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Strontium-84 enrichments in presolar grains provide first evidence of p-process nucleosynthesis in core-collapse supernovae

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Presolar grains are relic dust grains from dying stars. These microscopic dust particles are found in primitive Solar System materials. Their distinct isotopic compositions record the nucleosynthetic processes in their parent stars and the galactic chemical environment in which these stars formed. We studied presolar graphite grains of high-density type from the Murchison meteorite and found five grains with subgrains that show enrichments in 84Sr compared to the solar abundance. 84Sr is the neutron-deficient isotope of strontium that can be produced in the deep oxygen-rich interior of high-mass stars that end their lives as core-collapse supernovae. The observed 84Sr-excesses cannot be produced in low-mass asymptotic giant branch stars, the source of most high-density presolar graphites found in meteorites. High-density graphites with embedded 84Sr-excesses are, instead, compatible with a core-collapse supernovae origin. The graphite subgrains condensed from carbon-rich materials in the outer layers of core-collapse supernovae, where 84Sr was destroyed by neutron-captures during hydrostatic evolution of the stars and their final explosion. Based on current theoretical stellar models, a few percent contribution from the inner regions of core-collapse supernovae, that are enriched in p-process nuclides, to the outer carbon-rich regions is the most likely explanation for the observed enrichment of 84Sr in the subgrains of the high-density graphites. Thus, in this study, we present the first observational evidence that core-collapse supernovae produce and eject isotopes made by the p-process.

Length of presentation requested

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Observations

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