PRODUCTION OF SHORT-LIVED RADIOACTIVE NUCLEI IN SUPER ASYMPTOTIC GIANT BRANCH STARS.

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Introduction: It is well known from the composition of early Solar System condensates that now-extinct short-lived radionuclides (SLR) were present at the time these condensates formed [1]. Among the SLR, ^{26}Al, ^{36}Cl, ^{41}Ca, and ^{60}Fe in particular require that the nuclear reactions that produced them must have occurred close in both time and space to the birth of the Sun [2].

One scenario to explain the SLR is via irradiation by energetic solar particles, which is often termed the "in-situ scenario" [3]. This process is needed to explain the ^{10}Be, which cannot be made via nuclear reactions in stars. However, irradiation cannot produce ^{60}Fe, which is a unique product of stellar nucleosynthesis [4]. Various "stellar pollution scenarios" have been proposed to explain the SLR, including Asymptotic Giant Branch stars [5] and supernovae [6].

Chondrule data have confirmed a high solar system initial ^{60}Fe/^{56}Fe = $(6.3 \pm 2) \times 10^{-7}$, indicative of a stellar origin [7]. CAIs and corundum data show a bimodal distribution in the presence of ^{26}Al, with about half of the measured condensates showing no ^{26}Al, within the detection limits, and the other half showing ^{26}Al/^{27}Al close to the 'canonical' value of 5×10^{-5} [8,9]. This indicates that the injection of ^{26}Al in the protoplanetary disk was delayed, allowing some condensates to form without ^{26}Al. Furthermore, ^{26}Al-rich and ^{26}Al-poor CAIs and corundum grains show the same distribution in terms of their oxygen isotopic composition [8,9]. This indicates that the local event responsible for the presence of the SLR should not have modified the oxygen isotopic composition of the proto-planetary disk.

In this work we investigate the production of SLR in a nearby Super Asymptotic Giant Branch (SAGB) star. SAGB stars have an initial mass range of ~ 7–11 solar masses [10,11]. They burn H, He and C in their core, but do not experience further core burning and typically do not explode as core-collapse supernovae. Instead, after core carbon burning they go through the AGB phase, with the H and He shells activated alternately, episodic thermal pulses in the He shell, and strong stellar winds driving the H-rich envelope into the surrounding interstellar medium. The final remnants of the evolution of SAGB stars are mostly O-Ne white dwarves, though electron-capture supernovae can also occur.

Here we present the first predictions for SLR up to Fe in the winds of SAGB stars. These stars have not been considered to date as a possible source for the SLR in the early Solar System because model predictions for their detailed nucleosynthesis have not been available until now. This is because the modeling of SAGB stars is demanding in terms of both the algorithm needed to describe the core carbon burning – since the burning starts off centre and then moves towards the centre of the star, and the computational time – since these stars experience hundreds to thousands of thermal pulses.

Method: The structure of the SAGB models have been computed using the Monash/Mt Stromlo stellar evolution code [12]. Information such as temperatures, densities, and convective velocities (in convective regions in each mass shell of the stellar model during the life of the stars) were then fed to the Monash stellar nucleosynthesis post-processing code [13]. This program couples the stellar structure information with a detailed nuclear network of the isotopes up to Fe in order to compute the abundance changes brought by nuclear reactions and mixing in the star.

Discussion: We find that neutron captures occur during the thermal pulses in the He-burning shell of SAGB stars with ^{22}Ne(α,n)^{25}Mg as the neutron source reaction, producing ^{36}Cl, ^{41}Ca and ^{60}Fe, and that these nuclei are carried to the stellar surface by dredge-up episodes. At the same time, proton-captures at the base of the convective envelope produce ^{26}Al and modify the O composition of the star. In this talk we will compare the detailed abundances resulting from this SAGB nucleosynthesis to the powerful new constraints mentioned above arisen from measurements of CAIs [8], corundum [9], and chondrules [7]. On the basis of the comparison between the constraints of the ^{26}Al and O isotopes in the meteorite record and our stellar model predictions, we will be able to assert if a SAGB stars is a good candidate for the origin of SLR in the early Solar System. We will also address the questions of how the SAGB material was accreted and mixed in the proto-planetary disk and if we could expect to have an SAGB star present nearby the nascent Sun.

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