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CosmoSparks

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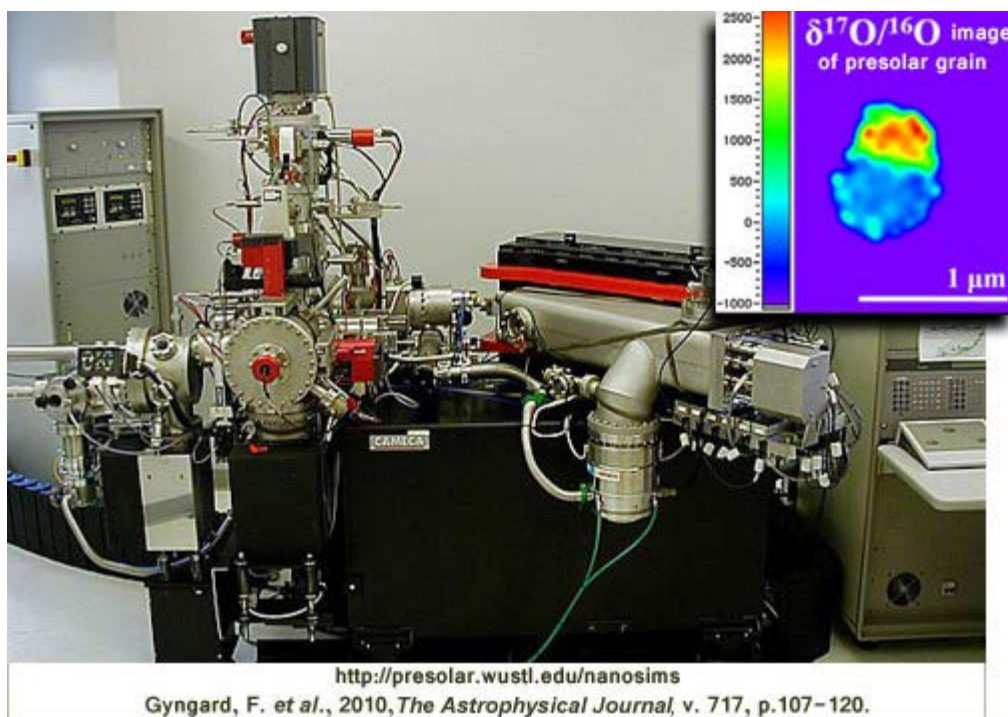About PSRD | Archive | Search | Subscribe | Glossary | Comments

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Stardust--Snapshots of Stars

A group of researchers from Washington University in St. Louis, Missouri and the Carnegie Institution of Washington collaborated with CAMECA to develop and implement an exciting new automated analysis technique on the NanoSIMS that expands on automated methods developed in the early 2000s to study **presolar grains**.

Preserved in primitive meteorites, presolar grains are literally stardust that formed in ancient stellar outflows and ejecta from supernova explosions, and became part of the **molecular cloud** out of which our own Sun and Solar System formed. Cosmochemists first identified these grains (nanodiamonds, SiC, and graphite) in the late 1980s by their unusual isotopic compositions compared to solar or terrestrial values. Since then, about 10,000 SiC grains (a few micrometers in diameter) have been individually and painstakingly analyzed! Other types of grains have also been found: Oxygen-rich grains, including alumina (Al_2O_3), spinel ($MgAl_2O_4$), hibonite ($CaAl_{12}O_{19}$), and silicates. Frank Gyngard and coauthors describe these grains as astrophysical fossils that provide precise isotopic compositions that researchers use to constrain their theoretical models of **nucleosynthesis** in asymptotic giant branch (**AGB**) phase stars and **supernovae**.

$\delta^{17}O/^{16}O$ image of presolar grain
1 µm

http://presolar.wustl.edu/nanosims
Gyngard, F. et al., 2010, The Astrophysical Journal, v. 717, p.107-120.

Development of high-tech instruments make it possible to analyze the abundances of isotopes in these astonishingly small grains. The NanoSIMS at Washington University in St. Louis, MO is one such workhorse. Gyngard and coauthors developed an automated, high-mass-resolution measurement technique for the NanoSIMS to analyze thousands of grains over several days without requiring a scientist's constant attention. It differs from previous automated systems in that it is completely integrated into the instrument's software, giving greater measurement flexibility for identifying isotopic anomalies. As a first test, the team successfully applied the technique to a search for presolar spinel ($MgAl_2O_4$) grains from the Murray CM2 carbonaceous chondrite meteorite [**Data link** from the Meteoritical Bulletin]. Out of about 3,100 grains found during the automatic mapping, they discovered 41 presolar oxide grains, most having oxygen isotopic compositions that researchers think are typical for oxide grains formed as condensates from either red giant branch or AGB

stars. However, some of the grains found in the study do not fit within this framework, and require different astrophysical origins. One grain has massive enrichments in ^{17}O, ^{25}Mg, and ^{26}Mg, which are considered isotopic signatures of condensation from nova ejecta. Two other spinel grains have large ^{25}Mg and ^{26}Mg isotopic anomalies that are difficult to explain by standard nucleosynthesis in a low-mass star and might indicate an origin in a binary star system. They found another grain with a $^{17}O/^{16}O$ ratio of 4.4 x 10^2, the largest ever observed in presolar oxygen-rich grains and at least an order of magnitude greater than the theoretical maximum value in current models of low-mass AGB stars.

The automated analysis technique developed by Gyngard and colleagues has proven to be robust for efficiently finding and measuring presolar grains. Tight integration of the system into the software interface of the NanoSIMS allows for measurement flexibility and software stability. The team plans some improvements to customize the technique to broaden its applicability and increase its efficiency. As presolar grains provide a ground-truth snapshot for models of nucleosynthesis, they are, and will continue to be, a hot research topic.

See: Gyngard, F., Zinner, E., Nittler, L. R., Morgand, A., Stadermann, F. J., and Hynes, K. M. (2010) Automated NanoSIMS Measurements of Spinel Stardust from the Murray Meteorite. *The Astrophysical Journal,* v. 717(1), p. 107-120, doi:10.1088/0004-637X/717/1/107. and the **PSRD** article *A New Type of Stardust*.

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