Tantalum Isotope Anomalies in CAIs: a Vestige of Irradiation in the Early Solar System

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Calcium-Aluminum-rich inclusions (CAIs) record the earliest history of our Solar System. A diversity of isotope anomalies has been found in CAIs for a range of elements, which is attributed to variable contributions of distinct components synthesized at different stellar sites [1]. So far, conventional models failed to explain the complexity in nucleosynthetic anomalies observed in CAIS. In an approach to identify processes acting on CAIs, and to search for exotic nucleosynthetic anomalies for narrowing down stellar sources, we combine high-precision high field strength element (HFSE) concentration and isotope measurements on 6 CAIs for Hf, Ta and W. Both element concentrations (by means of isotope dilution) and natural isotope compositions were obtained by MC-ICP-MS at Cologne-Bonn, whereas Ta isotope ratios were measured with a MC-ICP-MS at Thermo Scientific, Bremen, applying newly developed 10^{13} Ω resistors for Faraday cup amplifiers [2].

Tantalum isotopes show resolvable excess in ^{180}Ta in two of the analyzed CAIs. If these anomalies reflect nucleosynthetic heterogeneity, it is not correlated with p-, s-, or r-process anomalies in the neighboring elements Hf and W [3]. Then, the Ta anomalies may express variations in neutrino process derived nuclides, which would hint to decoupling of p-process supernova ejecta [4]. In the light of recent findings reporting excesses in ^{50}V and ^{138}La [5, 6], we propose an early irradiation origin of the ^{180}Ta excesses. Minor isotopes ^{50}V, ^{138}La, and ^{180}Ta are all odd-odd-isotopes occupying interstitial sites in the chart of nuclides, where they can be produced by (p,n) reactions on much more abundant isotopes ^{50}Ti, ^{138}Ba, and ^{180}Hf. We suggest that proton-irradiation from the nascent sun might have been more efficient in altering isotope compositions of certain heavy elements than previously thought.

[1] Dauphas & Schauble (2016) *Annu. Rev. Earth Planet. Sci.* **44**, 709–83. [2] Pfeifer *et al.* (2017) *J. Anal. At. Spectrom.* **32**, 130-143. [3] Peters *et al.* (2017) Earth Planet. Sci. Lett. **459**, 70-79. [4] Rauscher *et al.* (2013) *Rep. Prog. Phys.* **76**, 066201. [5] Shen & Lee (2003) *Astrophys. J.* **596**, L109–L112. [6] Sossi *et al.* (2017) Nat. Astron. **1**, 0055.