

COMPARISON BETWEEN CORE-COLLAPSE SUPERNOVA NUCLEOSYNTHESIS AND METEORIC STARDUST GRAINS: INVESTIGATING MAGNESIUM, ALUMINIUM, AND CHROMIUM.

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Introduction: Nucleosynthetic isotope variation in our solar system is best documented in the observed variability of ^{54}Cr isotope abundance among materials formed in different regions of the protoplanetary disk. Although the exact nucleosynthetic origin of this variation is uncertain, it has been clearly attributed to variable amounts of presolar, chromium-rich oxide (chromite) grains, which most likely come from some type of supernova explosion [e.g. 1]. The high precision Cr isotope data of [2] for these grains has been compared to a limited number of SN models and [2] concluded that the observations are best explained by models of rare stellar SN events, such as electron-capture SNe [3,4] and rare, high-density type Ia SNe [5] and models of core-collapse supernovae (CCSNe) by [6] provide a poor match. Recently we investigated whether CCSNe can be ruled out as the site of origin for these grains [7].

Results: We analyzed CCSN model yields [8,9,10,11,12,13, 14] of stars with initial stellar masses of 15, 20, and 25 M_{\odot} , and with solar metallicity in detail. We compared these models and found the total yields of Cr, Mg and Al to be consistent with differences in model features. For 9 models [8,9,10] we were able to study Cr, Mg, and Al isotopes as a function of enclosed mass in detail, see our compiled dataset in [7].

In general, there are two types of stellar sites with regions that are in good agreement with the observed $^{54}\text{Cr}/^{52}\text{Cr}$, $^{53}\text{Cr}/^{52}\text{Cr}$ and $^{50}\text{Cr}/^{52}\text{Cr}$ ratios of the chromites: the sites of explosive C ashes and He ashes. During the SN, the explosive C ashes produce the required Cr isotopic composition. In case of He-ashes, if we take into account that the nano-SIMS signal at atomic mass 50 could partly originate from ^{50}Ti [2], the products of He burning also match the observed Cr isotope ratios. In addition, we compared the Mg and Cr isotope composition of our candidate sites to the bulk meteorite data array of [15,16] and investigated possible mixing relations with solar composition. If we consider grains produced from the He ashes that are enriched in Al and Cr relative to Mg, similar to abundances in presolar chromite grains, simple 2 component mixing may reproduce the inferred correlation between Mg and Cr anomalies of the solar system. Chromite grains originating from the proposed C ashes sites, however, do not present significant Mg anomalies together with Cr isotopic variations, and could be consistent with a homogeneous Mg isotopic composition in the solar system [17]. High precision Mg isotope data on the same presolar chromites is needed to further evaluate the grain origin.

Conclusion: Core collapse supernovae may have generated the chromite grains responsible for the ^{54}Cr isotope variation in our solar system. In all candidate nucleosynthetic sites, non-radiogenic stable Mg isotope variations dominate over the Mg isotope variations expected from the short lived ^{26}Al . Candidate sites represent very limited regions of the exploding massive stars, which indicates very limited mixing of SN regions before grain condensation, which needs to be explained by future SN models. We note that electron-capture SNe and high-density type Ia SNe models share the same problem.

References:

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