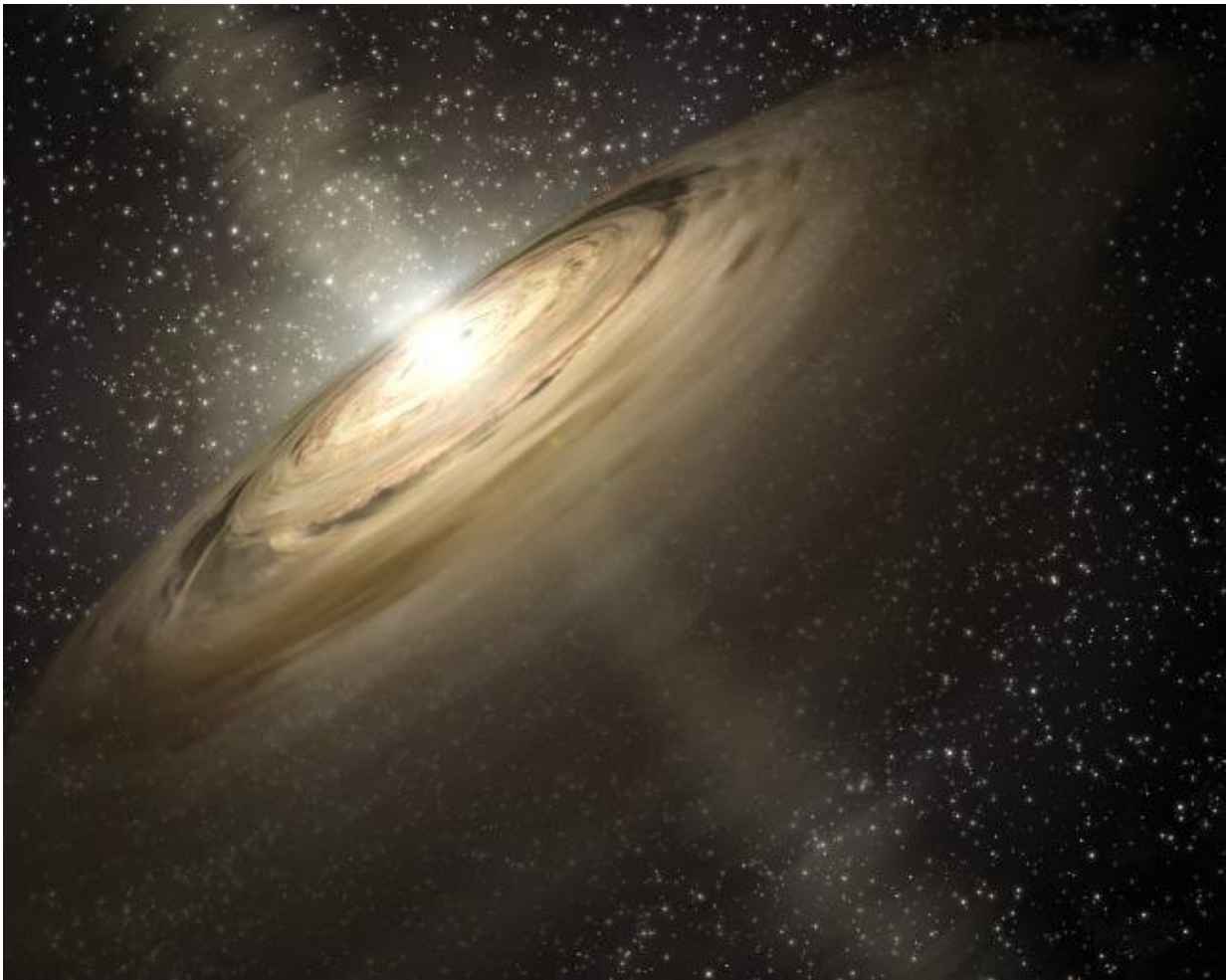


# Studying radioactive aluminum in stellar systems unlocks formation secrets

July 29 2020, by Rebecca Johnson

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This artist's concept available from NASA illustrates a stellar system that is a much younger version of our own. Dusty disks, like the one shown here circling the star, are thought to be the breeding grounds of planets, including rocky ones like Earth. Credit: NASA/JPL-Caltech

An international team of astronomers including Stella Offner of the University of Texas at Austin has proposed a new method for the formation of aluminum-26 in star systems that are forming planets. Because its radioactive decay is thought to provide a heat source for the building blocks of planets, called planetesimals, it's important for astronomers to know where aluminum-26 comes from. Their research is published in the current issue of *The Astrophysical Journal*.

"Atoms like aluminum and its radioactive isotope aluminum-26 allow us to perform solar system 'archeology,'" Offner said. "It is exciting that the abundances of different atoms today can provide clues about the formation of our solar system billions of years ago."

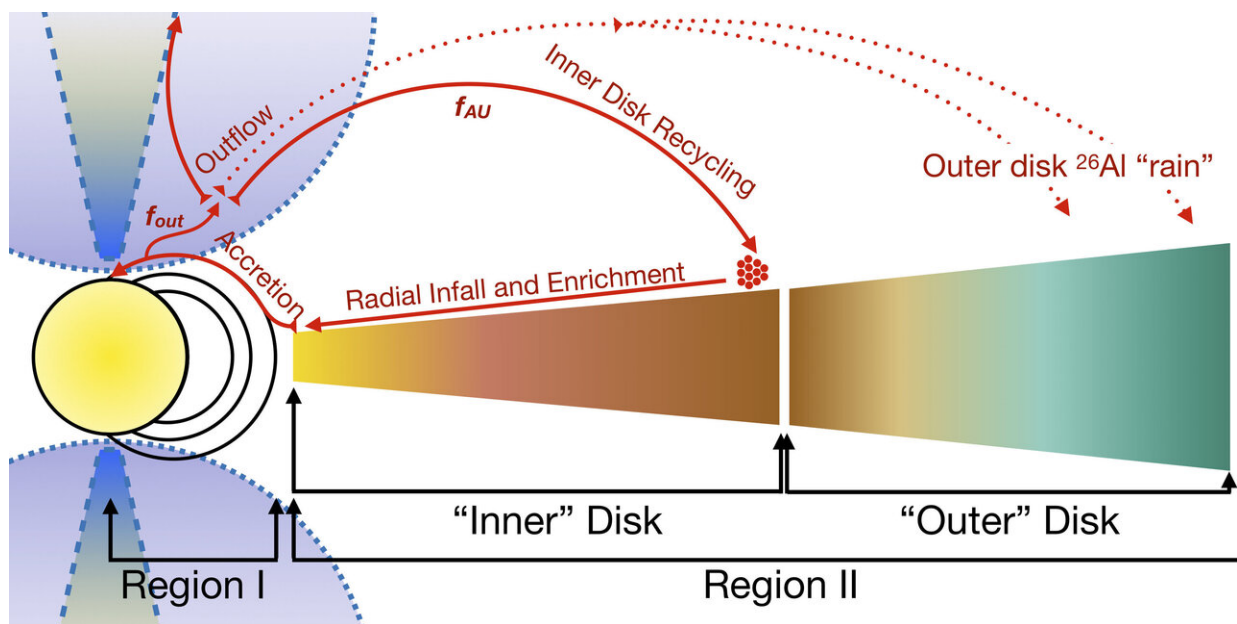
Since its discovery in the Allende meteorite in 1976, astronomers have debated the origin of the considerable amount of aluminum-26 in our early solar system. Some have suggested that it was blown here by supernova explosions and winds from massive [stars](#). However, these scenarios require a good deal of chance: Our sun and planets would have to form at exactly the right distance from [massive stars](#), which are quite rare.

Offner's team has proposed an explanation that does not require an outside source. They propose that aluminum-26 formed close to the young sun in the inner part of its surrounding planet-forming disk. As material fell from the disk's inner edge onto the sun, it created shockwaves that produced high-energy protons known as [cosmic rays](#).

Leaving the sun at nearly the speed of light, the cosmic rays slammed into the surrounding disk, colliding with the isotopes aluminum-27 and silicon-28, changing them into aluminum-26.

Due to its very short half-life of about 770,000 years, aluminum-26 must have been formed or mixed into the young sun's surrounding planet-

forming disk shortly before the condensation of the first solid matter in our solar system. It plays an important part in the formation of planets like Earth, since it can provide enough heat through radioactive decay to produce planetary bodies with layered interiors (like Earth's solid core topped by a rocky mantle and above that, a thin crust). The [radioactive decay](#) of aluminum-26 also helps to dry out early planetesimals to produce water-poor, rocky planets.



This schematic of the proposed mechanism shows a cutaway view of a young star and the disk of gas surrounding it, in which planets may form. The gas parcel Offner's team modeled is depicted as a cluster of red dots. The 'inner disk' is the region from the star out to Earth's distance from the Sun (1 Astronomical Unit, or about 93 million miles). Some fraction of the enriched outflow gas may fall onto the disk where the cosmic ray irradiation is weak. Regions I and II denote different regions of cosmic ray transport. Credit: Brandt Gaches et al./Univ. of Cologne

Aluminum-26 appears to have a fairly constant ratio to the isotope of aluminum-27 in the oldest bodies of our solar system, the comets and asteroids. Since the discovery of aluminum-26 in meteorites (which are chips off of asteroids), a significant amount of effort has been directed towards finding a plausible explanation for both its introduction into our early solar system and the fixed ratio between aluminum-26 and aluminum-27.

Offner's team focused their studies on a transition period during the sun's formation: when the gas surrounding the young star becomes depleted and the amount of gas falling onto the sun decreases significantly. Nearly all young stars undergo this transition during the last few tens to hundreds of thousands of years of formation.

As our sun was forming, infalling gas followed magnetic field lines to its surface. This produced a violent shockwave, the "accretion shock," that accelerated cosmic rays. These cosmic rays streamed outwards until they hit gas in the planet-forming disk and caused chemical reactions. The scientists calculated different models for this process.

"We found that low accretion rates are able to produce the amounts of aluminum-26, and the ratio of aluminum-26 to aluminum-27 that is present in the solar system," said the paper's lead author, Brandt Gaches of Germany's University of Cologne.

The proposed mechanism is generally valid for a wide range of low-mass stars, including sun-like stars. It is in these systems that astronomers have discovered the majority of exoplanets now known.

"Cosmic rays that were accelerated by accretion onto forming young stars may provide a general pathway for aluminum-26 enrichment in many planetary systems," Gaches concluded, "and it is one of the great questions if the proposed mechanism of acceleration through

shockwaves will be observed in forming stars."

**More information:** Brandt A. L. Gaches et al. Aluminum-26 Enrichment in the Surface of Protostellar Disks Due to Protostellar Cosmic Rays, *The Astrophysical Journal* (2020). [DOI: 10.3847/1538-4357/ab9a38](https://doi.org/10.3847/1538-4357/ab9a38)

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