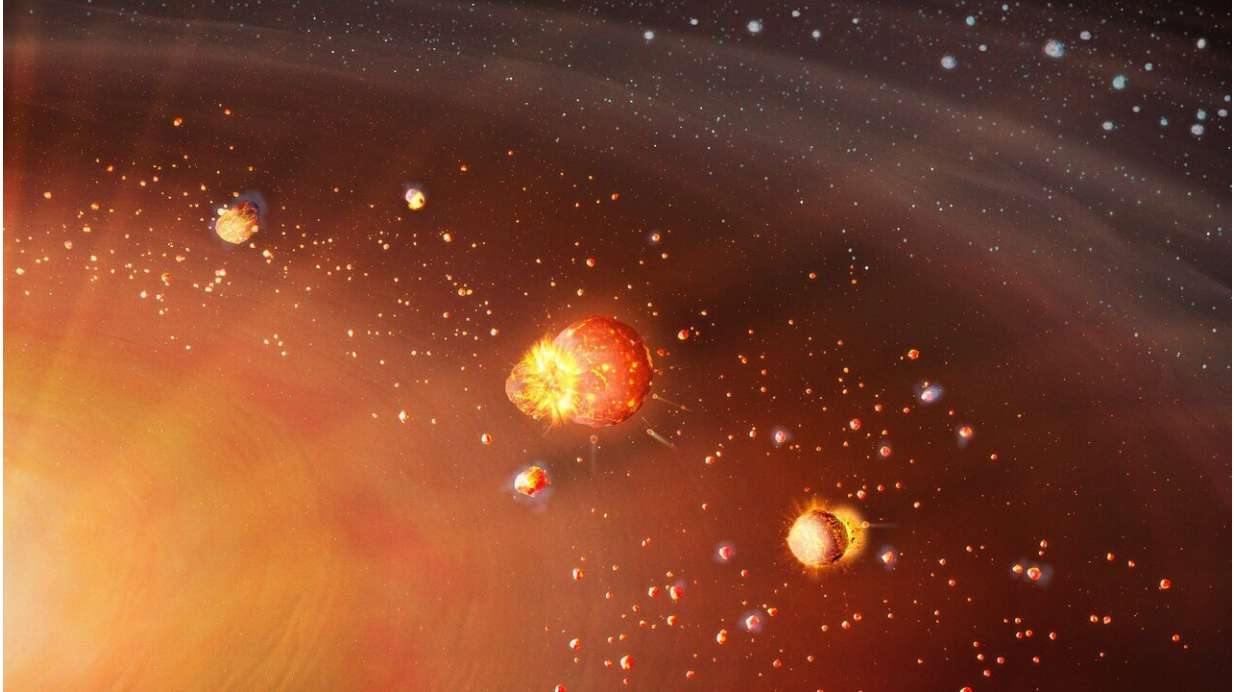


Solar system formation in two steps

January 21 2021



The inner terrestrial protoplanets accrete early, inherit a substantial amount of radioactive ^{26}Al , and hence melt, form iron cores, and degas their primordial volatile abundances rapidly. The outer Solar System planets start to accrete later and further out with less radiogenic heating, and hence retain the majority of their initially accreted volatiles. Credit: Mark A Garlick/markgarlick.com

An international team of researchers from the University of Oxford, LMU Munich, ETH Zurich, BGI Bayreuth, and the University of Zurich discovered that a two-step formation process of the early Solar System can explain the chronology and split in volatile and isotope content of the

inner and outer Solar System.

Their findings will be published in *Science*.

The paper presents a new theoretical framework for the formation and structure of the Solar System that can explain several key features of the terrestrial [planets](#) (like Earth, Venus, and Mars), outer Solar System (like Jupiter), and composition of asteroids and meteorite families. The team's work draws on and connects recent advances in astronomy (namely observations of other solar systems during their formation) and meteoritics—laboratory experiments and analyses on the isotope, iron, and [water content](#) in meteorites.

The suggested combination of astrophysical and geophysical phenomena during the earliest formation phase of the Sun and the Solar System itself can explain why the inner Solar System planets are small and dry with little water by mass, while the outer Solar System planets are larger and wet with lots of water. It explains the meteorite record by forming planets in two distinct steps. The inner terrestrial protoplanets accreted early and were internally heated by strong radioactive decay; this dried them out and split the inner, dry from the outer, wet planetary population. This has several implications for the distribution and necessary formation conditions of planets like Earth in extrasolar planetary systems.

The numerical experiments performed by the interdisciplinary team showed that the relative chronologies of early onset and protracted finish of accretion in the inner Solar System, and a later onset and more rapid accretion of the outer Solar System planets can be explained by two distinct formation epochs of planetesimals, the building blocks of the planets. Recent observations of planet-forming disks showed that disk midplanes, where planets form, may have relatively low levels of turbulence. Under such conditions the interactions between the dust

grains embedded in the disk gas and water around the orbital location where it transitions from gas to ice phase (the snow line) can trigger an early formation burst of planetesimals in the inner Solar System and another one later and further out.

The two distinct formation episodes of the planetesimal populations, which further accrete material from the surrounding disk and via mutual collisions, result in different geophysical modes of internal evolution for the forming protoplanets. Dr. Tim Lichtenberg from the Department of Atmospheric, Oceanic and Planetary Physics at the University of Oxford and lead-author of the study notes: "The different formation time intervals of these planetesimal populations mean that their internal heat engine from radioactive decay differed substantially. Inner Solar System planetesimals became very hot, developed internal magma oceans, quickly formed iron cores, and degassed their initial volatile content, which eventually resulted in dry planet compositions. In comparison, outer Solar System planetesimals formed later and therefore experienced substantially less internal heating and therefore limited iron core formation, and volatile release.

"The early-formed and dry inner Solar System and the later-formed and wet outer Solar System were therefore set on two different evolutionary paths very early on in their history. This opens new avenues to understand the origins of the earliest atmospheres of Earth-like planets and the place of the Solar System within the context of the exoplanetary census across the galaxy."

This research was supported by funding from the Simons Collaboration on the Origins of Life, the Swiss National Science Foundation, and the European Research Council.

The full study, "Bifurcation of planetary building blocks during Solar System formation," will be published on 22 January 2021 in *Science*,

371, 6527.

More information: "Bifurcation of planetary building blocks during Solar System formation" *Science* (2021). [science.sciencemag.org/cgi/doi... 1126/science.abb3091](https://science.sciencemag.org/cgi/doi/10.1126/science.abb3091)

Provided by University of Oxford

Citation: Solar system formation in two steps (2021, January 21) retrieved 20 March 2024 from <https://phys.org/news/2021-01-solar-formation.html>

<p>This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.</p>
--