The minimum mass of a proto-solar system disk

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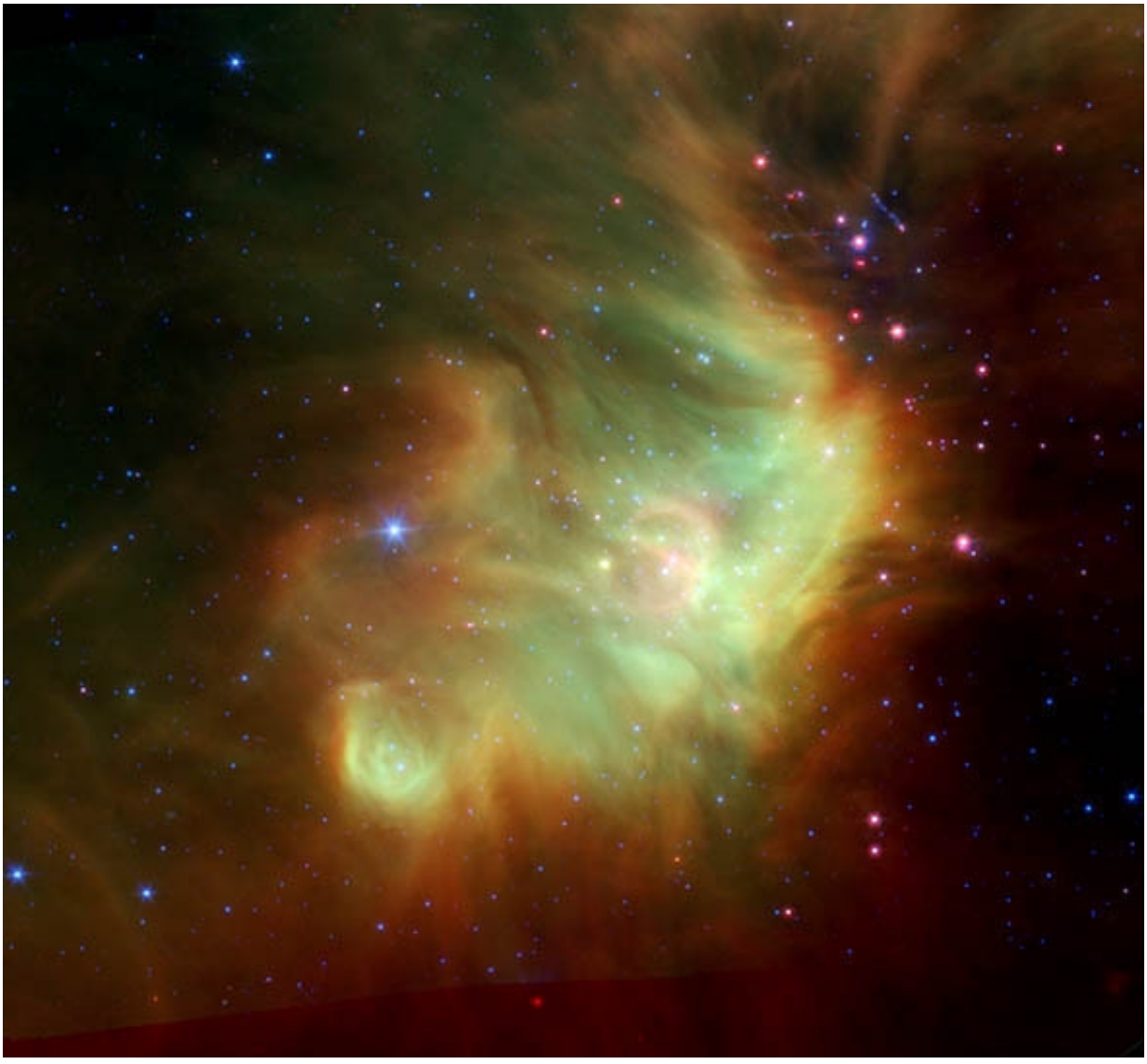

An image of the young star forming region IC348 in Perseus (about 2-3 million

years old) as seen by the infrared cameras onboard the Spitzer Space Telescope. Astronomers studying the birth of solar systems have found thirteen stars in this complex with detectable disks, none of which is as massive as the early Solar system's disk. Credit: NASA, ESA, J. Muzerolle (STScI), E. Furlan (NOAO and Caltech), K. Flaherty (Univ. of Arizona/Steward Observatory), Z. Balog (Max Planck Institute for Astronomy), and R. Gutermuth (Univ. of Massachusetts, Amherst)

Astronomers estimate that at the time the Solar system formed, its proto-planetary disk contained the equivalent of about twenty Jupiter-masses of gas and dust. This so-called "minimum mass solar nebula (MMSN)" is derived from the current masses of the rocky planets and calculations of how they formed; a minimum mass is used in case the planet formation mechanism is somehow less efficient than expected. (Some earlier estimates had MMSN values up to about 100 Jupiter-masses.) As a nebula ages and its planets develop, its disk mass naturally decreases; current models estimate that a planetary system can form in under five million years.

CfA astronomer Sean Andrews and his colleagues have been studying the early stages of planet-forming nebulae around other stars using the fact that such disks are cool and emit radiation primarily in the infrared and submillimeter regimes. The team used the submillimeter camera on the James Clerk Maxwell Telescope in Hawaii to map the emitting dust in a cluster of young stars known as IC348 located in the Perseus molecular cloud about a thousand light-years away from us. The cluster is estimated to be about two to three million years old, and its planetary systems should therefore be partially developed.

The scientists found thirteen submillimeter point sources in the cloud indicative of disks, in a total population of about three hundred and seventy known objects. From its emitted luminosity the scientists can

estimate the mass of a disk, and they find these disks range in size between 1.5 and 16 Jupiter-masses—smaller than a MMSN. Their results imply that disks as massive as the early solar system's are, at least by this age, very rare. Furthermore, expecting that the undetected sources all have smaller and fainter disks, the team combined the observations of all the sources to estimate what the average disk mass was: one-half a Jupiter-mass. The astronomers conclude that fewer than about 1% of stars have a MMSN disk. If most disks start off with the solar minimum mass value, therefore, they must have evolved very rapidly in order to have depleted most of the mass after a few millions years.

More information: L. Cieza et al. A SCUBA-2 850-μm survey of protoplanetary discs in the IC 348 cluster, *Monthly Notices of the Royal Astronomical Society* (2015). DOI: 10.1093/mnras/stv2044

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