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CNO as key elements in stellar and galactic evolution

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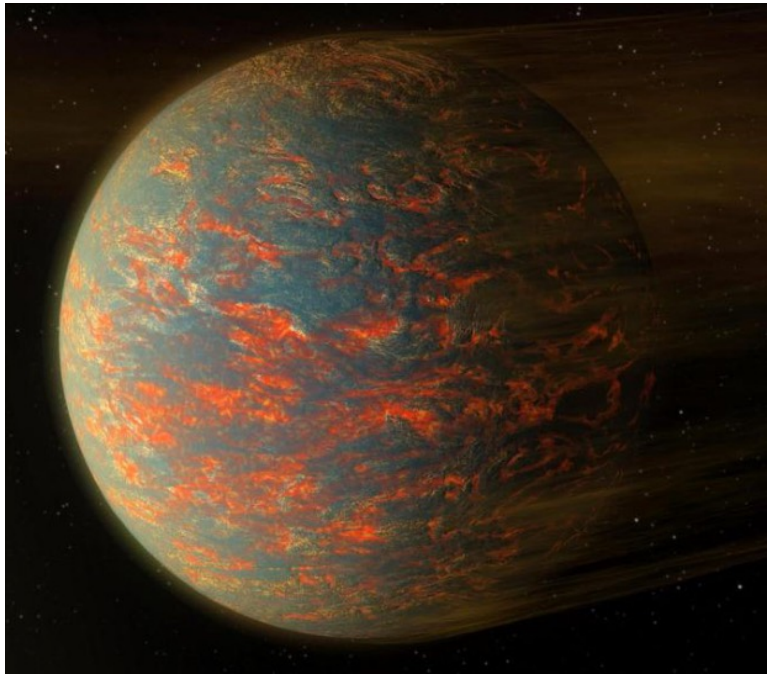
Carbon, nitrogen, and oxygen:

- comprise in stars most of the mass of elements heavier than helium
- are among the first elements to form in the nucleosynthesis chain
- play important roles in stellar interiors as sources of opacity and energy production through the CNO cycle, and thus affect the star's lifetime, its position in the Hertzsprung-Russell diagram, and its heavy-element yields
- provide information on mixing processes in stars
- C/N ratios start serving as stellar age indicators
- C/O ratios in planet hosting stars control an amount of carbides and silicates that can be formed in exoplanets



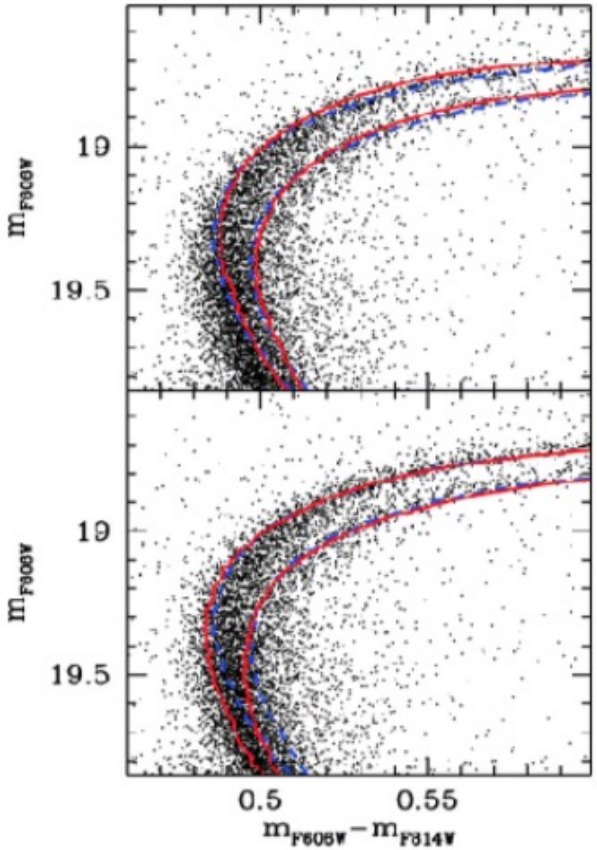
An artist rendering of 55 Cancri e, an exoplanet rich in carbon (NASA/JPL-CalTech)

NGC 1851 has two subgiant branches

It is not surprising that old globular clusters have two generations of stars, the first being primordial, while the second one being born from the ejecta of a fraction of the stars of the first population.

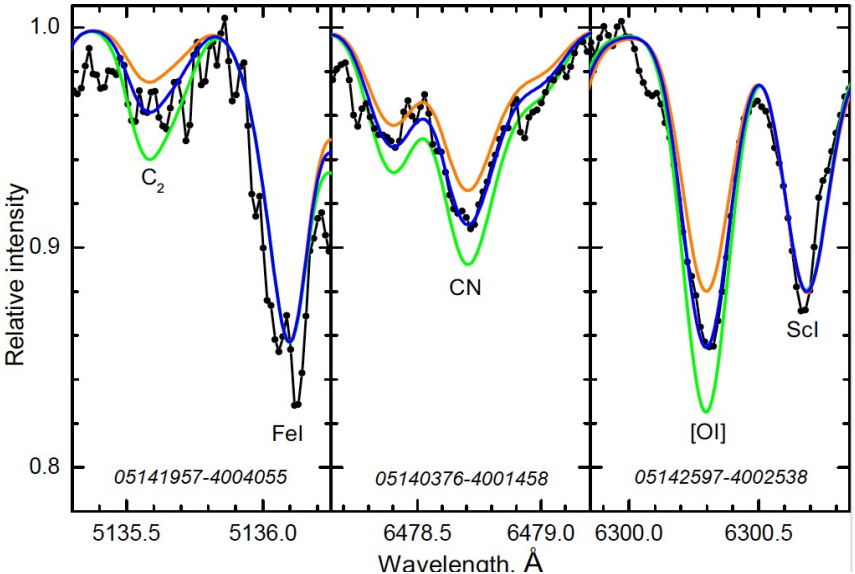
However, NGC 1851 has two branches with slightly different metallicity (Carretta et al. 2010, 2011; Gratton et al. 2012)

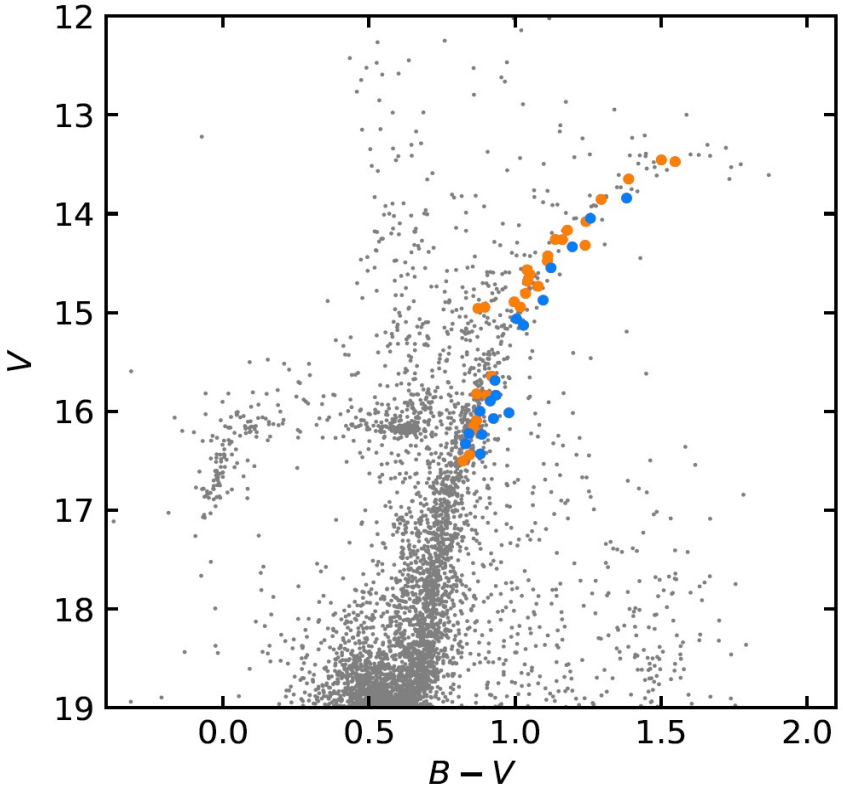
Knowing the A(C+N+O) abundance it is possible to answer the question whether a spread in the subgiant branch is caused by the difference in A(C+N+O) or in age.



Gaia-ESO Spectroscopic Survey

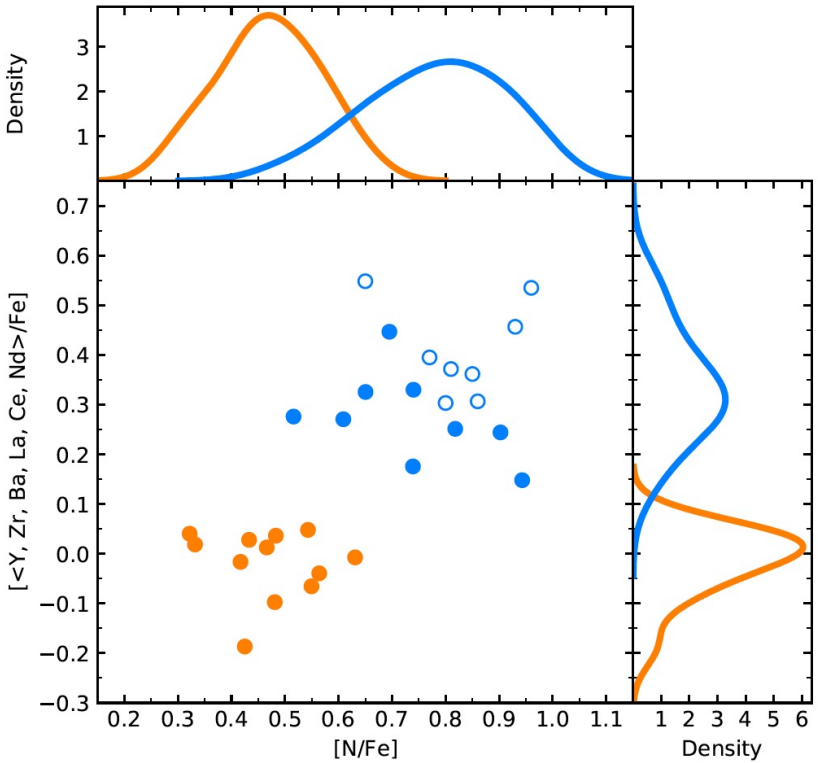
8.2 m VLT telescope
UVES, Resolution 47 000
4700–6840 Å, S/N ≈ 40 – 180
45 giants: metal-rich metal-poor
Abundances of 29 elements determined.

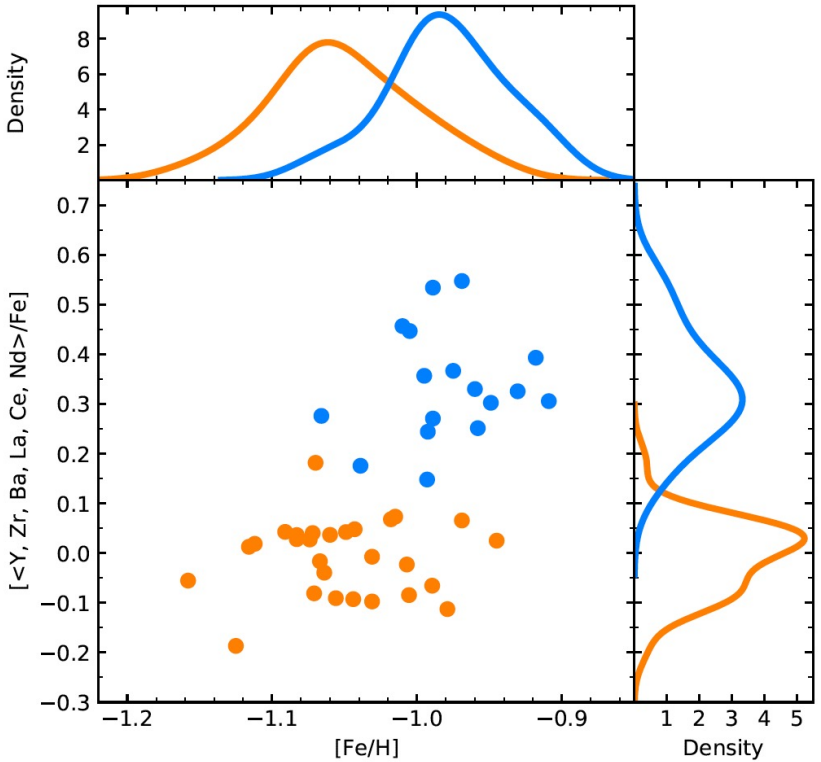




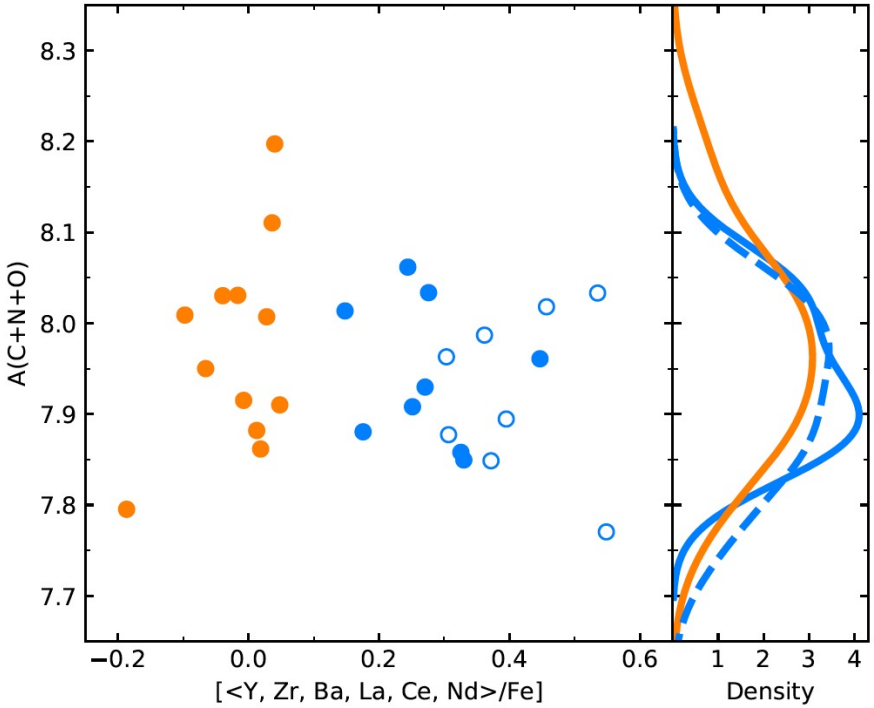
Tautvaisiene et al. (2022, A&A 658, A80)

The investigated stars were divided into subsamples of 17 metal-rich and 28 metal-poor stars with averaged metallicities of -0.98 ± 0.04 dex and -1.05 ± 0.05 dex, respectively





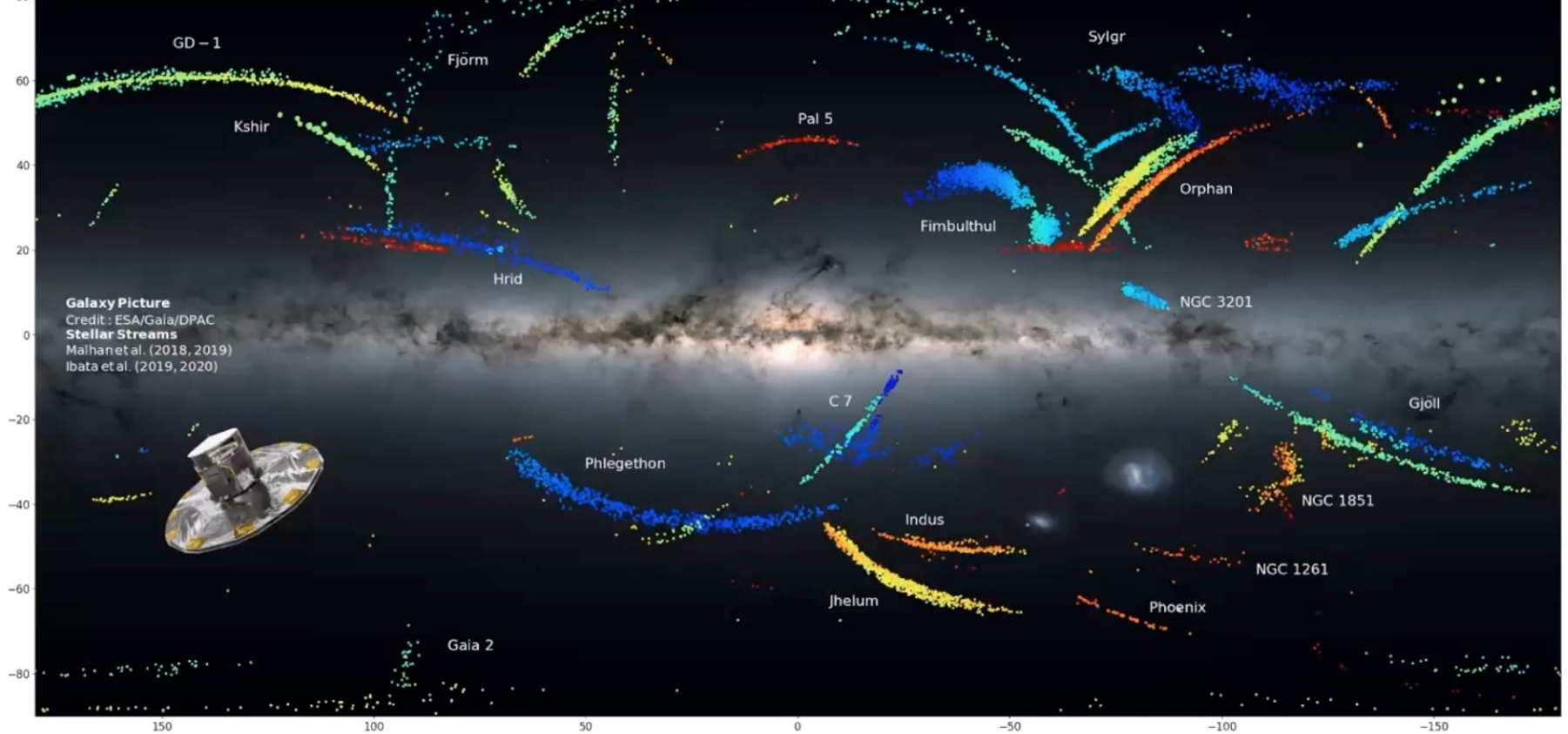
Formation scenario for NGC1851



Our study shows that there is a spread of about 0.1 dex in A(C+N+O) in both populations, however the averaged values between the populations do not differ.

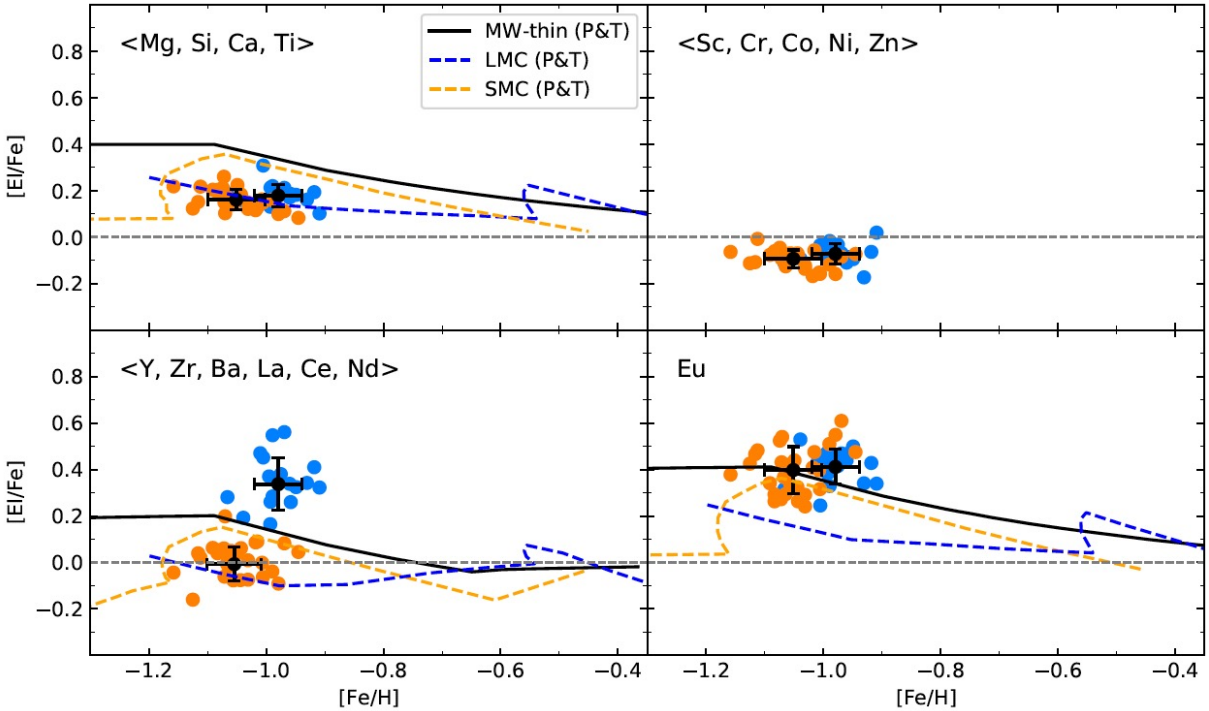
Gratton et al. (2012c) evaluated that the metal-rich subsample would be older by 0.6 Gyr than the metal-poor if the total A(C+N+O) abundance is the same in both subsamples.

NGC1851 is composed of two clusters, the metal-rich cluster being by about 0.6 Gyr older than the metal-poor one.



Based on the Gaia space mission kinematics, Massari et al. (2019) attributed NGC1851 to the Gaia-Enceladus which merged to the Milky Way.
According to Helmi et al. (2018), the Gaia-Enceladus was slightly more massive than the Small Magellanic Cloud.

Chemical composition supports the extragalactic origin



Comparison of mean abundances of chemical elements dominated by different nucleosynthesis processes with the corresponding models of the Milky Way, Large and Small Magellanic Clouds evolution by Pagel & Tautvaisiene (1995, 1997, 1998).

According to its chemistry, NGC1851 fits to the Gaia-Enceladus parent galaxy and even may be its nucleus as suggested by Bekki & Yong (2012) and Forbes (2020).

Congratulations to 550th anniversary of the birth of Nicolaus Copernicus !

Wilhelmina Iwanowska a co-founder of the Nicolaus Copernicus University in Toruń

Wilhelmina Iwanowska
in Vilnius