Fractionation of Cd isotopes during evaporation and re-condensation

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Stable isotope studies of volatile elements can provide constraints on possible scenarios of volatile element loss and redistribution [e.g, 1, 2]. Here, Cd stable isotope and volatile element fractionation during evaporation from silicate melt at about 1300 °C and during re-condensation onto Al_2O_3 condensation plates is studied experimentally, at atmospheric pressure in air and in CO-CO_2. The experiments can serve to address questions that are important for the interpretation of volatile element stable isotope data in cosmochemistry, e.g.: How much do atmospheres with variable fO_2 suppress (Cd) isotope fractionation? Are there conditions where volatile metal loss by evaporation can occur without measurable stable isotope fractionation? Will (kinetic) condensation result in significant stable isotope fractionation?

Our experiments show that evaporation at atmospheric pressure only yields strongly suppressed Cd isotope fractionation, with a vapor-melt fractionation factor α for $^{114}Cd/^{110}Cd$ that corresponds to -1.6 ‰ (air) and -0.3 ‰ (CO-CO_2). This compares to about -10 ‰ observed for evaporation into vacuum [3] and the theoretical prediction of -17.7 ‰ as calculated from Graham's law.

In addition, Cd also displays isotope fractionation along the temperature gradient of the Al_2O_3 condensation plates with light Cd isotopes being enriched in the condensates closest to the melt.

The observed suppressed isotope fractionation during evaporation may result from back reaction into the melt phase and more efficient Cd^0 vapor formation at reduced conditions.

[1] Humayun & Clayton (1995) *GCA* **59**, 2131-2148.
[2] Wombacher *et al*. (2008) *GCA* **72**, 646-667.
[3] Wombacher *et al*. (2004) *GCA* **68**, 2349-2357.

A method to constrain the size of the Protosolar Nebula

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Observations indicate that the gaseous circumstellar disks around young stars vary significantly in size, ranging from tens to thousands of AU. Models of planet formation depend critically upon the properties of these primordial disks, yet in general it is impossible to connect an existing planetary system with an observed disk. We present a method by which we can constrain the size of our own protosolar nebula using the properties of the small body reservoirs in the solar system. In standard planet formation theory, after Jupiter and Saturn formed they scattered a significant number of remnant planetesimals into highly eccentric orbits. In this paper, we show that if there had been a massive, extended protoplanetary disk at that time, then the disk would have excited Kozai oscillations in some of the scattered objects, driving them into high-inclination ($i \gtrsim 50°$), low-eccentricity orbits ($q \gtrsim 30$ AU). The dissipation of the gaseous disk would strand a subset of objects in these high-inclination orbits; orbits that are stable on Gyr timescales. To date, surveys have not detected any Kuiper-belt objects with orbits consistent with this dynamical mechanism. Using these non-detections by the Deep Ecliptic Survey and the Palomar Distant Solar System Survey we are able to rule out an extended gaseous protoplanetary disk ($R_D \gtrsim 80$ AU) in our solar system at the time of Jupiter's formation. Future deep all sky surveys such as the Large Synoptic Survey Telescope will allow us to further constrain the size of the protoplanetary disk.

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