Researchers use new method to calculate interstellar cloud core age

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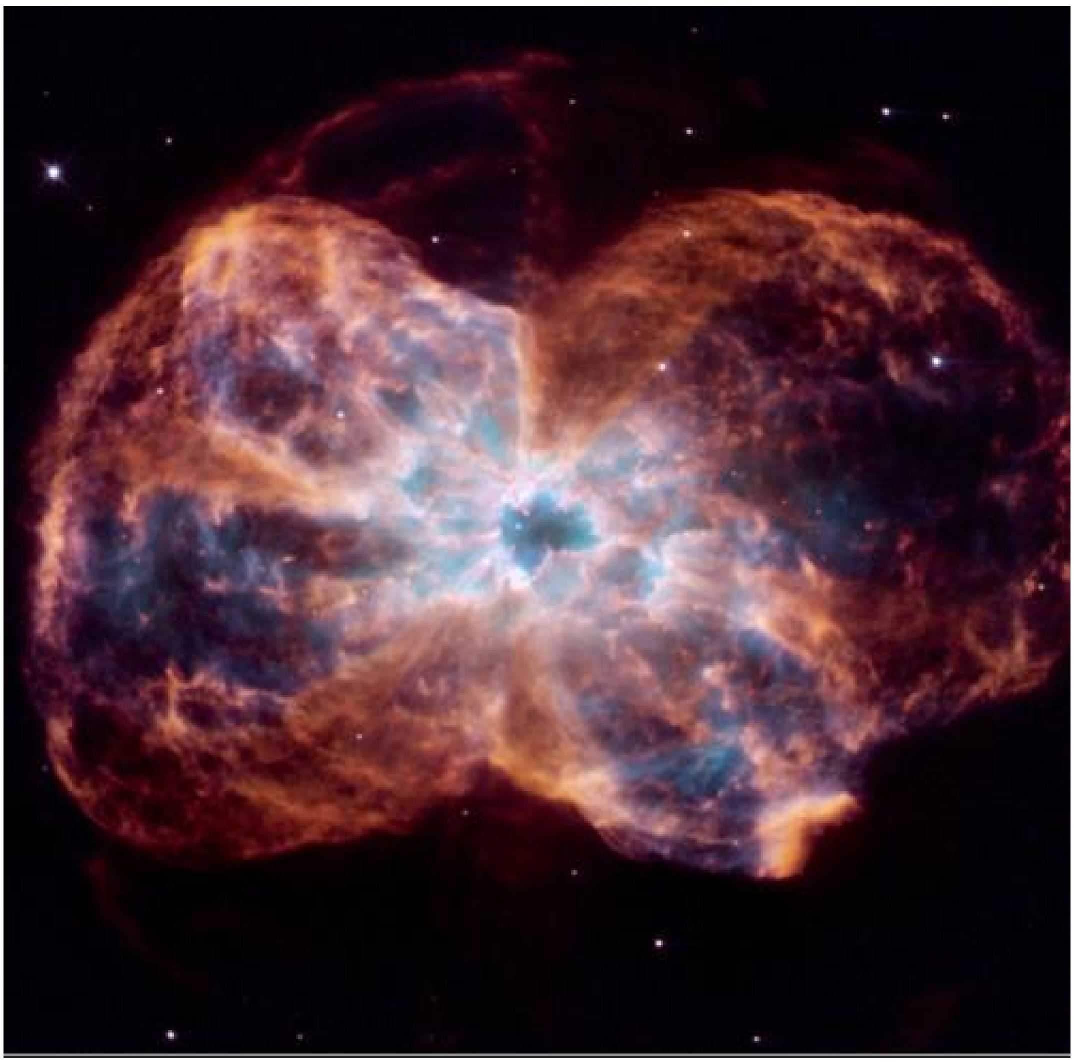

This image, taken by NASA's Hubble Space Telescope, shows the colorful "last hurrah" of a star like our Sun. The star is ending its life by casting off its outer layers of gas, which formed a cocoon around the star's remaining core. Credit: NASA/ESA

(Phys.org) —A team of space researchers with members from Germany, Finland and the U.K. has calculated the age of an interstellar cloud core using a new chemical analysis method. In their paper published in the journal *Nature*, the team describes their new technique and explains how measuring chemical changes as cloud contraction occurs can lead to revealing the core's age.

Scientists believe that stars, like our own sun, form in clouds made up of gases and dust—a nursery of sorts that sets the stage for both birth and development. Stars form inside them as material initially coalesces and then when compaction occurs, giving birth first to a proto-star. But determining how this process actually works and how long it takes has been elusive—it's believed the process is driven by gravity, but exactly how remains a mystery.

Determining interstellar cloud core age has been notoriously difficult, the researchers point out and because of that, estimates of their ages has ranged from tens of thousands of years, to millions of years. In this new effort the researchers used data obtained from the aircraft observatory SOFIA and the APEX telescope in Chile, to gather chemical composition data of the core at the center of a star system known as IRAS 16293-2422 in the constellation Ophiuchus, approximately 400 light years from us.

Specifically, they looked at two types of molecular ions that are made from two hydrogen atoms and one heavy hydrogen (deuterium) atom (ortho- and para-H_2D^+). The relative amounts of the two change over time, the team notes, as the cloud ages, offering researchers a type of "chemical clock." Using this method, the team calculated that the stars in the system are not older than 100,000 years, but the core itself is approximately a million years old, which means the core apparently sat brewing for approximately 900,000 years before giving birth to the stars.

Figuring out how old cloud cores are is important in cosmological study, because if offers a way of dating our own system and the stars that make up the Milky Way Galaxy. The research team claims that their new method of dating cloud cores is the most accurate every used.

More information: H2D+ observations give an age of at least one million years for a cloud core forming Sun-like stars, *Nature* (2014) DOI: 10.1038/nature13924

Abstract
The age of dense interstellar cloud cores, where stars and planets form, is a crucial parameter in star formation and difficult to measure. Some models predict rapid collapse, whereas others predict timescales of more than one million years. One possible approach to determining the age is through chemical changes as cloud contraction occurs, in particular through indirect measurements of the ratio of the two spin isomers (ortho/para) of molecular hydrogen, H2, which decreases monotonically with age. This has been done for the dense cloud core L183, for which the deuterium fractionation of diazenylium (N2H+) was used as a chemical clock to infer7 that the core has contracted rapidly (on a timescale of less than 700,000 years). Among astronomically observable molecules, the spin isomers of the deuterated trihydrogen cation, ortho-H2D+ and para-H2D+, have the most direct chemical connections to H2 and their abundance ratio provides a chemical clock that is sensitive to greater cloud core ages. So far this ratio has not been determined because para-H2D+ is very difficult to observe. The detection of its rotational ground-state line has only now become possible thanks to accurate measurements of its transition frequency in the laboratory, and recent progress in instrumentation technolog. Here we report observations of ortho- and para-H2D+ emission and absorption, respectively, from the dense cloud core hosting IRAS 16293-2422 A/B,

a group of nascent solar-type stars (with ages of less than 100,000 years). Using the ortho/para ratio in conjunction with chemical models, we find that the dense core has been chemically processed for at least one million years. The apparent discrepancy with the earlier N2H+ work arises because that chemical clock turns off sooner than the H2D+ clock, but both results imply that star-forming dense cores have ages of about one million years, rather than 100,000 years.