Al-26 and Fe-60 distribution during early star and disk formation in the context of Giant Molecular Clouds

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The short-lived Al-26 and Fe-60 radionuclides are synthesized and expelled in the galactic interstellar medium by core-collapse supernova events. The solar system's first solids, calcium-aluminium refractory inclusions (CAIs), contain evidence for the former presence of the Al-26 nuclide defining the canonical Al-26/Al-27 ratio of ~5e-5. A different class of refractory objects thought to be temporally related to the canonical CAIs are CAIs with fractionation and unidentified nuclear effects (FUN CAIs), which record a low initial Al-26/Al-27 of ~1e-6 and are characterized by nucleosynthetic anomalies in several elements. This contrasting level of Al-26 between these two classes of objects is often interpreted as reflecting the admixing of the supernova-derived Al-26 nuclide to the young solar system during the early phase of the formation of the Sun. We use giant molecular cloud (GMC) scale adaptive mesh-refinement simulations to trace the abundance of Al-26 and Fe-60 in star-forming gas during the early stages of accretion of low mass protostars. After modelling the star formation process on the time scale of an evolving GMC structure, we zoom in on individual stars to study their accretion dynamics down to scales of a few astronomical units (AU). We find that the Al-26/Al-27 and Fe-60/Fe-56 ratios of accreting gas within a vicinity of ~1000 AU of the stars closely follow the predicted decay curves of the initial abundances at time of star formation without evidence of spatial or temporal heterogeneities for the first 100 kyr of star formation, although variability is observed at thereafter. Hence, the observed differences in Al-26/Al-27 ratios between FUN and canonical CAIs are most likely not caused by admixing of supernova material during the early evolution of the proto-Sun. An extrasolar origin for FUN CAIs followed by transport to the nascent solar system via stellar outflows is unlikely based on an analysis of the spatial distribution of stars with contrasting Al-26/Al-27 values in our simulations. Thus, we propose that selective thermal processing of different generation of dust grains may be a more viable scenario to account for the observed heterogeneity in Al-26/Al-27 ratios at the time of solar system formation.