Academia Sinica Press Release

Best ALMA Image Ever Reveals a Planet Nursery around a Young Star

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Recently, the Atacama Large Millimeter/submillimeter Array (ALMA) obtained its highest-ever resolution image, revealing the surroundings of HL Tau, a young star of one million years old soon to become a Sun. The latest image of HL Tau from the telescope demonstrates both the very high sensitivity and very high angular resolution of ALMA. ALMA is the largest and most advanced astronomical telescope in the world, run by a collaboration of teams of astronomers from Europe, North America and East Asia. Researchers from Academia Sinica Institute of Astronomy and Astrophysics, (ASIAA) representing Taiwan as “ALMA-Taiwan”, play an integral role in many ALMA projects.

“This image is exactly the reason why we built the ALMA. We are getting an exciting peek at how planets might be forming around this sun-like star,” said Academician, Paul Ho, the principal investigator of Taiwan’s part of the ALMA project.

“The image unveils in exquisite detail the distribution of dust grains in the disk around HL Tau, challenging our understanding of how these disks develop and how planets form,” he added.

Recently, ALMA started to observe the Universe using long baseline configurations, with antennas placed at unprecedented distances of up to 15 kilometers from each other. Starting at the end of August 2014, the ALMA antennas were gradually relocated further apart from each other. The longest baseline of 15 kilometers was reached on 13 October 2014. Other facilities operating at millimeter wavelengths provide antennas separated by no more than two kilometers.

Associate Research Fellow of ASIAA, Satoki Matsushita contributed to the hardware testing and system checking in this long baseline mode.

“This high-resolution image is a result of a lot of experience and knowledge accumulated from the building of the Submillimeter Array (SMA). It shows that the pioneering work in years by ASIAA in instrumentation has reached a new climax,” he said. The SMA is the world’s first sub-millimeter interferometer array, located in Hawaii, which has been jointly operated by ASIAA and the Smithsonian Astrophysical Observatory since 2003.

The resolution achieved to obtain the new images of HL Tau could only be achieved with the long baseline capabilities of ALMA, explained ALMA Director, Pierre Cox. “[They] …provide astronomers with new information that is impossible to collect with any other facility, even the Hubble Space Telescope,” he said.

ALMA displays, as never seen before, the structure of the disk around HL Tau, which is in one of the nearest-by star-forming region at a distance of 450 light-years. The image shows a series of concentric and bright rings, with dark patches, as well as intriguing radial structures, feather-like features and arc-shaped gaps. The details are seen with a resolution corresponding to five times the distance between the Sun and the Earth.

“These features are almost certainly the result of young planet-like bodies that are being formed in the disk. No theory predicts that, in such a young star, dust grains have settled and grown to large bodies, capable of shaping the disk into the structure seen by ALMA.” said ALMA Deputy Director Stuartt Corder. “In our first image at such a resolution, we found something completely unexpected. Perhaps we should change our expectations.”

Young stars, like HL Tau, are born in clouds of gas and fine dust that have collapsed by gravitation. Over time, the remaining dust particles stick together, growing into sand, pebbles and larger-sized rocks, which settle down into a thin disk. In the mid-plane of this disk, these icy rocks will accumulate to form asteroids, comets and eventually planets. But once they get massive enough, the young planets will disrupt the disk, leaving rings, gaps and holes. The ALMA image provides the clearest evidence to date that not only does this process occur, but also that it is faster than previously thought.

For the past 30 years, most of what is known about planet formation has been based on theory. Images with this level of detail were relegated to artist conceptions or more specifically computer simulations. Due to advances made with ALMA, it can now been seen directly.

This high-resolution image of HL Tau illustrates what ALMA can achieve when using the long baseline configurations and shows that future observations with this facility will provide entirely new ways to explore the Universe.

ALMA is a single telescope of revolutionary design, composed initially of 66 high precision antennas located on the Chajnantor plateau, 5000 meters altitude in northern Chile. It is an international partnership of Europe, North America and East Asia in cooperation with the Republic of Chile. Taiwan joined the ALMA project in 2005 in collaboration with the ALMA-Japan team. In 2008 Taiwan also joined the ALMA-North America team. “ALMA-Taiwan”, based at the ASIAA, participated in the construction of ALMA and has made many indispensable contributions.

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