Isotopic compositions of presolar SiC: First measurements with CHILI

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CHILI (the CHicago Instrument for Laser Ionization), a resonance ionization mass spectrometry (RIMS) nanobeam instrument is designed for isotopic and chemical analysis at the few-nm scale with a useful yield of ~40% and near-elimination of isobaric interferences, capabilities well beyond those of modern secondary ion mass spectrometers. After several years of construction of CHILI, we report the first sample measurements.

Twenty-two presolar SiC grains from Murchison separate KJG were pressed into gold and analyzed. Six tunable Ti:sapphire lasers allowed simultaneous resonance ionization of strontium, zirconium, and barium with independent two-photon ionization schemes. A three-prism beam combiner brings all six laser beams into the analysis chamber along a single line. Atoms were desorbed from samples and standards with a 351 nm laser, focused to ~1 μm using a Schwarzschild optical microscope. Precision on standards is in the few ‰ range (2σ)

Ten of the 22 grains selected had sufficient barium content and eight of these ten grains had sufficient strontium content for isotope analysis with CHILI. However, none of the grains had detectable Zr. The reasons for the nondetection of zirconium are unclear, but trace element abundance measurements by synchrotron XRF and ion microprobe have shown that some grains are strongly deplected in zirconium. Strontium and barium isotope ratios were normalized to ^{86}Sr and ^{136}Ba, respectively. Seven grains have strontium and barium isotopic patterns similar to those seen previously in mainstream SiC grains, and these patterns are consistent with formation in low-mass asymptotic giant branch (AGB) stars. One grain is depleted in ^{84}Sr, ^{87}Sr, ^{134}Ba, and ^{135}Ba and enriched in ^{88}Sr, ^{130}Ba, ^{132}Ba, ^{137}Ba, and ^{138}Ba. Such isotope effects are consistent with formation in a neutron burst, likely caused by a shock wave passing through ejecta in the immediate aftermath of a Type II supernova explosion. Two grains are depleted in ^{84}Sr, ^{87}Sr, and ^{88}Sr (or enriched in ^{86}Sr). This pattern has not been observed before. It is very difficult to produce in AGB stars, but might be produced in supernova ejecta.