Embryos of stars

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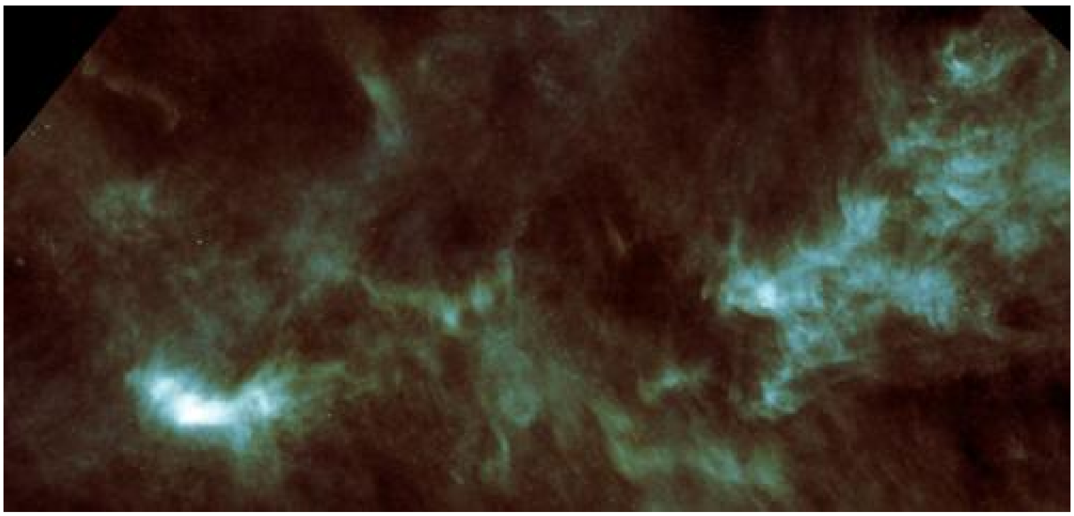

A far-infrared image of the cold pre-stellar cloud L1544 (the cloud is at the lower left, with other clouds of gas and dust nearby). The cloud is about 450 light-years from Earth in the nearest large region of star formation. New studies of the gas motions in the core show that the stellar embryo is slowly collapsing in a manner that agrees well with some models and excludes others. Credit: ESA/Herschel/SPIRE

Stars like the Sun begin their lives as cold, dense cores of dust and gas that gradually collapse under the influence of gravity until nuclear fusion is ignited. Exactly how the critical collapse process occurs in these embryos, however, is poorly understood, with several competing ideas having been advanced. Material might just freely fall to the center, although in more likely scenarios the infall is inhibited by pressure from warm gas, turbulent motions, magnetic fields, or even perhaps by some combination of them. It might be possible to distinguish between these alternative collapse hypotheses by examining how the core's density varies with radius, but it turns out that (at least for spherical clouds) the predicted density distributions all look about the same. The predicted distributions of velocity for the infalling gas, however, are quite different.

The dust in these cores makes them completely opaque in the optical, and so studying their behaviors requires techniques at other wavelengths. One of the most exciting developments in astronomy over the past decade has been the development of far-infrared and millimeter wavelength tools for the tasks of identifying pre-stellar cores as such, and determining their properties. CfA astronomer Eric Keto and two colleagues used observations of emission lines from water and carbon monoxide at both wavelength regimes to measure the velocity distribution of the gas in a pre-stellar, dense core. Each of these gas molecules traces a sightly different density of gas (the typical value in these clouds is about one hundred thousand particles per cubic centimeter).

The data clearly prefer the scenario in which the gas temperature is nearly constant throughout the cloud with just enough total mass present for gravity to drive slow contraction. Actually, the paper's authors were the first to advocate and describe just such a possibility, and these observations of this particular core bring a satisfying confirmation that no magnetic fields or turbulence is present or needed. The new results highlight the dramatic modern successes in unraveling the earliest stages of stellar birth, and the power of new technology. More cores now need to be measured in order to determine if these particular conclusions have general validity.

More information: "The dynamics of collapsing cores and star formation." arXiv:1410.5889 [astro-ph.SR] arxiv.org/abs/1410.5889

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