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Desiccated rocky planet populations from ^{26}Al heating

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Abstract

Rapid seeding and inward-migration of water-rich planetary embryos during formation [1, 2] suggest that a substantial fraction of solid-dominated exoplanets are covered in thick volatile ice envelopes: ocean worlds [3, 4]. Using numerical models of planet formation, evolution, and interior structure, we demonstrate the power of ^{26}Al, a short-lived radioisotope whose abundances deviate by orders of magnitude across young planetary systems [5], to control the water content of rocky exoplanets [6]: planet bulk water fraction and radius are suggested to be anti-correlated with the host system's ^{26}Al levels (Fig. 1), indicating a system-wide homogenization of bulk volatile abundances, and a location-independent scarcity of water, consistent with the inferred compositions of the TRAPPIST-1 planets [7].

The generic sensitivity of exoplanet observables on primordial ^{26}Al inferred from our models suggests two distinct classes of rocky exoplanets: high-^{26}Al systems form small, water-depleted planets, those devoid of ^{26}Al form ocean worlds. Such compositionally deviating populations differ in their mean transit radii by up to $\approx$ 10% (Fig. 2), approaching the sensitivity regime of current and near-future transit missions, such as PLATO, with potentially near-future prospects of uncovering statistical trends in M star planet populations with TESS [8].

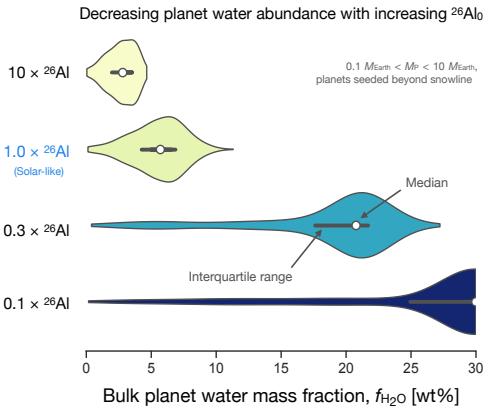

Figure 1: Decrease in G star planet bulk water budgets with increasing initial ^{26}Al$_0$ abundances.

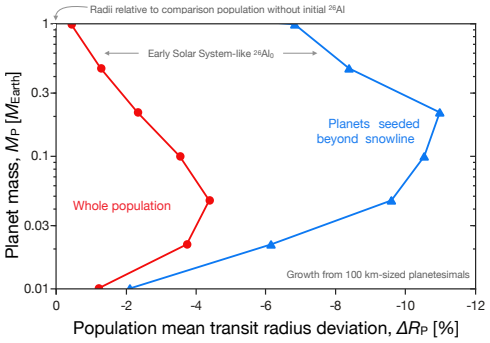

Figure 2: Shift in planet population mean transit radii for Solar-like ^{26}Al$_0$ versus ^{26}Al-free systems.

References

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