Contribution ID: **57** Type: **Talk**

The isotope distributions of presolar SiC grains from carbon-rich asymptotic giant branch stars

Thursday 13 June 2024 12:10 (20 minutes)

Presolar grains, microscopic dust formed around various types of stars in their advanced evolutionary stages, recorded intricate details of nucleosynthesis and mixing within their parent stars, offering invaluable insights into diverse stellar processes (Nittler & Ciesla, 2016). Among these, silicon carbide (SiC) stands out as the most extensively studied presolar mineral phase, with the majority of SiC grains, including Types MS, Y, and Z, believed to have originated from carbon-rich asymptotic giant branch (AGB) stars.

However, existing studies have highlighted significant challenges. Firstly, the isotopic data of presolar SiC grains in the literature often suffered from terrestrial and/or asteroidal contamination, compromising the isotope data for elements such as N, Al, Sr, Mo, and Ba (Liu et al., 2015, 2021, 2022; Groopman et al. 2015). Secondly, there are a factor of two uncertainties in the inferred initial 26Al/27Al ratios for presolar SiC grains because of uncertainties in the relative sensitivity factor (RSF) of Mg/Al for secondary ion mass spectrometers (SIMS), the type of instrument used for Mg-Al isotope analysis of these grains (Hoppe et al., 2023).

In this study, we obtained new C, N, Mg-Al, and Si isotope data for a large number of presolar MS, Y, and Z SiC grains isolated from the CM2 Murchison meteorite. The grain data were obtained by adopting analytical procedures aimed at minimizing N and Al contamination (Liu et al., 2021). In addition, we inferred initial 26Al/27Al ratios using a recently reported SIMS Mg/Al RSF value with a ±6% error for SiC (Liu et al., 2024), which led to a factor of two increase in all the inferred initial 26Al/27Al ratios compared to the literature data. Our comprehensive dataset enabled a statistical analysis of isotope distributions, revealing several rare subtypes of AGB grains characterized by unique isotopic compositions. We will highlight a typical MS SiC grain with a 900 ‰ enrichment in 25Mg and a subgroup of MS grains with subsolar 14N/15N ratios and large 26Al-excesses (i.e., 26Al/27Al ratios of 0.01). These findings will be discussed within the framework of AGB stellar nucleosynthesis to constrain the properties of their parent AGB stars.

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Primary author: LIU, Nan (Boston University)

Co-authors: Dr ALEXANDER, Conel (Carnegie Institution for Science); Dr WANG, Jianhua (Carnegie Institution for Science)

Presenter: LIU, Nan (Boston University)

Session Classification: Seeds and grains: AGB stars as dust factories in galaxies