ASU forges strategic partnership to solve the mystery of planet formation

By Kim Baptista, ASU News
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Astronomers have long grappled with the question, “How do planets form?” A new collaboration among Arizona State University, Michigan State University and Lawrence Livermore National Laboratory will seek to answer this question with the help of a powerful telescope and high-performance computers.

The team of researchers will use 154 hours on the James Webb Space Telescope to probe the atmospheres of seven planets beyond our solar system — all of which were formed less than 300 million years ago, around the time dinosaurs roamed the Earth. In conjunction with JWST, this collaboration, called the KRONOS program, will use computers from Lawrence Livermore National Laboratory to create atmospheric models that could lead to understanding how planets form, evolve and possibly even harbor conditions favorable for life.

“We are taking some of the first steps to probe young exoplanet atmospheres — a largely unknown population. Through our strategic partnership, we will push the limits of our models and data, looking for new insights into both planetary atmospheres and their host stars,” said KRONOS co-principal investigator Luis Welbanks, a 51 Pegasi b Fellow and incoming assistant professor at ASU's School of Earth and Space Exploration. “Our results will reveal the physical and chemical processes shaping these distant worlds, guiding the future of both theoretical and observational research”

Three years into its operations, the JWST — a joint mission of NASA, the European Space Agency and the Canadian Space Agency — is already revolutionizing our understanding of planets beyond our solar system. Given the number of planets in our galaxy — 6,000 and counting — it’s clear that planet formation is pervasive. The details of how that happened, however, are still elusive. One way to find out is to observe planets of different ages, particularly young exoplanets less than 300 million years old, as they transit their host stars.

During this transit, some of the starlight passes through the planet's atmosphere, and molecules such as water or carbon dioxide absorb some of the light. Scientists observe exoplanet transits at different wavelengths to probe how the light is absorbed to uncover the composition of an exoplanet atmosphere.

By using physics-driven models of atmospheres, astronomers can explore an exoplanet's composition, linking it to planetary formation and evolution theories.

"The outstanding data quality of JWST's observations can only be explained using models that capture the complex interactions between light and matter," said Michael Line, associate professor in the School of Earth and Space Exploration at ASU, who is part of the team. "We must describe how molecules form, interact and get destroyed."

The problem is these models come at a huge computational cost. To combat this, the KRONOS team won 22 million hours of computing time through the LLNL Computing Grand Challenge Program. This program provides significant quantities of institutional computing resources to LLNL scientists to perform cutting-edge research.

The models KRONOS creates will be used to understand the compositions of a wide variety of exoplanet atmospheres. This in turn can be used to understand how planets are formed.

"Understanding the compositions of planetary atmospheres at different ages is still a big unknown because these planets are hard to find and even harder to characterize," said KRONOS program co-principal investigator Adina Feinstein, a NASA Sagan Fellow and incoming assistant professor at MSU. "With the precision and instruments aboard JWST, we're excited to have the ability to begin to directly address questions of what natal planets look like."

In addition to the seven planets being studied by KRONOS, the team will generate models for all 70 exoplanets that have been observed by JWST.

"An endeavor to uniformly model such a large sample of planets — from scorching worlds more massive than Jupiter to temperate and small Earth-mass planets — has yet to be undertaken," said LLNL principal investigator Peter McGill. "This task can really only be accomplished using LLNL's world-class, high-performance computing platforms."

Once completed, the atmospheric models developed by the team will be made publicly available to the astronomy community. The goal is to encourage open collaborative science and make a lasting impact on the field.

Press release written by Bethany Mauger, Michigan State University with contributions from Kim Baptista at ASU's School of Earth and Space Exploration.

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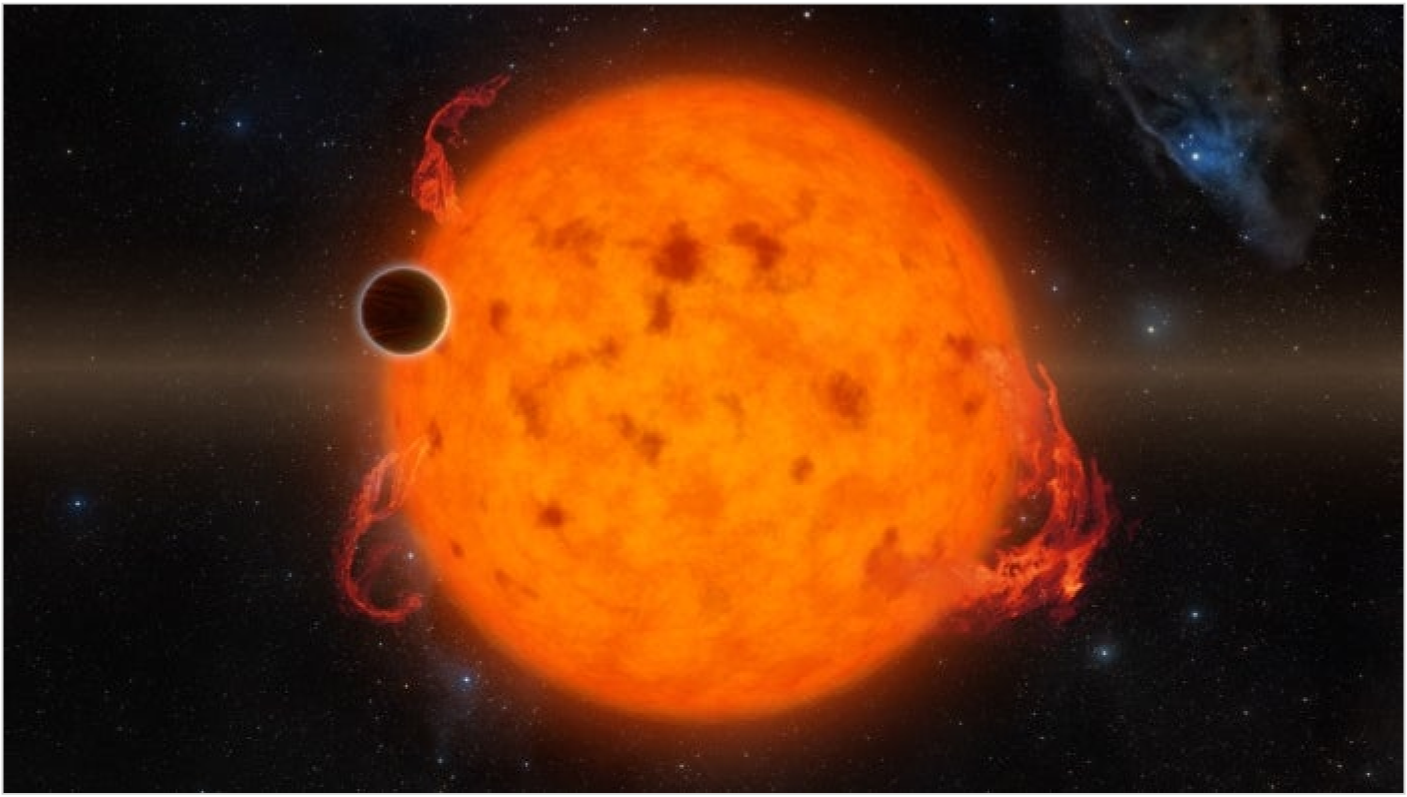
Main image



An artist's conception of the exoplanet K2-33b, a 10 Myr Jupiter-sized planet, transiting in front of its active host star. This system is comparable to those that will be observed by the KRONOS collaboration. Illustration courtesy of NASA/JPL-CalTech