Astronomers observe how two suns collect matter in a binary system

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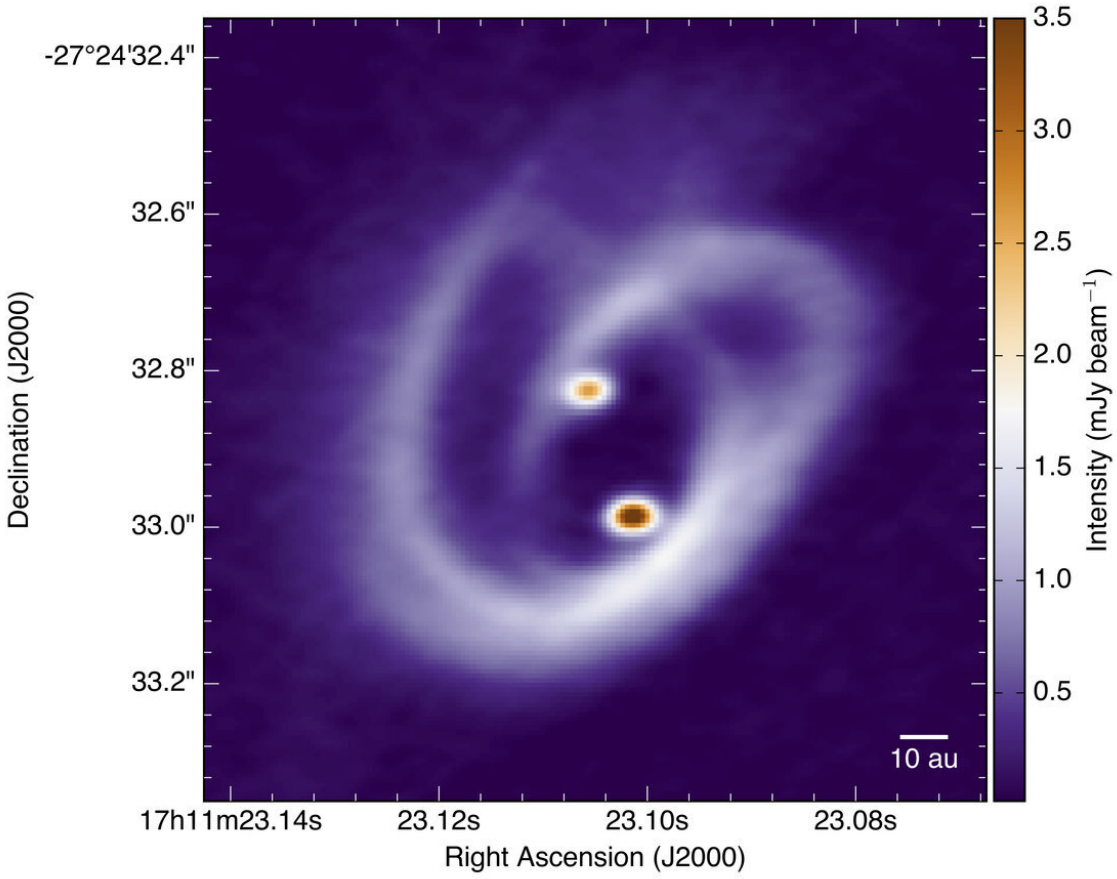
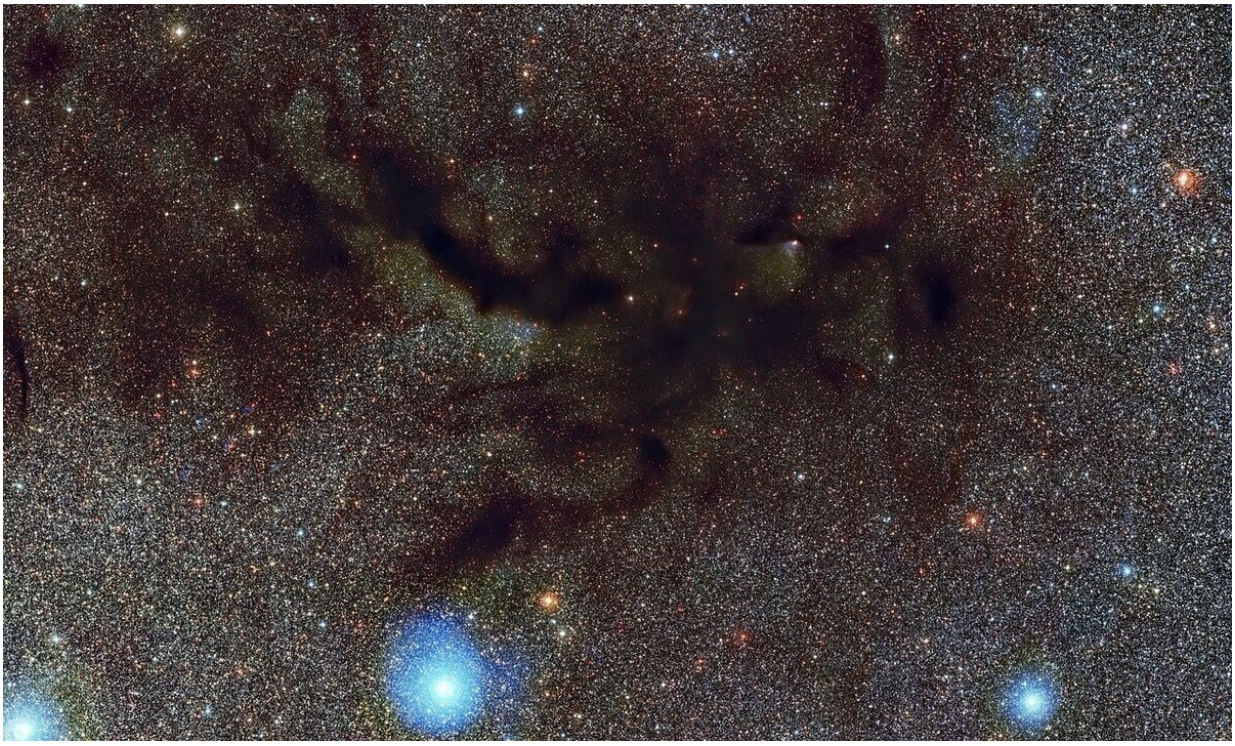


Cosmic delivery room: This picture shows Barnard 59, part of a vast dark cloud of interstellar dust called the Pipe Nebula. The proto-binary systems [BHB2007] 11 studied with high-resolution images is embedded in dense clouds, but can be observed at longer wavelengths with the radio telescope ALMA (Atacama Large Millimeter/submillimeter Array). Credit: ESO

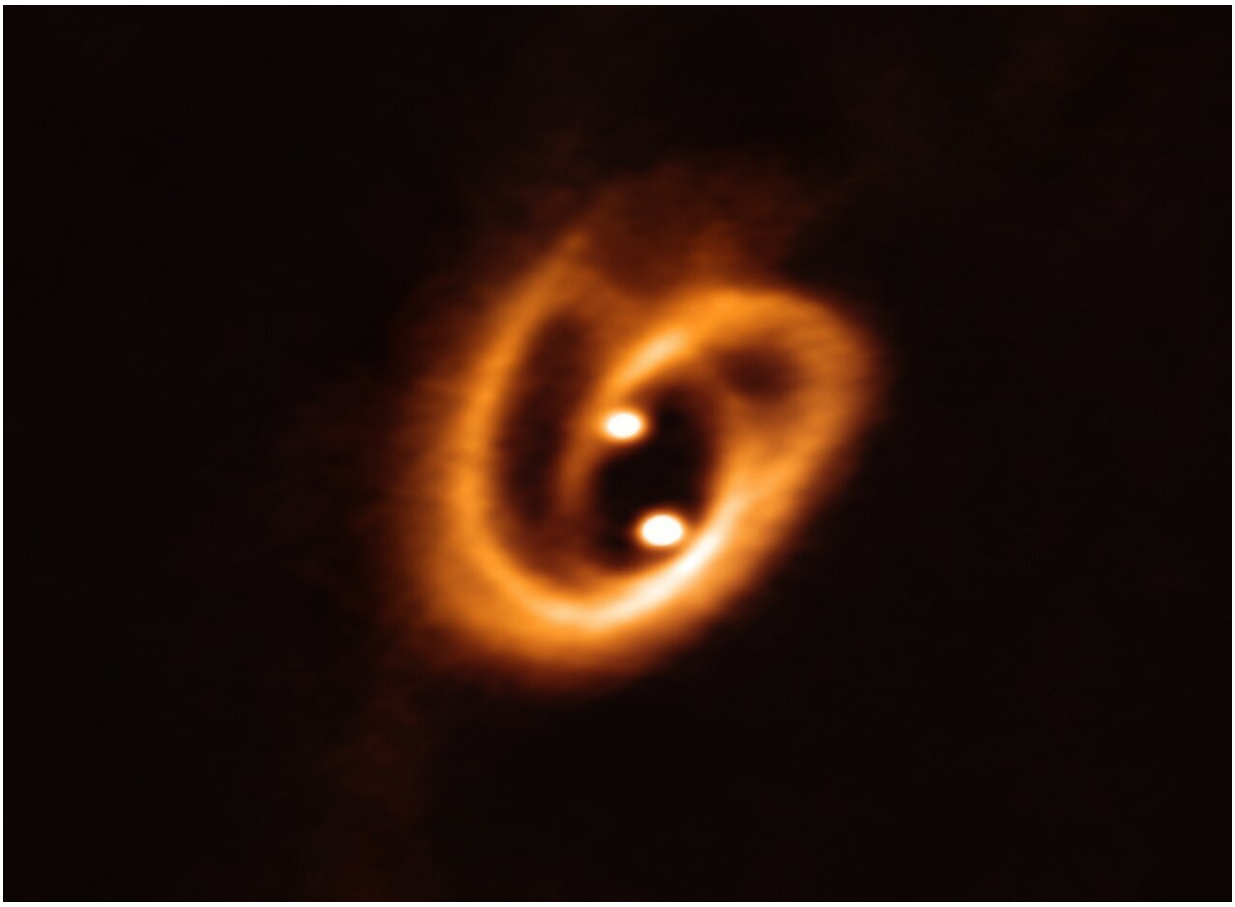
Stars are born in the midst of large clouds of gas and dust. Local densifications first form "embryos," which then collect matter and grow. But how exactly does this accretion process work? And what happens when two stars form in a disk of matter? High-resolution images of a young stellar binary system for the first time reveal a complex network of accretion filaments nurturing two protostars at the center of the circumbinary disk. With these observations, an international team of astronomers led by the Max Planck Institute for Extraterrestrial Physics was able to identify a two-level accretion process, circumbinary disk to circumstellar disk to stars, constraining the conditions leading to the formation and evolution of binary star systems.

Most stars in the universe come in the form of pairs—binaries—or even multiple star systems. Now, the formation of such a binary star system has been observed for the first time with high-resolution ALMA (Atacama Large Millimetre/submillimeter Array) images. An international team of astronomers led by the Max Planck Institute for Extraterrestrial Physics targeted the system [BHB2007] 11, the youngest member of a small cluster of young stellar objects in the Barnard 59 core in the Pipe nebula molecular cloud. While previous observations showed an accretion envelope surrounding a circumbinary disk, the new observations now also reveal its inner structure.

"We see two compact sources, that we interpret as circumstellar disks around the two young stars," explains Felipe Alves from MPE, who led the study. "The size of each of these disks is similar to the asteroid belt in our Solar System, and their mutual distance is about 28 times the distance between the Earth and the Sun." Both protostars are surrounded by a circumbinary disk with a total mass of about 80 Jupiter masses, which shows a complex network of dust structures distributed in spiral shapes. The shape of the filaments suggest streamers of in-falling material, which is confirmed by the observation of molecular emission lines.



A zoom into the shared disk: this observation of ALMA shows that the proto-binary system [BHB2007] 11 is surrounded by dust filaments, where the southern (brighter) young star accretes more material. Credit: MPE



The Atacama Large Millimeter/submillimeter Array (ALMA) captured this unprecedented image of two circumstellar disks, in which baby stars are growing, feeding with material from their surrounding birth disk. The complex network of dust structures distributed in spiral shapes remind of the loops of a pretzel. These observations shed new light on the earliest phases of the lives of stars and help astronomers determine the conditions in which binary stars are born. Credit: ALMA (ESO/NAOJ/NRAO), Alves et al.

"This is a really important result," says Paola Caselli, director and MPE and head of the center of Astrochemical Studies. "We have finally imaged the complex structure of young binary stars, with their "feeding filaments" connecting them to the circumbinary disk. This provides important constraints for current models of star formation."

The astronomers interpret the filaments as inflow streamers from the extended circumbinary disk, where the circumstellar disk around the less massive of the two protostars receives more input, consistent with theoretical predictions. The estimated accretion rate is only about 0.01 Jupiter masses per year, which agrees with rates estimated for other protostellar systems. In a similar way as the circumbinary disk feeds the circumstellar disks, each circumstellar disk feeds the protostar in its center. At the disk-star level though, the accretion rate inferred from the observations is higher for the more massive object. The observation of emission from an extended radio jet for the northern object confirms this result, which is an independent indication that this protostar is indeed accreting more material.

"We expect this two-level accretion process to drive the dynamics of the binary system during its mass accretion phase," says Alves. "While the good agreement of these observations with theory is already very promising, we will need to study more young binary systems in detail to further constrain the conditions that lead to stellar multiplicity."

More information: F.O. Alves el al., Gas flow and accretion via spiral streamers and circumstellar disks in a young binary protostar, *Science* (2019). science.sciencemag.org/cgi/doi … 1126/science.aaw3491

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