 as the slope-one line. The mainstream SiC grains, by contrast, show a slope 4/3 correlation in the same plot, which would look like the green curve (5). The difference presents an interesting puzzle for a Galactic-chemical evolution interpretation of the observed correlation (6,7).

Figure 5: Evolution of the ISM-normalized $^{29}\text{Si}/^{28}\text{Si}$ deviations relative to that of $^{30}\text{Si}/^{28}\text{Si}$.

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