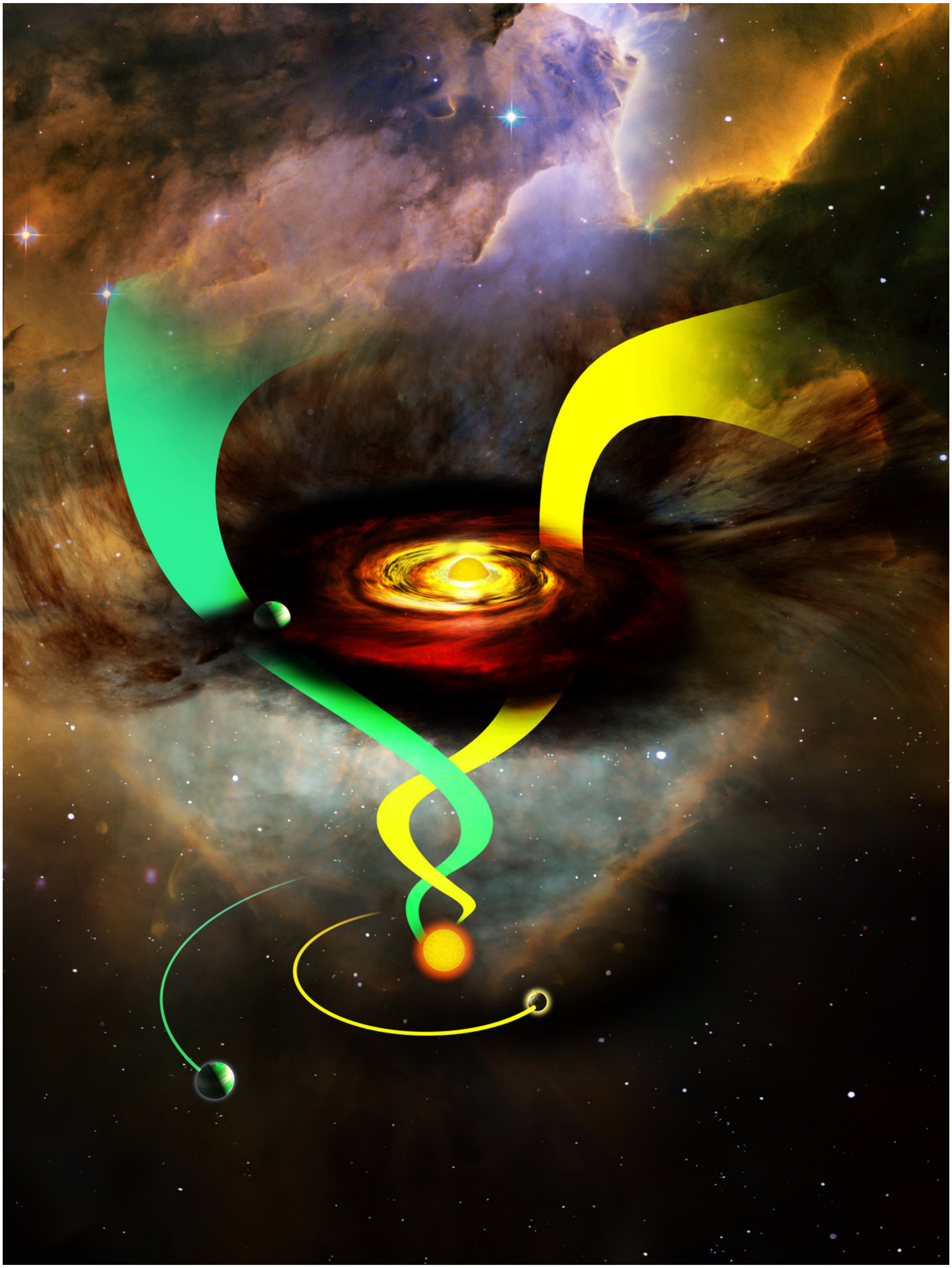
Iron-rich stars host shorter-period planets

January 10 2018



An artist's rendering of how the iron content of a star can impact its planets. A normal star (green label) is more likely to host a longer-period planet (green orbit), while an iron-rich star (yellow label) is more likely to host a shorter-period planet (yellow orbit). Credit: Dana Berry/SkyWorks Digital Inc.; SDSS collaboration

Astronomers with the Sloan Digital Sky Survey (SDSS) have learned that the chemical composition of a star can exert unexpected influence on its planetary system—a discovery made possible by an ongoing SDSS survey of stars seen by NASA's Kepler spacecraft, and one that promises to expand our understanding of how extrasolar planets form and evolve.

"Without these detailed and accurate measurements of the iron content of stars, we could have never made this measurement," says Robert Wilson, a graduate student in astronomy at the University of Virginia and lead author of the paper announcing the results.

The team presented their results today at the American Astronomical Society (AAS) meeting in National Harbor, Maryland. Using SDSS data, they found that stars with higher concentrations of iron tend to host planets that orbit quite close to their host star—often with orbital periods of less than about eight days—while stars with less iron tend to host planets with longer periods that are more distant from their host star. Further investigation of this effect may help us understand the full variety of extrasolar planetary systems in our Galaxy, and shed light on why planets are found where they are.

The story of planets around sun-like stars began in 1995, when a team of astronomers discovered a single planet orbiting a sun-like star 50 light years from Earth. The pace of discovery accelerated in 2009, when NASA launched the Kepler spacecraft, a space telescope designed to look for extrasolar planets. During its four-year primary mission, Kepler monitored thousands of stars at a time, watching for the tiny dimming of starlight that indicates a planet passing in front its host star. And because Kepler looked at the same stars for years, it saw their planets over and over again, and was thus able to measure the time the planet takes to orbit its star. This information reveals the distance to from star to planet, with closer planets orbiting faster than farther ones. Thanks to Kepler's tireless monitoring, the number of exoplanets with known orbital periods increased dramatically, from about 400 in 2009 to more than 3,000 today.

Although Kepler was perfectly designed to spot extrasolar planets, it was not designed to learn about the chemical compositions of the stars around which those planets orbit. That knowledge comes from the SDSS's Apache Point Observatory Galactic Evolution Experiment (APOGEE), which has studied hundreds of thousands of stars all over the Milky Way Galaxy. APOGEE works by collecting a spectrum for each star—a measurement of how much light the star gives off at different wavelengths (colors) of light. Because atoms of each chemical element interact with light in their own characteristic way, a spectrum allows astronomers to determine not only which elements a star contains, but also how much—for all elements including the key element iron.

"All sun-like stars are mostly hydrogen, but some contain more iron than others," says Johanna Teske of the Carnegie Institution for Science, a member of the research team. "The amount of iron a star contains is an important clue to how it formed and how it will evolve over its lifetime."

By combining data from these two sources—planetary orbits from Kepler and stellar chemistry from APOGEE—astronomers have learned about the relationships between these "iron-enriched" stars and the planetary systems they hold.

"We knew that the element enrichment of a star would matter for its own evolution," says Teske, "But we were surprised to learn that it matters for the evolution of its planetary system as well."

The work presented today builds on previous work, led by Gijs Mulders of the University of Arizona, using a larger but less precise sample of spectra from the LAMOST-Kepler project. (LAMOST, the Large-Area Multi-Object fiber Spectroscopic Telescope, is a Chinese sky survey.) Mulders and collaborators found a similar trend—closer-in planets orbiting more iron-rich stars—but did not pin down the critical period of eight days.

"It is encouraging to see an independent confirmation of the trend we found in 2016," says Mulders. "The identification of the critical period really shows that Kepler is the gift that keeps on giving."

What is particularly surprising about the new result, Wilson explained, is that the iron-enriched stars have only about 25 percent more iron than the others in the sample. "That's like adding five-eighths of a teaspoon of salt into a cupcake recipe that calls for half a teaspoon of salt, among all its other ingredients. I'd still eat that cupcake," he says. "That really shows us how even small differences in stellar composition can have profound impacts on planetary systems."

But even with this new discovery, astronomers are left with many unanswered questions about how extrasolar planets form and evolve, especially planets Earth-sized or slightly larger ("super-Earths"). Do iron-rich stars intrinsically form planets with shorter orbits? Or are planets orbiting iron-rich stars more likely to form farther out and then migrate to shorter period, closer-in orbits? Wilson and collaborators hope to work with other astronomers to create new models of protoplanetary disks to test both of these explanations.

"I'm excited that we still have much to learn about how the chemical compositions of stars impact their planets, particularly about how small planets form," Teske says. "Plus, APOGEE provides many more stellar chemical abundances besides iron, so there are likely other trends buried within this rich dataset that we have yet to explore."

Provided by Sloan Digital Sky Survey

Citation: Iron-rich stars host shorter-period planets (2018, January 10) retrieved 27 April 2024 from https://phys.org/news/2018-01-iron-rich-stars-host-shorter-period-planets.html