EXCELENCIA SEVERO OCHOA

THE EXTREME ENHANCEMENT IN CNO OF THE IRON-POOR DWARF STAR J0815+4729

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ABSTRACT:

Low-mass extremely metal-poor (EMP) stars formed from a mixture of material of the primordial nucleosynthesis and matter ejected from the first supernovae. The chemical composition of EMP stars, especially those still on the main sequence, holds crucial information on the properties of the first stars, the first supernovae and the early chemical enrichment of the Universe.

We discovered the iron-poor dwarf star SDSS J0815+4729 (Aguado et al. 2018a, ApJ Letters) using the OSIRIS spectrograph at the 10.4m-GTC telescope in La Palma (Canary Islands, Spain), revealing already the huge C enhancement in this primitive star with a million times less iron than the Sun.

We have recently acquired high-resolution spectroscopy with HIRES at the 10m-KeckI telescope, uncovering the unique abundance pattern of J0815+4729 (González Hernández et al. 2020, ApJ Letters). We derive [Fe/H] = -5.5 and detect the near-IR OI triplet for the first time in an ultra metal-poor star, confirming the extreme CNO abundances of J0815+4729 with ratios [X/Fe] > 4.

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Carbon Abundances in Metal Poor Stars

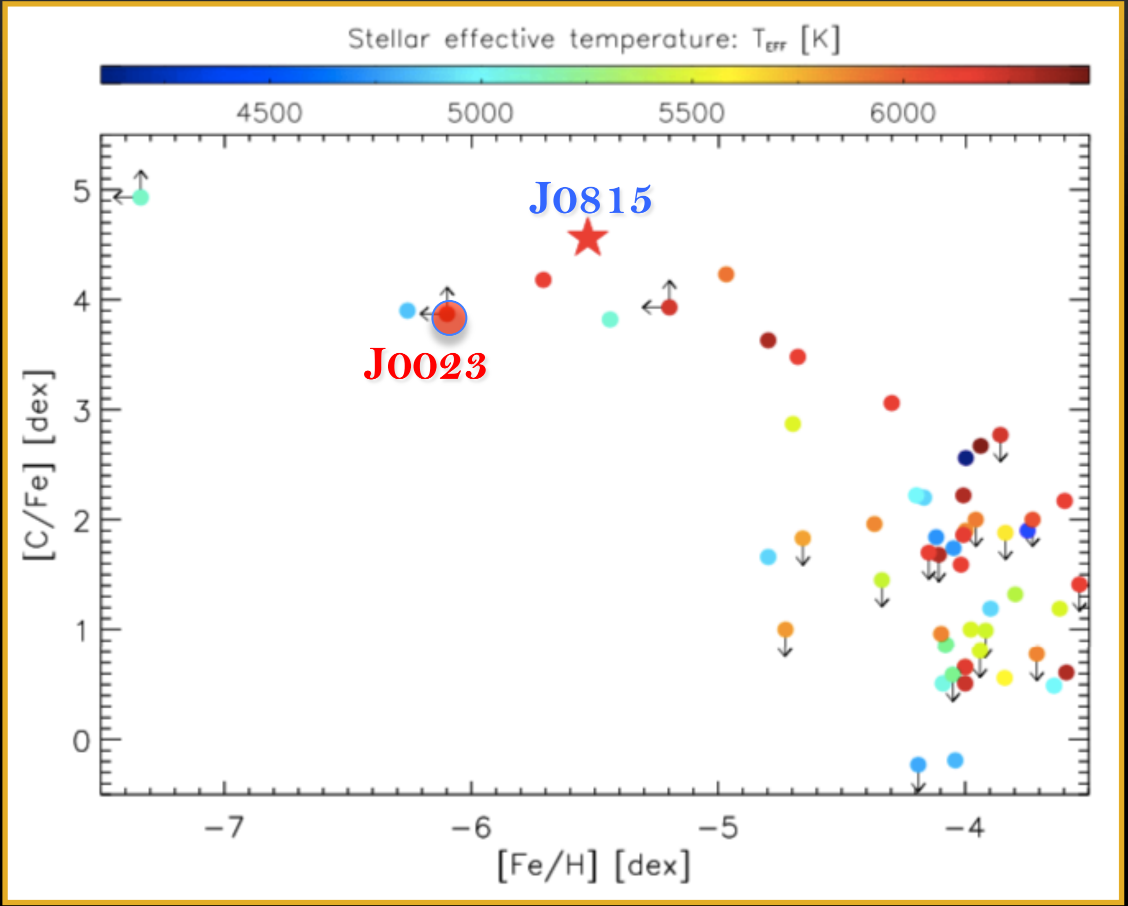

Fig. 1: taken from González Hernández et al. (2020, ApJ Letters, 889, L13)

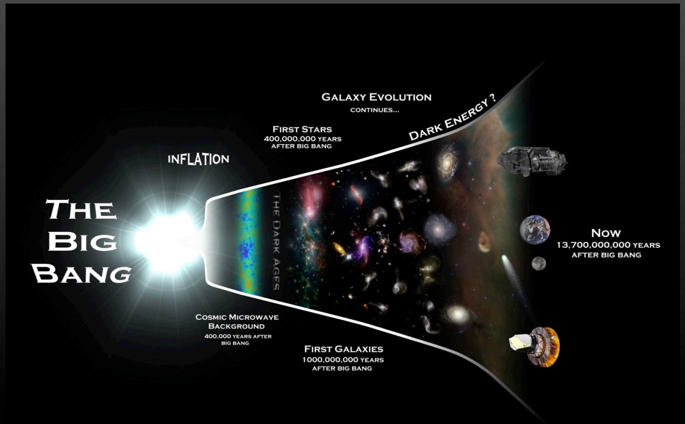

Image credit: Rhys Taylor

A significant fraction of stars in metal poor stasrs is carbon-rich, the so-called CEMP stars. At the lowest metallicities (see Fig. 1) this carbon-enhancement is considered a primordial signature of chemical enrichment by the first (faint) supernovae.

Finding stars at the lowest metallicities provides us a direct connection with the first 500 Myr of the Universe.

J0815+4729 : Aguado et al. (2018a, ApJ Letters); González Hernández et al. (2020, ApJ Letters)

J0023+0307 : Aguado et al. (2018b, ApJ Letters; 2019, ApJ Letters)

J0815+4729 : BOSS + ISIS + OSIRIS

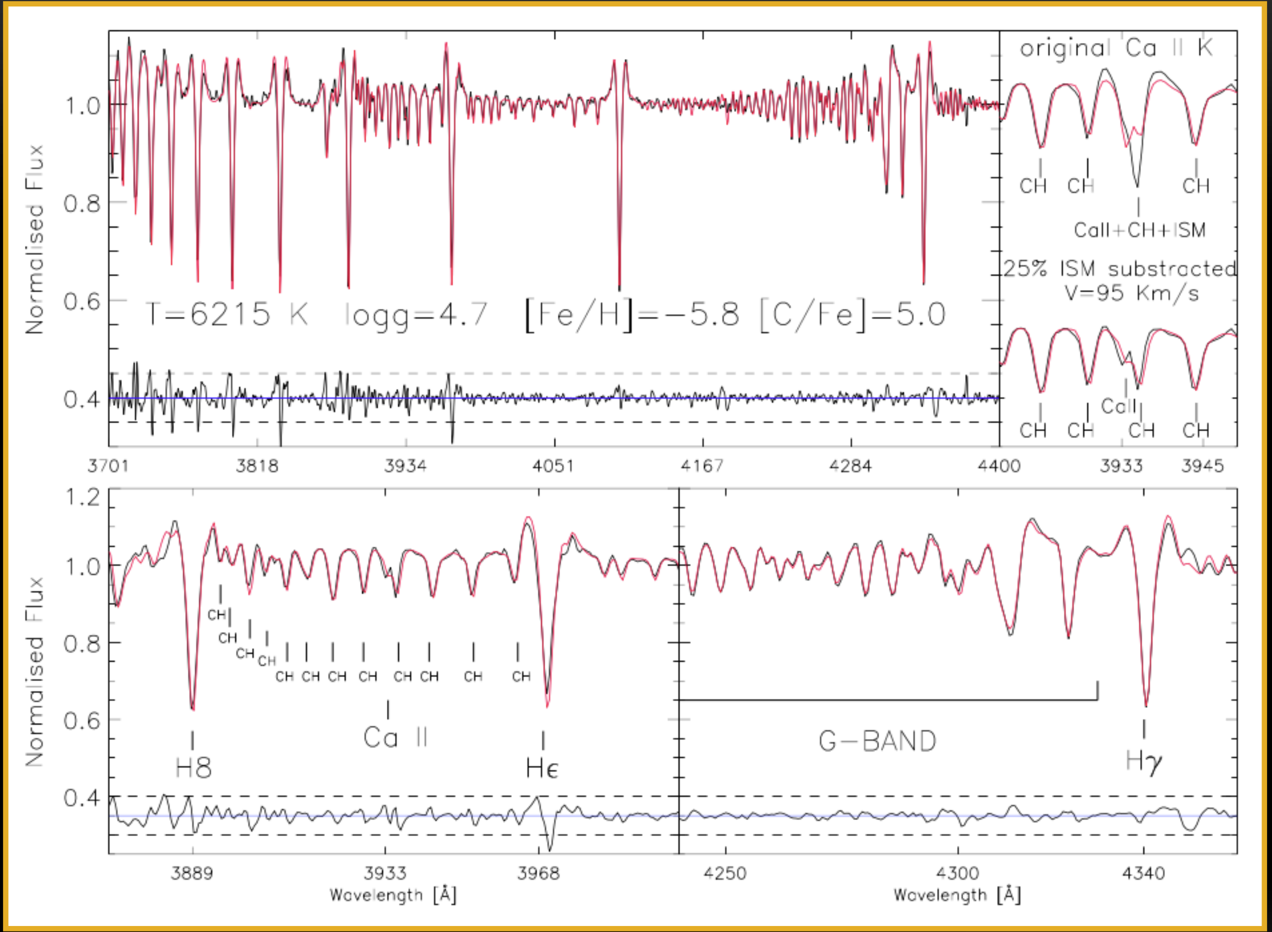

Fig. 2: taken from Aguado et al. (2018a, ApJ, 852, L20)

Image credit: Daniel López

In the last years, our group have discovered two extremely iron-poor stars, J0023+0307 and J0815+4729, both carbon enhanced but with very different abundace patterns.

We search these stars in SDSS/SEGUE and BOSS database and then follow up with WHT and GTC. In Fig. 2 we display the impressive OSIRIS@GTC spectrum almost perfectly matched with a synthetic spectrum using the FERRE code.

J0815+4729: a HMP dwarf star (Fe/H] < -5.8) with the highest carbon abundance : A(C) ~ 7.7

Aguado et al. (2018a, ApJ Letters)

EXTREMELY IRON POOR STARS: J0815+4729

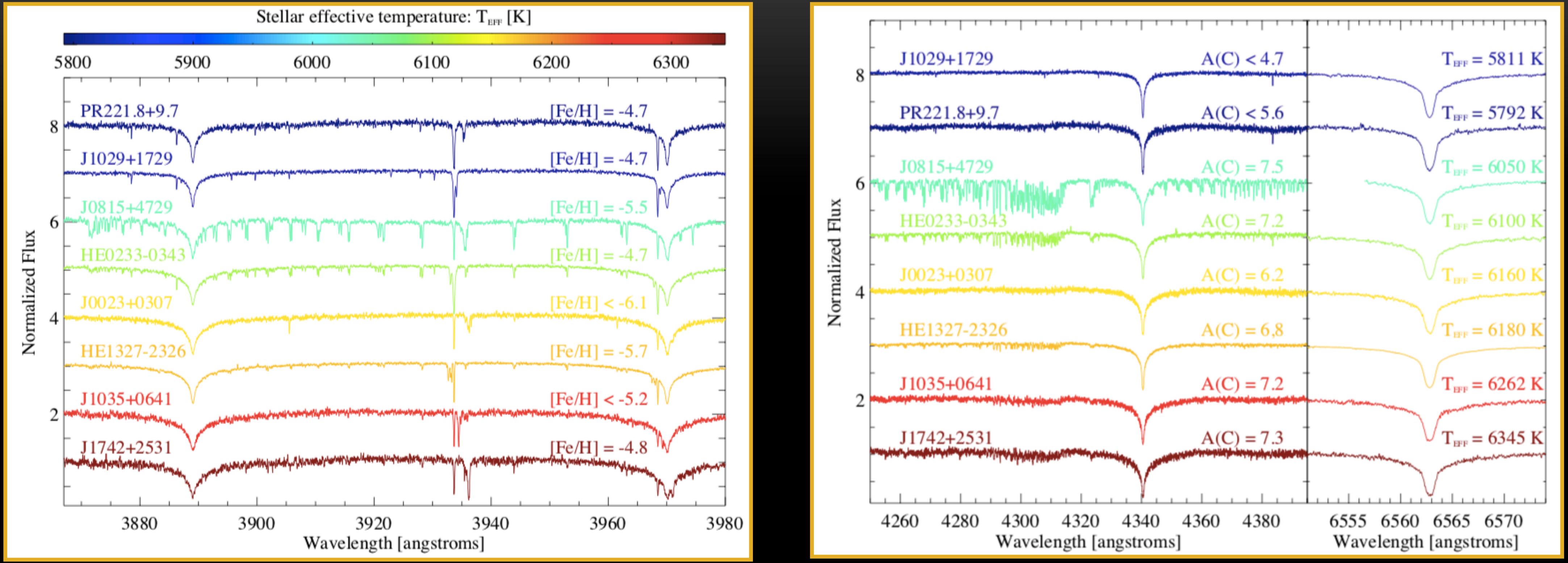

Fig. 3: taken from González Hernández et al. (2020, ApJ Letters, 889, L13)

High quality spectra of these rare stars can unveil unique chemical abundance patterns, revealing the primordial composition of the first faint supernovae of the first stars formed in the Early Universe.

In Fig. 3 we compare high resolution spectra of the most iron-poor unevolved stars, we note the extreme carbon – enhancement of J0815+4729 (green), covered by narrow CH features and strong G-band at 430nm.

LITHIUM IN METAL POOR STARS : J0023+0307

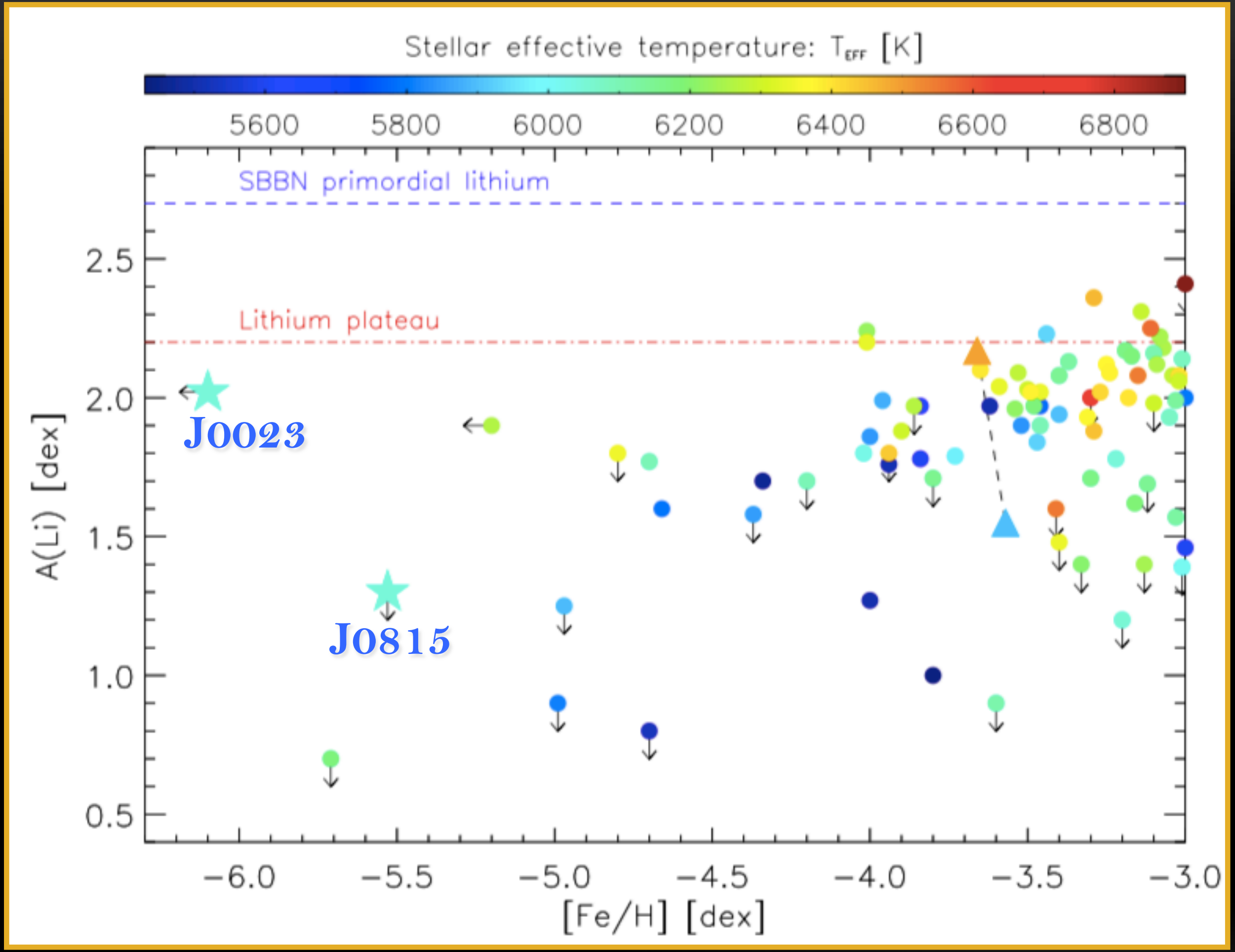

Fig. 4: taken from González Hernández et al. (2020, ApJ Letters, 889, L13)

Unevolved metal-poor stars allows us to look into the Big Bang Nucleosynthesis (BBN) through their lithium abundances (Spite & Spite 1982; Rebolo et al. 1988).

Remarkably the upper-envelope (Lithium Plateau, see Fig. 4) of the Li abundances in metal-poor stars does not agree with the predicted Li by the standard BBN.

We did not detect Li in J0815+4729, with an upper-limit at A(Li)< 1.3 dex, about 0.7 dex below the surprising Li detection, at the level of the lithium plateau, in J0023+0307 (Aguado et al. 2019, ApJ Letters), and exacerbating the cosmological lithium problem (e.g. González Hernández et al. 2019, A&A).

OXYGEN IN POOR STARS: J0815+4729

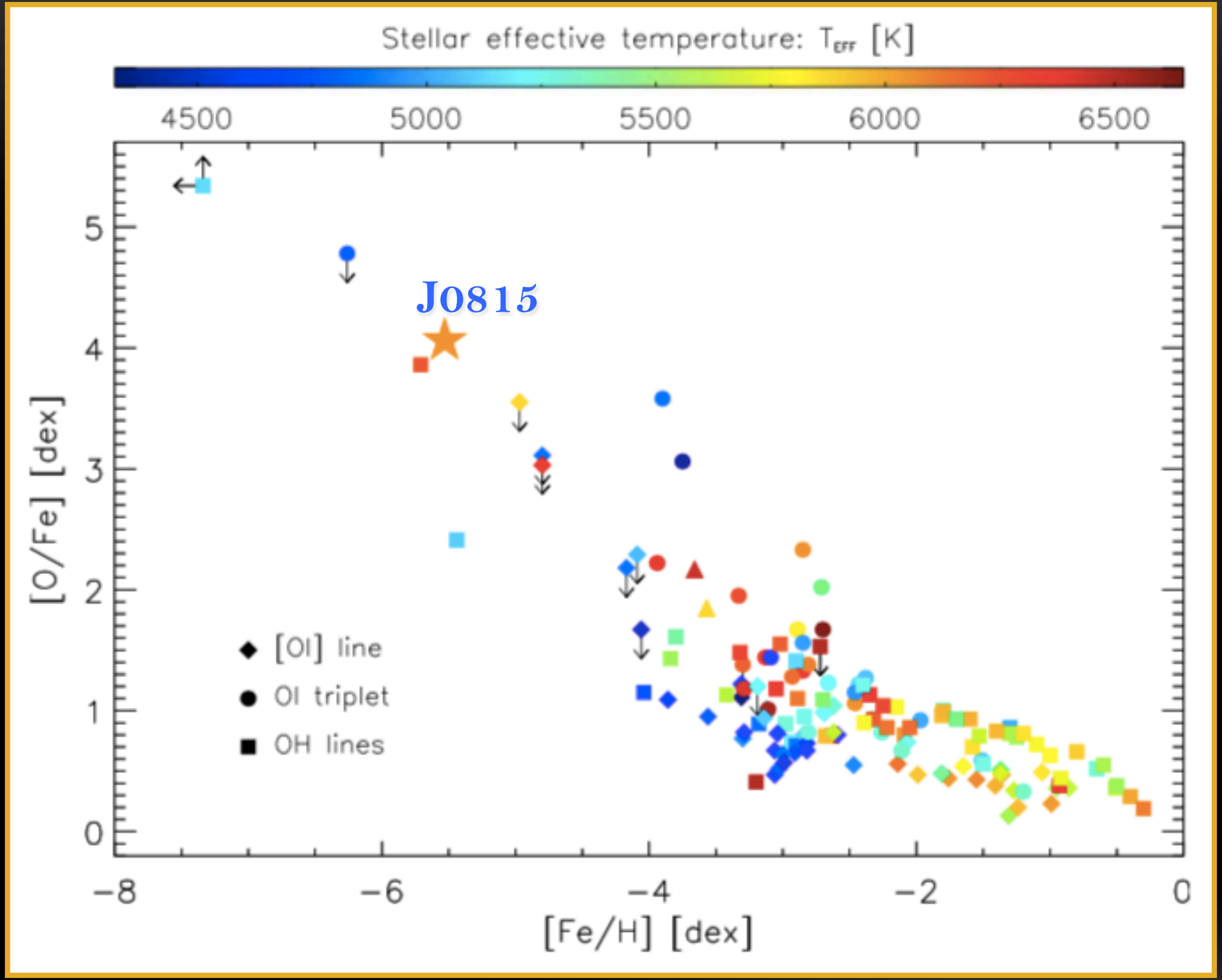

Fig. 5: taken from González Hernández et al. (2020, ApJ Letters, 889, L13)

Image credit: Gabriel Pérez (IAC)

Fig. 5 shows the Galactic chemical evolution of oxygen in 1D-LTE, an increasing trend of [O/Fe] towards decreasing iron content [Fe/H].

Clearly, there is a lack of stars at the lowest metallicities as seen for C, Li and O that we aim to fill up with more discoveries in the coming years thanks to new facilities such as WEAVE and DESI, which certainly will provide new iron-poor candidates that we will follow up with GTC, improving our understanding of the Early Universe and the Early phases of the formation of the Galaxy.