How new planets form near the Seven Sisters

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Color composite image of the Pleiades star cluster produced by Inseok Song of the Spitzer Science Center, using montage software developed by IPAC/California Institute of Technology. An artist's rendering of a collision in the Pleiades (inset), by Lynette R. Cook, for Gemini Observatory.

Rocky terrestrial planets, perhaps like Earth, Mars or Venus, appear to be forming or to have recently formed around a star in the Pleiades ("seven sisters") star cluster, the result of "monster collisions" of planets or planetary embryos.

Astronomers using the Gemini Observatory in Hawaii and the Spitzer Space Telescope report their findings in an upcoming issue of the *Astrophysical Journal*.

"This is the first clear evidence for planet formation in the Pleiades, and the results we are presenting may well be the first observational evidence that terrestrial planets like those in our solar system are quite common," said Joseph Rhee, a UCLA postdoctoral scholar in astronomy and lead author of the research.

The Pleiades star cluster, in the constellation Taurus, is well-known in many cultures. It is named for the seven daughters of Atlas and Pleione, who were placed by Zeus among the stars in Greek mythology and is cited in the Bible — "Can you bind the beautiful Pleiades? Can you loose the cords of Orion?" (Job 38:31). The automaker Subaru's name is the Japanese word for the Pleiades, Rhee said.

The Pleiades is probably the best known star cluster and the most striking to the naked eye. "You've seen it many times, and it's now easily visible in the evening sky," said research co-author Benjamin Zuckerman, UCLA professor of physics and astronomy.

Although referred to as the "seven sisters," "the cluster actually contains some 1,400 stars," said co-author Inseok Song, a staff scientist at NASA's Spitzer Science Center at the California Institute of Technology and a former astronomer with the Gemini Observatory.

Located about 400 light-years away, the Pleiades is one of the closest star clusters to Earth. One of the cluster's stars, known as HD 23514, which has a mass and luminosity a bit greater
than those of the sun, is surrounded by an extraordinary number of hot dust particles — "hundreds of thousands of times as much dust as around our sun," Zuckerman said. "The dust must be the debris from a monster collision, a cosmic catastrophe."

The astronomers analyzed emissions from countless microscopic dust particles and concluded that the most likely explanation is that the

particles are debris from the violent collision of planets or planetary embryos.

Song calls the dust particles the "building blocks of planets," which can accumulate into comets and small asteroid-size bodies and then clump together to form planetary embryos, eventually becoming full-fledged planets.

"In the process of creating rocky, terrestrial planets, some objects collide and grow into planets, while others shatter into dust," Song said. "We are seeing that dust."

HD 23514 is the second star around which Song and Zuckerman recently have found evidence of terrestrial planet formation. They and their colleagues reported in the journal Nature in July 2005 that a sun-like star known as BD +20 307, located 300 light-years from Earth in the constellation Aries, is surrounded by one million times more dust than is orbiting our sun.

In an effort to uncover comparably dusty stars after their 2005 research, Rhee, Song and Zuckerman began looking through thousands of publicly accessible, deep-infrared images obtained by the Spitzer Space Telescope and soon discovered HD 23514. The astronomers then used the Gemini North telescope, located on Hawaii's dormant volcano Mauna Kea, to measure the heat radiation coming from the dust; the heat emerges at infrared wavelengths, just as the heat from our bodies does, Song said.

"The Gemini and Spitzer data were crucial in identifying and establishing the amount and location of dust around the star," Song said.

While our sun is 4.5 billion years old, the Pleiades Aries stars are "adolescents," about 100 million and 400 million years old, respectively,

Rhee said. Based on the age of the two stars and the dynamics of the orbiting dust particles, the astronomers deduce that most adolescent sun-like stars are likely to be building terrestrial-like planets through recurring violent collisions of massive objects. The cosmic debris from only a small percentage of such collisions can be seen at any one time — currently, only HD 23514 and BD +20 307 have visible debris.

"Our observations indicate that terrestrial planets similar to those in our solar system are probably quite common," Zuckerman said.

The astronomers calculate that terrestrial planets or planetary embryos in the Pleiades collided within the last few hundred thousand years — or perhaps much more recently — but they cannot rule out the possibility that multiple, somewhat smaller collisions occurred.

Many astronomers believe our moon was formed through the collision of two planetary embryos — the young Earth and a body about the size of Mars. That crash created tremendous debris, some of which condensed to form the moon and some of which went into orbit around the young sun, Zuckerman said.

By contrast, the collision of an asteroid with Earth 65 million years ago, the most favored explanation for the final demise of the dinosaurs, was a mere pipsqueak, he said.

"Collisions between comets or asteroids wouldn't produce anywhere near the amount of dust we are seeing," Song said.

HD 23514 and BD +20 307 are by far the dustiest not-so-young stars in the sky. "Nothing else is even close," Song said.

Very young stars — those 10 million years old or younger — may have a

similar amount of dust around them as a result of the star-formation process. However, by the time a star is 100 million years old, this "primordial" dust has dissipated because the dust particles get blown away or dragged onto the star, or the particles clump together to form much larger objects.

"Unusually massive amounts of dust, as seen at the Pleiades and Aries stars, cannot be primordial but rather must be the second-generation debris generated by collisions of large objects," Song said.

The Pleiades have been considered important by many cultures throughout history.

"To the Vikings, the Pleiades was Freyja's hens," Rhee said. In Bronze Age Europe, the Celts and others associated the Pleiades with mourning and funerals because the cluster rose in the eastern night sky between the autumnal equinox and the winter solstice, which was a festival devoted to the remembrance of the dead. The ancient Aztecs of Mexico and Central America based their calendar on the Pleiades.

The astronomers' research results are based on mid- and far- infrared observations made with the Gemini 8-meter Frederick C. Gillett Telescope at Gemini North and the space-based infrared observatories Infrared Astronomical Satellite (IRAS), Infrared Space Observatory (ISO) and NASA's Spitzer Space Telescope.

The Gemini Observatory is an international collaboration utilizing two identical 8-meter telescopes. The Frederick C. Gillett Gemini Telescope is located at Mauna Kea, Hawaii (Gemini North); the other is at Cerro Pachón in central Chile (Gemini South). Together they provide full coverage of both hemispheres of the sky. Both telescopes incorporate new technologies that allow large, relatively thin mirrors under active control to collect and focus both optical and infrared radiation from

space.

Source: University of California - Los Angeles