# New theory to explain why planets in our solar system have different compositions

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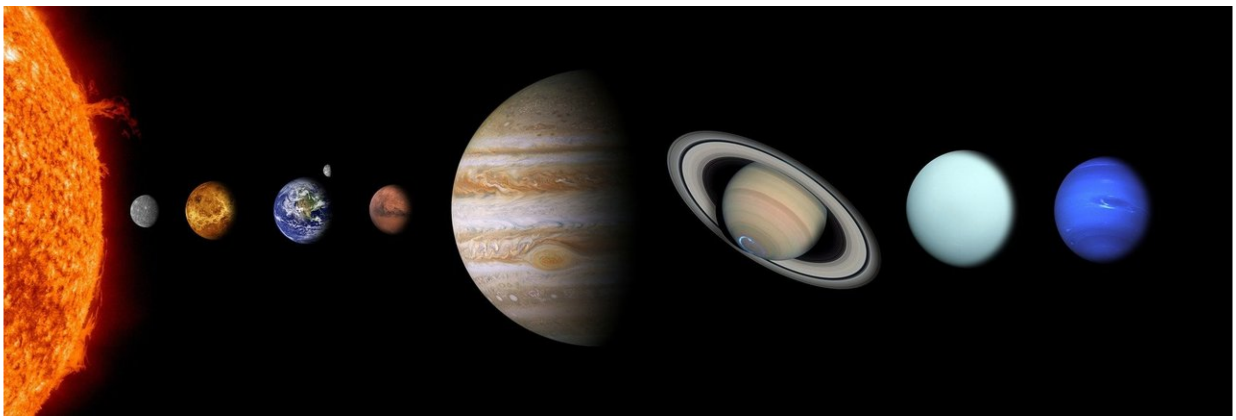

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A team of researchers with the University of Copenhagen and the Museum für Naturkunde, Leibniz-Institut für Evolutions has come up with a new explanation regarding the difference in composition of the planets in our solar system. In their paper published in the journal *Nature*, they describe their study of the calcium-isotope composition of certain meteorites, Earth itself, and Mars, and use what they learned to explain how the planets could be so different. Alessandro Morbidelli with Observatoire de la Côte d'Azur in France offers a News & Views piece on the work done by the team in the same journal issue.

As Morbidelli notes, most planetary scientists agree that the planets in our solar system had similar origins as small rocks orbiting the sun, comprising the protoplanetary disk, which collided and fused, creating increasingly larger rocks that eventually became protoplanets. But from that point on, it is not clear why the planets turned out so differently. In this new effort, the researchers have come up with a new theory to explain how that happened.

The protoplanets all grew at the same rate, the group suggests, but stopped growing at different times. Those that were smaller, they continue, stopped growing sooner than those that were larger. During this time, they further suggest, material was constantly being added to the disk. Early on it, it appears that the composition of the material was different from the material that came later, which explains why the rocky planets we see today have such differences in composition.

The researchers developed their theory after studying the calcium-isotope composition of several meteorites called angrites and ureilites, as well as that of Mars and Earth, and also from the asteroid Vesta. Calcium isotopes, they note, are involved in the formation of rock, and because of that, offer clues about their origins. The researchers found that isotopic ratios in samples correlated with the masses of their parent planets and asteroids, which they claim provides a proxy for their accretion timeline. And that, they further claim, provides evidence of the different compositions of the planets, as the smaller ones ceased accreting material while the larger ones continued to add material that was different from what had come before.

**More information:** Martin Schiller et al. Isotopic evolution of the protoplanetary disk and the building blocks of Earth and the Moon, *Nature* (2018). DOI: 10.1038/nature25990

**Abstract**

Nucleosynthetic isotope variability among Solar System objects is often

used to probe the genetic relationship between meteorite groups and the rocky planets (Mercury, Venus, Earth and Mars), which, in turn, may provide insights into the building blocks of the Earth–Moon system. Using this approach, it has been inferred that no primitive meteorite matches the terrestrial composition and the protoplanetary disk material from which Earth and the Moon accreted is therefore largely unconstrained6. This conclusion, however, is based on the assumption that the observed nucleosynthetic variability of inner-Solar-System objects predominantly reflects spatial heterogeneity. Here we use the isotopic composition of the refractory element calcium to show that the nucleosynthetic variability in the inner Solar System primarily reflects a rapid change in the mass-independent calcium isotope composition of protoplanetary disk solids associated with early mass accretion to the proto-Sun. We measure the mass-independent 48Ca/44Ca ratios of samples originating from the parent bodies of ureilite and angrite meteorites, as well as from Vesta, Mars and Earth, and find that they are positively correlated with the masses of their parent asteroids and planets, which are a proxy of their accretion timescales. This correlation implies a secular evolution of the bulk calcium isotope composition of the protoplanetary disk in the terrestrial planet-forming region. Individual chondrules from ordinary chondrites formed within one million years of the collapse of the proto-Sun7 reveal the full range of inner-Solar-System mass-independent 48Ca/44Ca ratios, indicating a rapid change in the composition of the material of the protoplanetary disk. We infer that this secular evolution reflects admixing of pristine outer-Solar-System material into the thermally processed inner protoplanetary disk associated with the accretion of mass to the proto-Sun. The identical calcium isotope composition of Earth and the Moon reported here is a prediction of our model if the Moon-forming impact involved protoplanets or precursors that completed their accretion near the end of the protoplanetary disk's lifetime.