Contribution ID: **36** Type: **Oral Contribution**

Diverse Stellar Neutron-Capture Isotopic Signatures Recorded in Presolar Silicon Carbide Grains

Tuesday 10 June 2025 11:30 (20 minutes)

Presolar grains are submicron- to micron-sized meteoritic grains that originate from stellar winds lost from the surfaces of multiple stars and from the ejecta produced by stellar explosions. Among the best-studied presolar phases is SiC. Multielement isotope analyses of presolar SiC grains indicate that most have origins in AGB stars and core-collapse Type II supernovae (CCSNe). AGB dust constitutes the majority of presolar SiC grains (>90%), including mainstream (MS), Y, and Z grains, while CCSN dust contributes a smaller fraction, including X, C, and D grains. Isotopic analyses of presolar SiC grains, therefore, enable detailed examination of AGB and CCSN nucleosynthesis at the level of isotopes.

We conducted a survey of Ni isotope ratios in presolar SiC grains using secondary ion mass spectrometry. We chose Ni isotopes for several reasons: (i) Ni is highly enriched in presolar SiC grains; (ii) the most neutron-rich isotope, 64Ni, is primarily produced by the s-process in AGB stars and is minimally affected by the initial stellar composition, making it a reliable proxy for probing s-process efficiency; (iii) the least neutron-rich isotope, 60Ni, is poorly produced by the s-process, largely reflecting the initial composition that indicates galactic chemical evolution (GCE); and (iv) under different neutron exposures, a variety of Ni isotope patterns are predicted for neutron bursts, a neutron-capture process driven by the 22Ne(α,n)25Mg reaction during CCSNe.

We selected a suite of presolar SiC grains based on their C, N, and Si isotope ratios for subsequent Mg-Al, Ti, and Fe-Ni isotope analyses. Statistically meaningful Ni isotope data were obtained for 56 new MS grains, 26 Y grains, 15 Z grains, 1 C grain, 1 D grain, and 17 X grains.
Our new Ni isotope data reveal several key observations: (i) Compared to existing data [1], we observed more extreme Ni isotope anomalies in MS grains, likely resulting from our methodology for suppressing Ni contamination. Our Ni isotope data align more closely with AGB models that have been calibrated against the Sr, Zr, Mo, and Ba isotopic compositions of MS grains [2]. (ii) By mitigating contamination, we robustly constrained the s-process efficiency in the parent AGB stars of MS, Y, and Z grains, following the order of Y > Z > MS. This contrasts with previous inferences based on Si and Ti isotope data [3]. (iii) The 60Ni/58Ni ratios of MS/Y and Z data are influenced by homogeneous and heterogeneous GCE effects, respectively. (iv) C and X CCSN grains exhibit distinct Ni isotopic patterns, indicating a wide range of neutron exposures experienced by the grains in their parent CCSN ejecta. Notably, the C grain recorded the highest neutron exposure, providing stringent constraints on the exposure condition during the explosion and relevant neutron-capture cross-sections, such as 63Ni(n,γ)64Ni. Detailed data-model comparisons will be presented at the meeting.

References:
[1] Trappitsch R. et al. (2018) GCA, 221, 87.
[2] Vescovi D. et al. (2020) ApJL, 897, L25.
[3] Zinner E. et al. (2007) GCA, 71, 4786.

Author: LIU, Nan (Boston University)

Co-authors: MEYER, Bradley (Clemson University); Dr ALEXANDER, Conel (Carnegie Institution for Science); VESCOVI, Diego (Istituto Nazionale di Astrofisica (INAF)); Dr WANG, Jianhua (Carnegie Institution for Science); Mr WALLS, Lucas (Clemson University); CRISTALLO, Sergio (Istituto Nazionale di Astrofisica (INAF))

Presenter: LIU, Nan (Boston University)