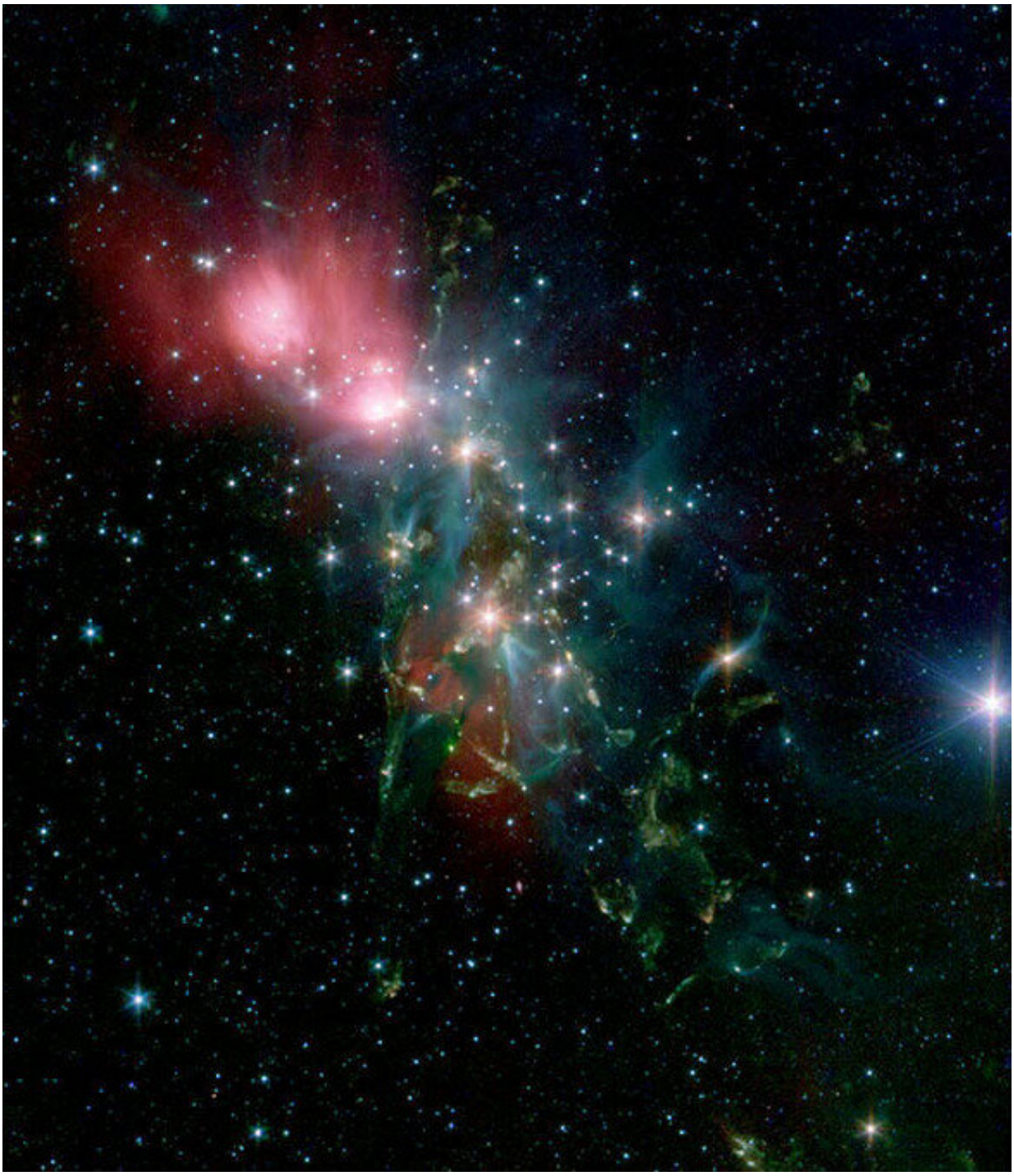
A submillimeter survey of protostars

February 17 2020



An infrared image of the young star forming complex NGC 1333 in Perseus. A new Submillimeter Array study of protostars in Perseus is the largest and most complete spectral imaging survey of protostars, including six extremely young objects known as first cores. Credit: IRAC/ NASA/JPL-Caltech/R. A. Gutermuth/Harvard-Smithsonian CfA

The formation of stars involves the complex interactions of many phenomena, including gravitational collapse, magnetic fields, turbulence, stellar feedback, and cloud rotation. The balance between these effects varies significantly between sources, and astronomers have adopted a statistical approach to understand the typical, early-stage star formation sequence. The earliest stage is called the protostellar stage. For low-mass stars (those with masses about that of the sun) this stage is usually separated into two subclasses as the star grows by accreting material from a massive envelope whose size can extend between five hundred and ten thousand astronomical units (AU) in a process that can last roughly half a million years. There are considerable uncertainties, however: some gas is ejected back into the medium in strong outflows, for example.

The lack of a large, systematic survey of such sources has made it hard for astronomers to sort out the multiple processes at play. CfA astronomers Ian Stephens, Tyler Bourke, Mike Dunham, Phil Myers, Sarah Sadavoy, Katherine Lee, Mark Gurwell, and Alyssa Goodman led a team using the Submillimeter Array to compile and publish the largest public, high resolution submillimeter spectral line survey of young protostars. The team observed 74 young objects in the Perseus molecular cloud located about 1000 light-years away. The program, called MASSES (Mass Assembly of Stellar Systems and their Evolution with the SMA), observed the protostars with both high and low spatial resolution, sampling scales from about three hundred AU to more than nine thousand AU in as many as forty molecular lines (although not every source had all lines).

This region had been studied before and was known to have many bipolar protostellar outflows, but the new high-resolution images reveal a wealth of outflow properties, mostly as seen in carbon monoxide gas.

The study examined six of these objects that are so young they are not yet hot enough to dissociate their primary constituent gas, molecular hydrogen. These protostars are known as "first cores" and the MASSES program detected outflows in four of them, identifying one as being the most promising example of its type because of its compact nature and slow outflow velocity. This new study, the largest and most complete public survey of its kind, offers astronomers a new database for studying low-mass star formation in its earliest stages.

More information: Ian W. Stephens et al. Mass Assembly of Stellar Systems and Their Evolution with the SMA (MASSES)—Full Data Release, *The Astrophysical Journal Supplement Series* (2019). DOI: 10.3847/1538-4365/ab5181

Provided by Harvard-Smithsonian Center for Astrophysics