Surprising theorists, stars within middle-aged clusters are of similar age

December 17 2014

NGC 1615, a middle-age star cluster located in the Large Magellanic Cloud, contains stars that are of a more uniform age than previously believed. Credit: NASA/ESA Hubble Space Telescope/Fabian RRRR

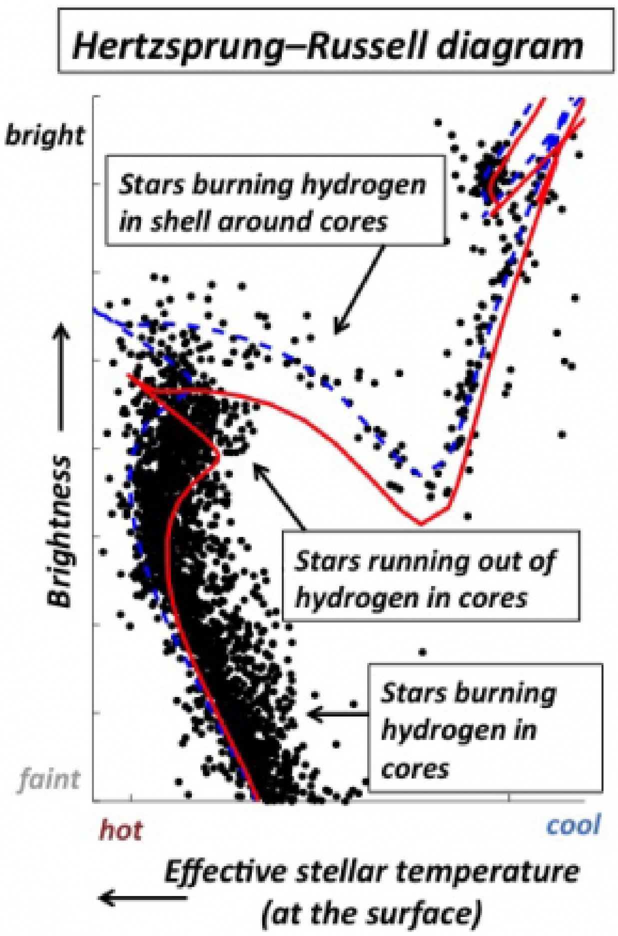
A close look at the night sky reveals that stars don't like to be alone; instead, they congregate in clusters, in some cases containing as many as several million stars. Until recently, the oldest of these populous star clusters were considered well understood, with the stars in a single group having formed at different times, over periods of more than 300 million years. Yet new research published online today in the journal *Nature* suggests that the star formation in these clusters is more complex.

Using data from the Hubble Space Telescope, a team of researchers at the Kavli Institute for Astronomy and Astrophysics (KIAA) at Peking University and the Chinese Academy of Science's National Astronomical Observatories in Beijing have found that, in large middle-aged clusters at least, all stars appear to be of about the same age.

Stars begin their lives as billowing clouds of dust and gas. Pulled together by gravity, these clouds slowly coalesce into dense spheres that, if they grow large enough, heat up and begin to convert hydrogen into helium in their cores. This process releases energy and makes them shine. Billions of years later, when they reach the end of their core hydrogen supply, the stars begin to burn hydrogen in a shell around their cores and, as a result, their temperature changes.

Previous observations of massive star clusters revealed a relatively large amount of variation in temperature from stars reaching the end of their core hydrogen supply, suggesting that the stars within the clusters varied in age by as much as 300 million years or more.

"This has long been surprising," said Chengyuan Li, a doctoral student at Peking University and the lead author of the new study. "Young clusters are thought to quickly lose any remaining star-forming gas during the first 10 million years of their lifetimes," which would make it difficult for the stars in a single cluster to vary in age by more than about 10 million years.



Observational data (black points) reveal that models characterized by an age spread of about 450 million years (young model shown in blue, old model in red) can fully describe the NGC 1651 cluster stars powered by hydrogen fusion in their cores, but not the phase in which they burn hydrogen in a shell around the cores. Credit: Chengyuan Li and Richard de Grijs, KIAA

Observing a middle-aged, 2 billion-year-old star cluster located in the Large Magellanic Cloud called NGC 1651, the researchers looked for both the change in temperature that occurs when stars reach the end of their hydrogen supply - which is what previous studies had focused on - and a second change in temperature that occurs as the stars burn hydrogen in a shell around their core.

While they found the expected wide variation in temperature of stars finishing their core hydrogen reserves, the astronomers were surprised to find very little variation when looking at the brightnesses of stars of similar temperatures burning hydrogen in the shell outside the core. The lack of variation among these stars led the researchers to conclude that the stars in this cluster must all be within just 80 million years of the same age - a very small age range for such an old cluster.

"NGC 1651 is the best example found to date of a truly single-age stellar population," said Richard de Grijs, a faculty member at KIAA involved in the study. "We have since identified a handful of other middle-aged clusters that appear to show similar features."

The research suggests that, for middle-aged clusters at least, today's conventional wisdom may be wrong and it might be common for all stars in a single cluster to be of approximately the same age.

A decade ago, astronomers actually thought that the stars within any cluster should all be about the same age, but that idea fell out of favor when clear evidence of the presence of stars of different ages within a single cluster was discovered, at least for the oldest and most populous clusters in our Milky Way. Based on today's *Nature* paper, a reverse shift looks necessary.

In addition to that important realization, the paper's authors suggest that the wide range of brightness seen in stars reaching the end of their core hydrogen supply may actually be due to stellar rotation. That's because two stars of exactly the same age can exhibit different levels of observed temperature if they rotate at significantly different rates.

Most current models don't take stellar rotation into account, de Grijs said. Future studies may offer even greater insight into the age of star clusters by better modeling stellar rotation rates and using those models to interpreting the variation in temperature of stars burning the last of their core hydrogen, he said.

Licai Deng, principal scientist at the National Astronomical Observatories, said, "these latest results resolve nearly a decade of debate among scientists; as such, the results were deemed 'solid and welcome' by the peer-reviewers."

More information: www.nature.com/nature/journal/ … ull/nature13969.html

Provided by The Kavli Foundation