Alpha-rich 'young' stars are actually not young

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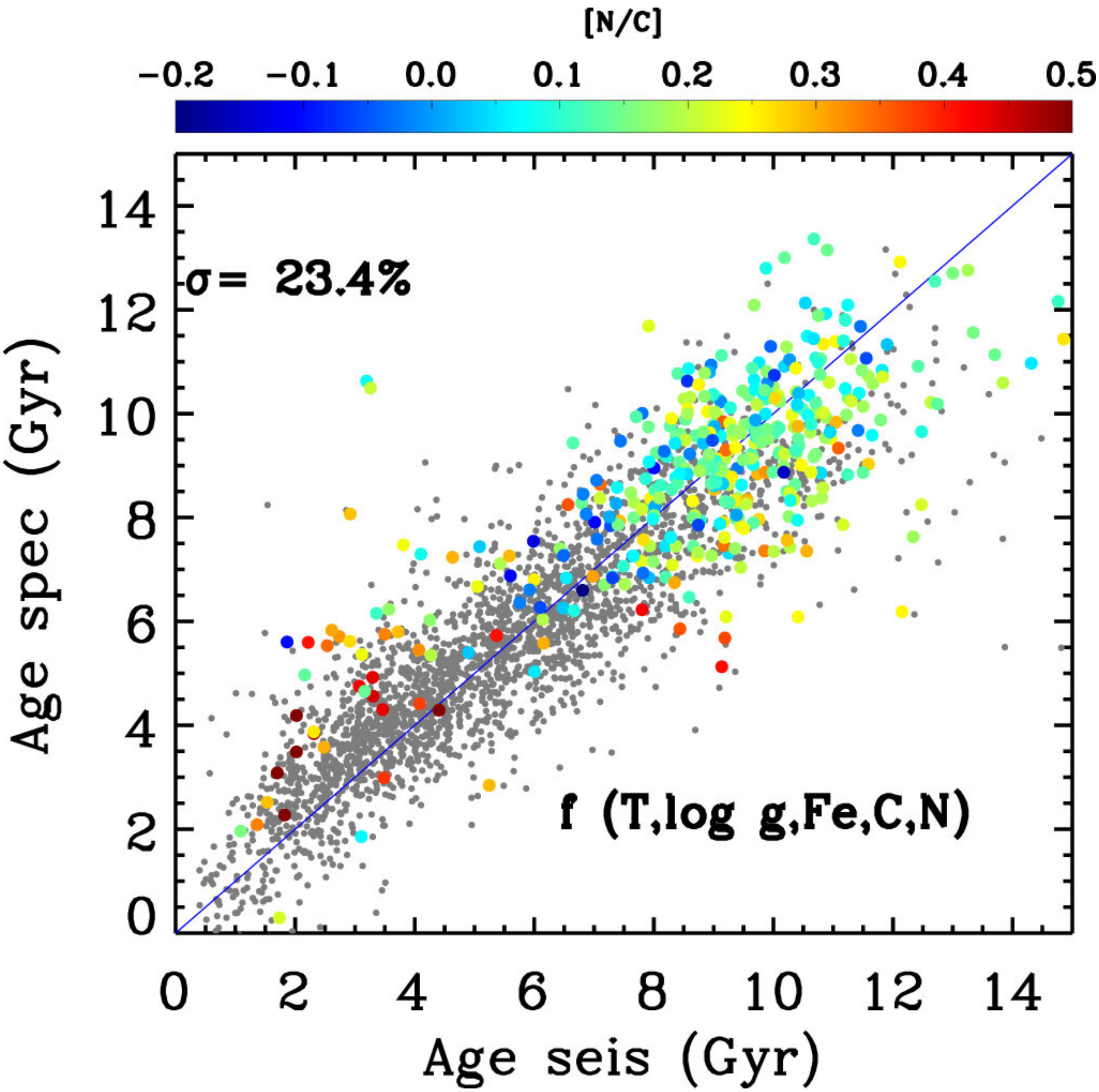

Figure 1. One-to-one comparison between asteroseismic ages and ages derived with the quadratic fitting method based on the spectroscopically determined stellar atmospheric parameters, including T_{eff}, log g, [Fe/H], as well as [N/Fe] and [C/Fe]. The [N/C] ratios of the high-α stars ([α/Fe] > 0.18 dex) are shown with color-coded dots. The "spectroscopic" ages of the high-α "young" stars with their different [N/C] ratios are also in good agreement with their asteroseismic ages. Credit: DOI: 10.3847/1538-4357/ac22a5

The alpha-rich giant stars with theoretical young ages have been treated as an abnormal population, since they cannot be understood in the canonical scheme of the Galactic chemical evolution.

A new study led by Ph.D. student Zhang Meng and Prof. Zhang Huawei from Peking University as well as Dr. Xiang Maosheng from Max-Planck Institute for Astronomy has uncovered the nature of these stellar anomalies.

The results were published in *The Astrophysical Journal.*

Recent observations have revealed a population of alpha-element enhanced giant stars with unexpected high masses. Assuming single-star evolution, their masses imply young ages. However, in the context of the Galactic chemical evolution, stars formed at early epochs are enhanced in alpha-elements. So alpha-rich stars are generally believed to be old.

Several scenarios have been proposed to explain the origins of these alpha-rich "young" stars. Some try to use special Galactic chemo-dynamic events, for instance, star formation events near the edge of the Galactic bar; and some attribute to binary evolution.

In this work, taking advantage of the large sample of stars from LAMOST spectroscopic surveys, the researchers found more than 1000 alpha-rich "young" stars. Combining with the astrometric data provided by the Gaia satellite, they studied the chemistry and kinematics of these stars.

They found that these stars share the same kinematics as the canonical alpha-rich old stars, however, their chemical properties are different from the old stars. The alpha-rich "young" stars have typically more carbon and nitrogen, and the content of barium is significantly high in about 15% of these stars, compared to most of those old stars. It could not be explained by their single-star evolution, so external sources of these extra elements are needed.

Considering the element barium is mostly produced by asymptotic giant branch (AGB) stars who have evolved to the late stage of their life, AGB stars naturally become the candidate donors. This can be achieved if they are in a binary system, namely an alpha-rich "young" star can "eat" the materials with rich carbon and barium from its AGB companion.

"When the single stellar evolution is considered, these stars look young, because they are massive. However, our results support the previous suggestion that these stellar anomalies are products of binary evolution. Their high mass is the result of accreting materials from their companions in the binary systems," said Zhang Meng, the first author of the study. "Our study confirms that most, if not all, alpha-rich stars in the Galactic disk seem to be old."

It is the first time to study the chemistry and kinematics of the alpha-rich massive stars using such a large sample.

The Large Sky Area Multi-Object Fabre Spectroscopic Telescope (LAMOST) at the Xinglong Station in China is operated by the National Astronomical Observatories of Chinese Academy of Sciences (NAOC).

More information: Meng Zhang et al, Most "Young" α-rich Stars Have High Masses but are Actually Old, *The Astrophysical Journal* (2021). DOI: 10.3847/1538-4357/ac22a5

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