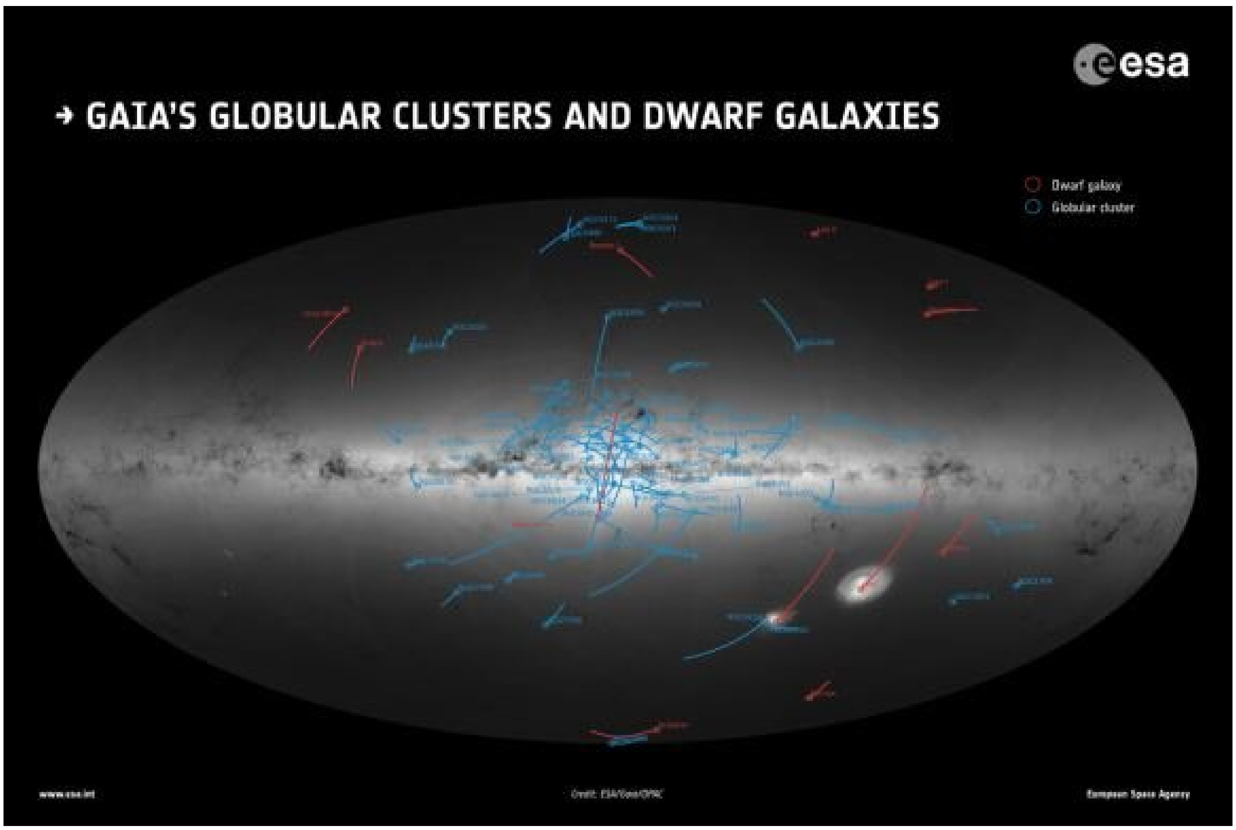
According to globular clusters, the universe is 13.35 billion years old

July 28 2020, by Matt Williams



Globular clusters in the Milky Way, based on data from the ESA's Gaia Observatory. Credit: ESA/Gaia/DPAC

It is a widely accepted theory today that when the first stars formed in our universe approximately 13 billion years ago, they quickly came together to form globular clusters. These clusters then coalesced to others to form the first galaxies, which have been growing through mergers and evolving ever since. For this reason, astronomers have long suspected that the oldest stars in the universe are to be found in globular clusters.

The study of stars in these clusters is therefore a means of determining the age of the universe, which is still subject to some guesswork. In this vein, an international team of astronomers and cosmologists recently conducted a study of globular clusters in order to infer the age of the universe. Their results indicate that the universe is about 13.35 billion years old, a result that could help astronomers learn more about the expansion of the cosmos.

Their study, titled "Inferring the Age of the Universe with Globular Clusters," recently appeared online and was submitted for consideration to the *Journal of Cosmology and Astroparticle Physics*. The study was led by David Valcin, a predoctoral researcher from the Institute of Cosmos Sciences at the University of Barcelona (ICCUB), who was joined by a team from France, Spain, and the US.

As noted, globular clusters are of particular interest to astronomers given their unusual nature. These spherical collections of stars are found in a galaxy's halo orbiting beyond the galactic core and are considerably denser than open clusters (which are found in the galaxy's disk). Most globular clusters are also uniform in age, containing older stars that have entered into their red-giant branch (RGB) phase.

In fact, studies of globular clusters in the Milky Way have shown that some of the oldest stars in our galaxy exist within them. While the origins of globular clusters and their role in galactic evolution are still something of a mystery, astronomers believe that the study of these collections of old stars will yield valuable information about both. As

Valcin and his colleagues shared with Universe Today via email:

Globular clusters M80 (left) and NGC 1866 (right) showing both older red stars and blue, young stars. Credit: NASA/HHT/STScI/AURA/ESA/Hubble & NASA

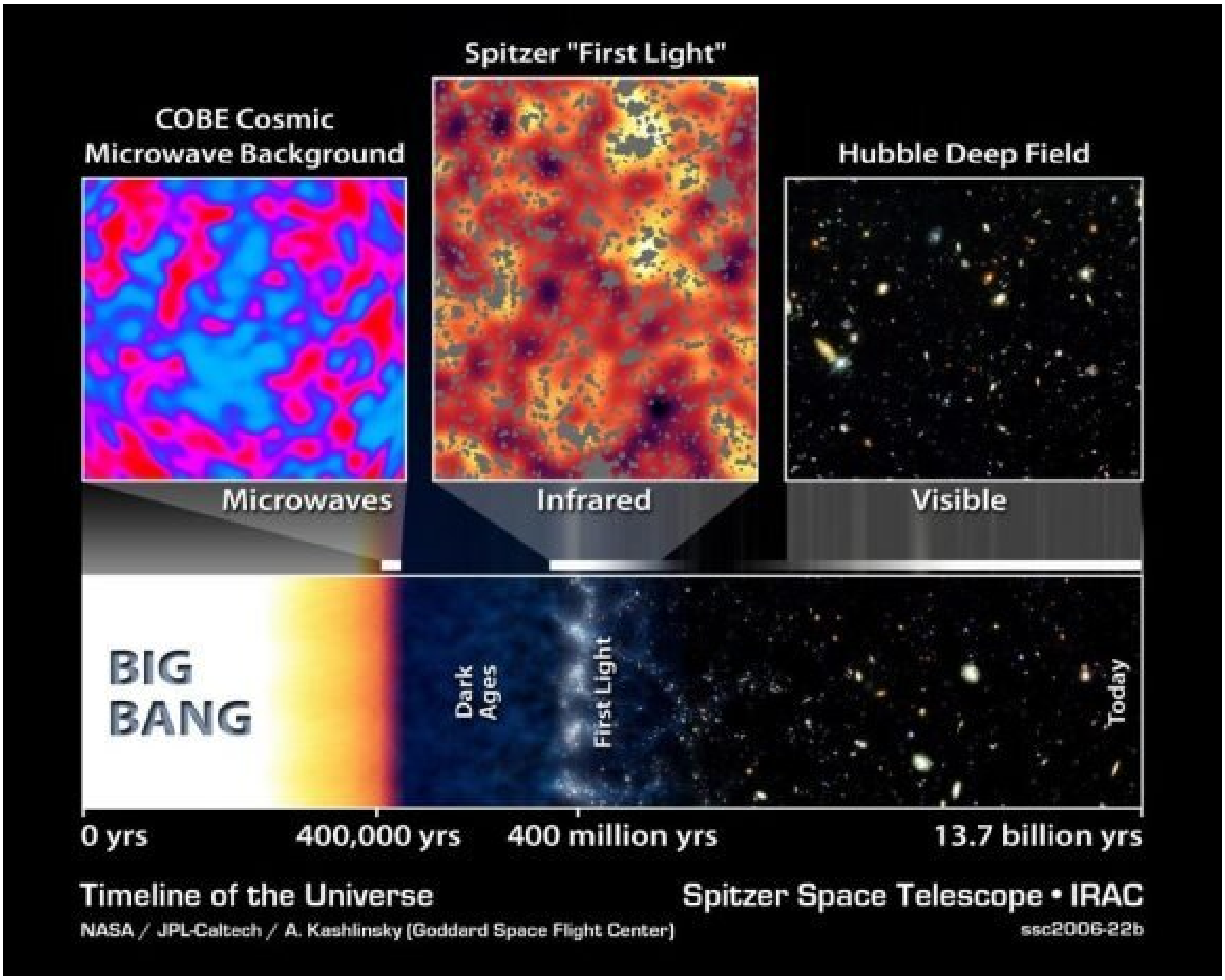
"Globular clusters are among the first stellar structures formed in the universe and so can be used as a good estimator of the epoch of galaxy and star formation to infer the age of the universe. From an astrophysical point of view, they provide a wealth of information about the formation and evolution of galaxies and stars."

For the sake of their study, the team examined 68 galactic globular clusters, which were observed by the Hubble Space Telescope's Advanced Camera for Surveys (ACS). Specifically, they studied the distribution of stars in these clusters based on their magnitude, which was obtained by using a modified version of isochrones to model the data.

This software package takes synthetic photometry provided by stellar models and then interpolates their magnitude based on where stars of the same mass are found on the evolutionary track at the same age. Valdin explained:

"Using the catalog from Sarajedini et al (2007) survey of globular clusters with the Hubble Space Telescope, we extracted information from the Color Magnitude Diagram Of Globular Clusters using theoretical isochrones (isochrones are a set of stellar models computed at the same age for a range of different masses). Indeed, the way stars are distributed in the diagram according to their magnitude and color can constrain the parameter sensitivity of stellar isochrones, which correspond to a population of stars with the same age."

Similarly, the team relied on the Mesa Isochrones and Stellar Tracks (MIST) stellar model, as well as the Dartmouth Stellar Evolution Database (DSED). In the end, they obtained an average age estimate of the oldest global clusters to be 13.13 billion years. After taking into account the amount of time it would take for these globular clusters to form, they were able to infer an age estimate of 13.35 billion years.



The Big Bang timeline of the universe. Cosmic neutrinos affect the CMB at the time it was emitted, and physics takes care of the rest of their evolution until today. Credit: NASA / JPL-Caltech / A. Kashlinsky (GSFC)

This result has a 68% confidence level and includes a range of uncertainty of ±0.16 billion years (statistical) and ±0.5 billion years (systemic). This value is compatible with the previous age estimate of 13.8 ± 0.02 billion years, which was inferred by data obtained by the Planck mission on the cosmic microwave background (CMB) – the remnant background radiation created by the Big Bang that is visible in all directions.

What's more, the previous estimate is dependent on the CDM cosmological model, a version of the Big Bang model that contains three major components: dark energy, "cold" dark matter (CDM) and ordinary matter. This essentially means that globular clusters can accurately constrain the age of the universe in a way that's not dependent on theoretical models.

What's more, since their age estimates are consistent with estimates that are based on cosmic expansion, this information could also provide clues to the latter. Of course, Valdin and his colleagues acknowledge that more observations and data are necessary if scientists hope to figure out why there has historically been such a discrepancy between age estimates in the first place:

"In the ongoing uncertainty about the expansion of the universe, it is important to collect more data on which interpretation is as cosmology-independent as possible to understand the origin of the discrepancy. Even though globular clusters don't provide direct measurement of the expansion, they allow us to constrain the age of the universe, which can be related to the expansion. The age of the universe is determined by CMB observations, too, but this determination is very model-dependent. A valuable aspect of the expansion estimate is the fact that it's obtained without assuming any cosmological model. The agreement between these two measurements can be used to confirm important aspects of the cosmological model."

More information: Valcin et al., Inferring the Age of the Universe with Globular Clusters. arXiv:2007.06594v1 [astro-ph.CO]. arxiv.org/pdf/2007.06594.pdf

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