IRON AND NICKEL ISOTOPIC COMPOSITIONS OF PRESOLAR SILICON CARBIDE GRAINS FROM AGB STARS MEASURED WITH CHILI.

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Introduction: Presolar grains formed in the vicinity of dying stars and recorded their isotopic properties. These grains can therefore yield valuable information on stellar nucleosynthesis as well as galactic chemical evolution (GCE). Iron and nickel isotopes are of special interest here. While the neutron-rich isotopes in presolar grains from asymptotic giant branch (AGB) stars are mainly dominated by the slow neutron capture process in the star, the neutron-poor isotopes are only slightly altered and can be used as proxies to study GCE. We previously reported simultaneous measurements of iron and nickel isotopic compositions in "presolar grains" [1]. However, subsequent SEM-EDX analysis of the grain residues showed that the analyzed phases were probably not presolar SiC grains. Here we report the results of 74 confirmed (by their carbon and silicon isotopic compositions) presolar SiC grains for their iron and nickel isotopic compositions measured with the Chicago Instrument for Laser Ionization (CHILI) [2].

Methods: The presolar SiC grains were acid-cleaned prior to being mounted on a gold substrate [3]. We then measured the carbon and silicon isotopic composition of all grains except one that was missed using the CAMECA NanoSIMS 50 at Washington University in St. Louis. We found 67 SiC mainstream, 2 AB, 2 Y, 1 X, and 1 Z grain. All presolar SiC grains were subsequently measured simultaneously for their iron and nickel isotopic composition using CHILI [3]. CHILI uses tunable Ti:sapphire lasers to resonantly ionize iron and nickel, which allows us measuring all isotopes without isobaric interferences [2].

Results & Discussion: Comparing our data with previous measurements [4] shows good agreement for the isotopic data, however, due to isobaric interferences, Marhas et al. [4] were unable to measure the minor isotopes. In addition, the higher sensitivity in CHILI allows us to measure the isotopic ratios of interest more precisely than previous studies. In our mainstream grains, we did detect a higher Fe/Ni ratio than found previously [4] by about an order of magnitude on average. Measuring the neutron-rich, minor isotopes, which could not be done previously [4], is essential in determining the masses and metallicities of the parent stars of the presolar grains. We measured enrichments in ^{58}Fe and in ^{64}Ni relative to ^{56}Fe and ^{58}Ni in presolar SiC mainstream grains of δ^{58}Fe = 0 to +467‰ and δ^{64}Ni = 0 to +1318‰. The δ^{64}Ni excesses were accompanied by excesses in δ^{60}Ni, δ^{61}Ni, and δ^{62}Ni of up to +100, +500, and +250‰, respectively. The Y, Z, and AB grains agree well with the mainstream grains in iron and nickel isotopes. Comparing our measurements with models [e.g., 5], we found that our measurements can best be explained by an AGB star model with 2 $M_\odot$, 0.5 $Z_\odot$, and a ^{22}Ne(α,n) reaction rate that is divided by two compared to the standard rate, as proposed previously [6]. Since the neutron-poor isotopes are not heavily influenced by the AGB star, they represent what the star originally was made of and therefore can be used as a proxy for GCE. Our results show clear correlations between isotope anomalies in δ^{29}Si, δ^{54}Fe, and δ^{60}Ni, indicating the path of GCE. The results agree fairly well with GCE models by Kobayashi et al. [7] for δ^{54}Fe and δ^{60}Ni, however, the GCE models do not predict the δ^{29}Si values we measured. This is most likely due to underproduction of ^{29}Si, which is mainly produced in type II supernovae. This underproduction of ^{29}Si has been reported previously by Timmes and Clayton [8]. Another interesting observation from our measurements is that the GCE trends go through the Solar System value within uncertainty. This shows that the Solar System itself is not special in its iron and nickel isotopic composition. Thus, an age-metallicity relationship for the observed isotope ratios is unlikely and other explanations have to be explored.

Conclusions: We measured a total of 74 presolar SiC grains for their carbon, silicon, iron, and nickel isotopic compositions. The neutron-rich isotopes show clear anomalies that can be tied to an origin in AGB parent stars. The trends in neutron-poor isotopes are clearly GCE-dominated and help deciphering the iron and nickel GCE trends.

References: [1] Trappitsch R. et al. 2016. Abstract #3025. 47th Lunar & Planetary Science Conference. [2] Stephan T. et al. 2016. Abstract #2793. 47th Lunar & Planetary Science Conference. [3] Levine J. et al. 2009. *International Journal of Mass Spectrometry* 288:36–43. [4] Marhas K. K. et al. 2008. *The Astrophysical Journal* 689:622–645. [5] Gallino R. et al. 1998. *The Astrophysical Journal* 497:388–403. [6] Liu N. et al. 2014. *The Astrophysical Journal* 786:66. [7] Kobayashi C. et al. 2011. *Monthly Notices of the Royal Astronomical Society* 414:3231–3250. [8] Timmes F. X and Clayton D. D. 1996. *The Astrophysical Journal* 472:723–741.