Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.17256

Chromium isotopic variation by dust growth and fragmentation in the solar nebula embeded with Jupiter

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Recent studies about nucleosynthetic isotopes (e.g., Ti, Cr, and Mo) in meteorites point out the early formation of proto-Jupiter [1]. The proto-Jupiter creates a gas gap structure in the solar nebula. Because the gas gap stops the radial drift of dust aggregates, which could inhibit the supply of solids from outside the proto-Jupiter. It is important to know the dust evolution in the presence of the proto-Jupiter for understanding the isotopic ratios of meteorites and the supply of solids to terrestrial planets. It is known that the transport of solids in the presence of Jupiter is not fully suppressed as previously thought if we consider the dust size evolution [2]. This is because there is the leaking of dust fragments from the gas gap via turbulent diffusion. However, it is still unclear the effect of the leaking on the isotopic ratios inside and outside the proto-Jupiter.

The aim of this work is to reveal the isotopic variation with the dust size evolution in presence of the proto-Jupiter. We construct a model to simulate the dust size evolution and isotopic ratio evolution with radial drift, turbulent diffusion, growth, and fragmentation. Assuming the heterogeneous chromium isotopic distribution, we survey chromium isotopic variation by the dust evolution in the solar nebula embedded with Jupiter. We compare our results with the chromium isotopic ratio and the accretion ages of meteorites [3].

Our simulation represents that the leaking of dust aggregates depends on the strength of turbulent diffusion and dust stickiness. We find that the chromium isotope ratio inside the proto-Jupiter is kept constant over the radial drift time scale of dust aggregate at the gas gap if the dust particles leak from the gap inefficiently. We also find the variation of chromium isotopic ratio inside the proto-Jupiter lasts several Myrs if the dust particles leak from the gap weakly. This time variation is consistent with the correlation between the chromium isotopic ratio and the accretion ages of Non-Cabonatious meteorites.

[1] Kleine et al. (2020) SSRv, 216, 55 [2] Stammer et al. (2023) A&A 670, L5 [3] Sugiura&Fujiya (2014) M&PS, 49, 772