

A PRESOLAR SPINEL GRAIN OF PROBABLE NOVA ORIGIN

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Introduction: Presolar grains from novae are exceedingly rare. A few SiC and graphite grains have been identified by large ^{13}C , ^{15}N , and ^{30}Si excesses [1, 2]. While some purported nova grains may have actually condensed in a supernova [3], some are undoubtedly nova condensates [4, 5]. Except in rare cases, the material ejected in nova explosions is O-rich, and it remains a puzzle why to date only carbonaceous phases, with one possible exception [6], have been identified. Here we report the discovery of a presolar spinel grain with a likely nova origin.

Experimental: The “CG” residue of Murray, prepared by physical and chemical separation [7] and consisting of high concentrations of spinel grains (diameter $\sim 0.5\mu\text{m}$), was scanned for O-anomalous grains with an automated measurement technique recently developed for the NanoSIMS [8]. Grain C4-8 was not identified by the particle definition software, but was recognized as an ^{17}O hotspot in an ion image taken during the automated surveys. High-resolution SEM images confirmed that it was surrounded by multiple grains. Subsequent removal of surrounding isotopically normal material [9] and manual measurement of $^{16,17,18}\text{O}$ revealed the grain to be extremely enriched in ^{17}O . Following O isotopic analysis, $^{24,25,26}\text{Mg}^+$ and $^{27}\text{Al}^+$ were measured in multicollection mode with an O^- primary beam in a separate measurement session.

Results: The O isotopic composition of C4-8 is characterized by a huge enrichment in ^{17}O and a modest depletion in ^{18}O , with $^{17}\text{O}/^{16}\text{O} = (4.40 \pm 0.01) \times 10^{-2}$ and $^{18}\text{O}/^{16}\text{O} = (1.10 \pm 0.02) \times 10^{-3}$. This isotopic signature is similar to that of Group 1 grains [10]. However, RGB and AGB stars undergoing 1st and 2nd dredge-up, the most likely sources of these grains [11], cannot produce $^{17}\text{O}/^{16}\text{O} > 4 \times 10^{-3}$ [12]. C4-8 is significantly enriched in $^{25,26}\text{Mg}$ ($\delta^{25}\text{Mg} = 949 \pm 9\%$ and $\delta^{26}\text{Mg} = 929 \pm 7\%$) and, similar to the situation for O, nucleosynthesis in the O-rich envelope of AGB stars ($\lesssim 3M_{\odot}$) cannot produce $\delta^{25}\text{Mg} \gtrsim 40\%$ [13]. The most likely condensation environment for a grain with extreme enrichments in both ^{17}O and ^{25}Mg is found in nova ejecta. The best match for the O isotopes in C4-8 is achieved by models for CO novae with a 0.8 or 1.15 M_{\odot} white dwarf; however, the Mg isotopic composition is much better explained by a 0.6 M_{\odot} CO model [2]. The only other putative nova oxide identified so far, T54 [14], is also ^{17}O rich, but has not been analyzed for Mg/Al and cannot help refine the model predictions. Recent model calculations have indicated nova nucleosynthesis beyond Ca [5], and future isotopic measurements (e.g. Ca, Ti) of C4-8 are planned to better constrain the origin of this unique grain.

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