Mapping the family tree of stars

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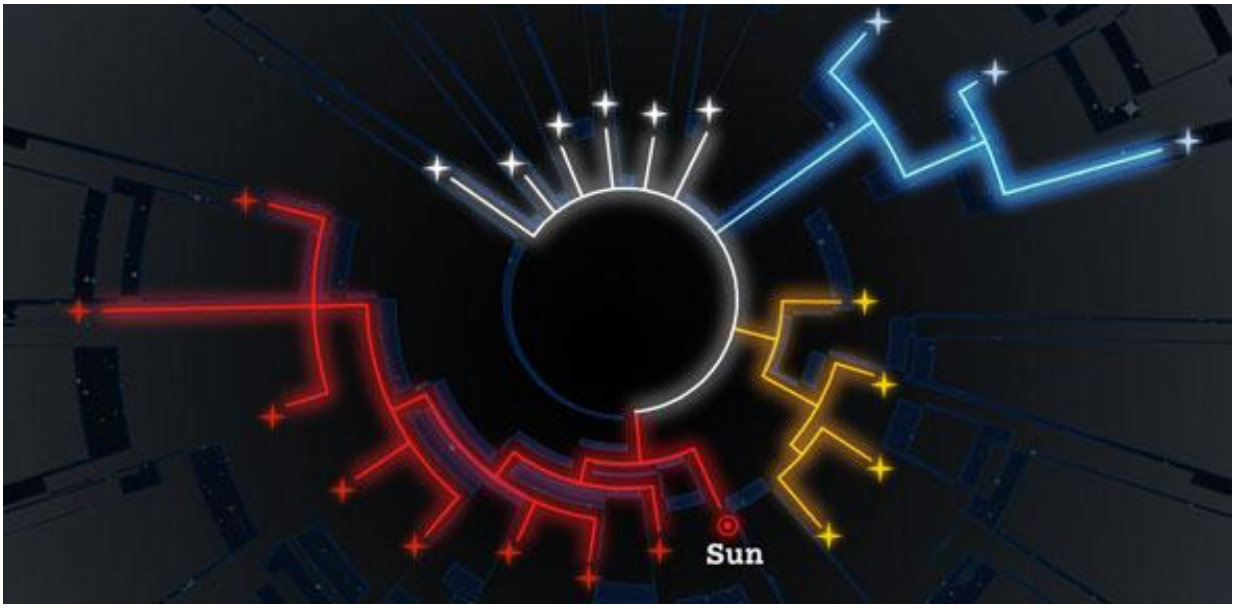

Image showing family trees of stars in our galaxy, including the Sun. Credit: Institute of Astronomy

Astronomers are borrowing principles applied in biology and archaeology to build a family tree of the stars in the galaxy. By studying chemical signatures found in the stars, they are piecing together these evolutionary trees looking at how the stars formed and how they are connected to each other. The signatures act as a proxy for DNA sequences. It's akin to chemical tagging of stars and forms the basis of a discipline astronomers refer to as Galactic archaeology.

It was Charles Darwin, who, in 1859 published his revolutionary theory that all life forms are descended from one common ancestor. This theory has informed evolutionary biology ever since but it was a chance encounter between an astronomer and an biologist over dinner at King's College in Cambridge that got the astronomer thinking about how it could be applied to stars in the Milky Way.

Writing in Monthly Notices of the Royal Astronomical Society, Dr Paula Jofré, of the University of Cambridge's Institute of Astronomy, describes how she set about creating a phylogenetic "tree of life" that connects a number of stars in the galaxy.

"The use of algorithms to identify families of stars is a science that is constantly under development. Phylogenetic trees add an extra dimension to our endeavours which is why this approach is so special. The branches of the tree serve to inform us about the stars' shared history" she says.

The team picked twenty-two stars, including the Sun, to study. The chemical elements have been carefully measured from data coming from ground-based high-resolution spectra taken with large telescopes located in the north of Chile. Once the families were identified using the chemical DNA, their evolution was studied with the help of their ages and kinematical properties obtained from the space mission Hipparcos, the precursor of Gaia, the spacecraft orbiting Earth that was launched by the European Space Agency and is almost halfway through a 5-year project to map the sky.

Stars are born from violent explosions in the gas clouds of the galaxy. Two stars with the same chemical compositions are likely to have been born in the same molecular cloud. Some live longer than the age of the solar system and serve as fossil records of the composition of the gas at the time they were formed. The oldest star in the sample analysed by the

team is estimated to be almost ten billion years old, which is twice as old as the Sun. The youngest is 700 million years old.

In evolution, organisms are linked together by a pattern of descent with modification as they evolve. Stars are very different from living organisms, but they still have a history of shared descent as they are formed from gas clouds, and carry that history in their chemical structure. By applying the same phylogenetic methods that biologists use to trace descent in plants and animals it is possible to explore the 'evolution' of stars in the Galaxy.

"The differences between stars and animals is immense, but they share the property of changing over time, and so both can be analysed by building trees of their history", says Professor Robert Foley, of the Leverhulme Centre for Human Evolutionary Studies at Cambridge.

With an increasing number of datasets being made available from both Gaia and more advanced telescopes on the ground, and on-going and future large spectroscopic surveys, astronomers are moving closer to being able to assemble one tree that would connect all the stars in the Milky Way.

Paula Jofré et al. 'Cosmic phylogeny: reconstructing the chemical history of the solar neighbourhood with an evolutionary tree' is published by *Monthly Notices of the Royal Astronomical Society*.

More information: Paula Jofré et al. Cosmic phylogeny: reconstructing the chemical history of the solar neighbourhood with an evolutionary tree, *Monthly Notices of the Royal Astronomical Society* (2017). DOI: 10.1093/mnras/stx075

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