New results from space telescope's explorations of stellar birthplaces

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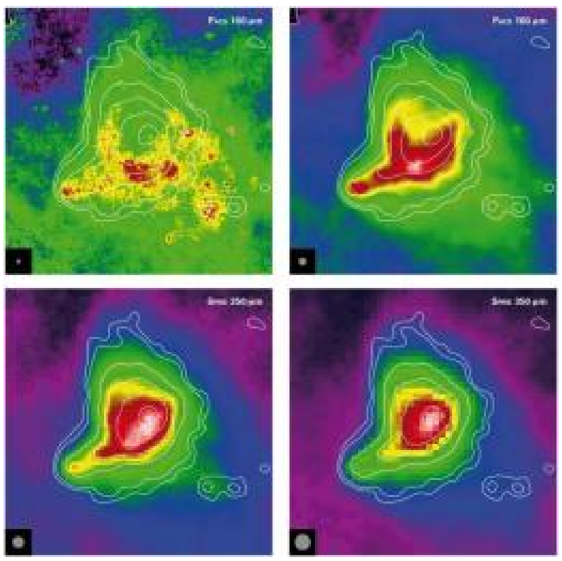

False-colour image of the dark cloud Barnard 68, prepared using data from the Herschel Space Telescope at different far-infrared wavelengths. The way in which the cloud appears to change shape depending on wavelength is a sign of uneven external illumination. In the bottom left corner, there are traces of an isolated object. This could be a cloud fragment in collision with Barnard 68. The wavelengths for the images are 100, 160, 250 and 350 micrometers, respectively. The image colors show the intensity of the radiation received at that wavelength, from purple and blue at low intensity to high intensities in red and white. Image credit: MPIA / Markus Nielbock

(Phys.org)—An astronomical project led by researchers from the Max Planck Institute for Astronomy (MPIA) has examined the earliest stages of star formation in unprecedented depth: Using the European Space Agency's Herschel Space Telescope and techniques more commonly encountered in Hollywood blockbuster computer graphics than in astronomy, the researchers produced a three-dimensional map of the molecular cloud B68, a possible future birthplace for a low-mass star. Turning their attention to much more massive molecular clouds, the researchers also managed to identify a previously unobserved class of object that is likely the earliest known precursor of the birth of massive stars.

Stars are born in hiding, when dense regions within clouds of gas and dust collapse under their own gravity. But the clouds not only provide the raw material for star formation, they also absorb most of the light from their interior, hiding from view the crucial details of stellar birth – one of the key astronomical processes if we want to understand our own origins!

Now, two groups in the EPoS ("Earliest Phases of Star formation") project led by MPIA's Oliver Krause, using ESA's Herschel Space Telescope, report new results in understanding the earliest stages of star formation.

On the trail of the origin of low-mass stars (with less than about twice the mass of our Sun), a team led by Markus Nielbock (MPIA) has completed a detailed investigation of one of the best-known potential stellar birthplaces: the dark cloud (or "globule") Barnard 68 in the constellation Ophiuchus. Combining the Herschel Space Telescope's unrivaled sharpness and sensitivity in the far-infrared range with a method more often encountered in visual effects companies working on Hollywood blockbusters than in astronomy, the researchers were able to construct the most realistic 3D model of the cloud to date.

The method, adapted for this particular use by MPIA's Ralf Launhardt, uses what is known as raytracing: For each minute portion of the object that we can see, the line of sight is traced back into the object itself. The contribution by each portion of the light's path – is light being absorbed at this particular point? is it being emitted? if yes, at which wavelengths? – are added up. Raytracing is routinely used to produce realistic-looking computer-generated creatures, objects or whole scenes. Here, it helped to match light emitted within Barnard 68 at different wavelengths with simplified models of the cloud's three-dimensional shape, density and temperature distribution.

The results have shaken up some of what astronomers thought they knew about this cloud. The emerging picture is one of Barnard 68 condensing from a drawn-out filament, heated by unevenly distributed external radiation from the direction of the central plane of our home galaxy. The astronomers also found some signs pointing to a cloud fragment in collision with Barnard 68, which might lead to the cloud's collapse, and the formation of one or more low-mass stars, within the next hundreds of thousands of years, and whose existence had been predicted by a previous study (Burkert & Alves 2009).

As cosmic clouds go, Barnard 68 is rather small. Clouds of this size will give birth to a few low-mass stars at most. To find out how massive stars are born (mass greater than about twice the mass of the Sun), a team led by MPIA's Sarah Ragan turned Herschel's PACS camera to 45 significantly more massive dark clouds. The clouds contain numerous stars about to be born, so-called "protostars". While previous missions, such as NASA's Spitzer Space Telescope, have also searched for protostars, Herschel enables astronomers to probe deeper into the clouds than ever before. Younger protostars are hidden much more effectively within their clouds than older ones. Herschel managed to find the youngest and most primitive protostars known.

The new observations swelled the ranks of known protostars from 330 to nearly 500 and, most excitingly, led to the discovery of a new type of not-quite-a-star: dense regions at a mere 15 degrees above absolute zero (-258 degrees Celsius) with no sign of a protostar. These regions are likely to be in an early precursor stage of star formation. In astronomy, where timescales of hundreds of millions or of billions of years are the norm, the fact that this precursor stage is expected to last less than 1000 years makes it extremely short-lived. Studying these elusive, pristine objects lays a necessary foundation for all subsequent studies of star formation.

The results presented here have been published in *Astronomy & Astrophysics* as Nielbock et al., "The Earliest Phases of Star formation (EPoS) observed with Herschel: the dust temperature and density distributions of B68" and as Ragan et al., "The Earliest Phases of Star Formation (EPoS): A Herschel Key Program – The precursors to high-mass stars and clusters".

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