SHORT-LIVED RADIOACTIVITIES AND RECENT STAR FORMATION.

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Introduction: A common model for the origin of live ^{26}Al and ^{60}Fe in the early Solar System is injection from a massive star (e.g., [1]). Recent data suggest, however, that that ^{60}Fe was not introduced into the early Solar System by a nearby supernova but rather was inherited from nucleosynthesis due to stellar activity in the millions of years prior to the Sun's birth [2]. In such a case, ^{26}Al would have been incorporated from the wind of a massive star, a scenarios that may in fact be rather commonplace [3].

To further evaluate the impact of recent star formation on the short-lived radioactivities in the early Solar System, we are modeling stellar activity in a large molecular cloud to predict the abundances of the other short-lived species at the time of the Sun's birth. We are also exploring the range of variations of those predictions due to parameterizations of star formation rates, stellar yields, and interstellar medium mixing.

Computational Model: Our computational model is built on top of the multi-zone modules of the open-source suite of codes NucNet Tools [4]. In particular, we construct a two-dimensional or three-dimensional molecular cloud with hundreds or thousands of zones. Zones within the cloud mix with each other on a timescale τ, which may vary with time or location but is constant for our present calculations. Calculations begin at time t=0 with solar abundances [4] throughout the cloud. As time progresses, we allow stars to form at random locations in the cloud with masses distributed according to an initial mass function [5]. The stars' formation times are distributed according to Poisson statistics. When a previously formed star dies, its ejecta (taken from [6]) are mixed into the local zone. We then follow the mixing of the stellar debris into the rest of the cloud and the decay of the radioactive species, and we keep track of the composition of each new star (solar system).

Results: Our models can reproduce the inferred initial solar ^{60}Fe/^{56}Fe ratio of [2] over a range of input conditions. Models that successfully reproduce ^{60}Fe/^{56}Fe fall quite short of the required ^{26}Al/^{27}Al, which confirms the need for a late source of ^{26}Al, such as a stellar wind. In some cases, solar systems in our models have values of ^{107}Pd, ^{129}I, and ^{182}Hf to within a factor of a few of the inferred solar values, but in these cases, ^{53}Mn and ^{60}Fe tend to be roughly an order of magnitude too large. It is thus not yet clear that the initial Solar System abundances of the mostly r-process radioactive species ^{107}Pd, ^{129}I, and ^{182}Hf can be explained all or in part as due to shell nucleosynthesis in massive stars. Not surprisingly in our model, isotopes with the shortest lifetimes tend to show the largest spatial variations in their abundances.

Conclusions: We have developed a multi-zone model of a molecular cloud that allows us to follow the time evolution of the abundances of species within zones of the cloud. The model can explain the abundance of ^{60}Fe in the early Solar System. We are exploring the model further to determine to what extent it can explain the initial solar abundances of other short-lived species.

References: [1] Meyer B. S. and Clayton D. D. 2000. *Space Sci. Rev.* 92:133-152. [2] Tang H. and Dauphas N. 2012. *EPSL* 359:248-263. [3] Gounelle M. 2014. Abstract #2113. 45th Lunar & Planetary Science Conference. [4] See http://sourceforge.net/p/nucnet-tools. [5] Anders E. and Grevesse N. 1989. *Geochimica et Cosmochimica Acta* 53:197-214. [5] Kroupa P. 2002. *Science* 295:82-91. [6] Rauscher T. *et al.* 2002. *Astrophys. J.* 576:323-348.