TWINKLE, TWINKLE, LITTLE STAR: UNRAVELLING THE STELLAR ATMOSPHERIC PARAMETERS OF CARMENES GTO M DWARFS USING THE SPECTRAL SYNTHESIS TECHNIQUE

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Abstract. We focus on our very first results in connection with the stellar atmospheric parameter determinations (T_{eff}, **log *g***, and **[M/H]**) of **M-type dwarfs** observed with carmenes under its **GTO programme** by means of the **spectral synthesis technique**. We also describe our three-step approach to the problem: **[1]** the careful selection of spectral ranges around iron and titanium atomic lines and molecular bands in three reference M-type stars: **GX And (M1.0 V)**, **Luyten's star (M3.5 V)**, and **Teegarden's star (M7.0 V)**; **[2]** the use of BT-Settl stellar model atmospheres, the radiative transfer code **Turbospectrum** and line data from the **VALD3** database to obtain a grid of synthetic spectra to be compared with the CARMENES spectra; and **[3]** the Markov Chain Monte Carlo process implemented in **SteParSyn** code designed to derive the probability distribution functions of the stellar atmospheric parameters.

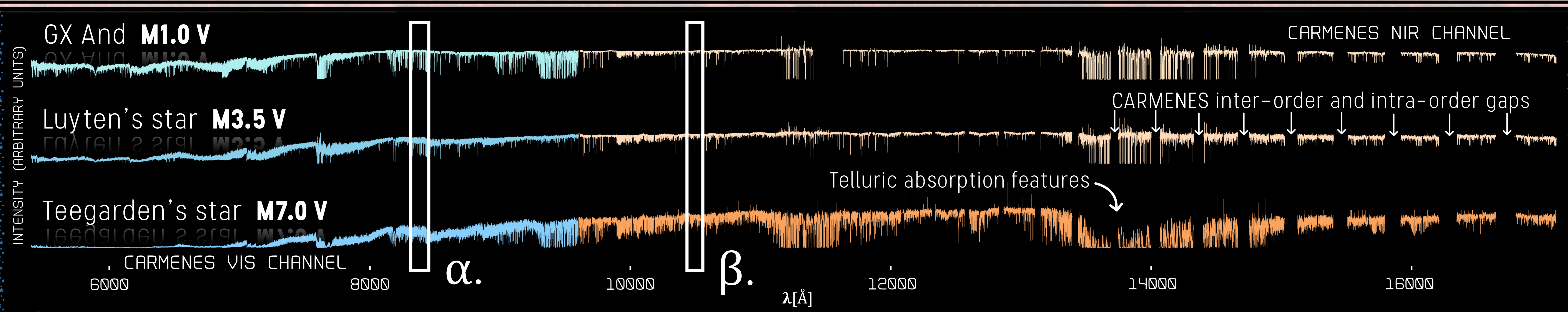

Figure 1. From top to bottom, individual CARMENES spectra of our three reference stars GX And (M1.0 V), Luyten's star (M3.5 V) and Teegarden's star (M7.0 V), respectively.

[1] Line selection stage: ~70 Fe I and Ti I lines picked over. Around each line we defined a **range** and a **mask** (see fig. 2).

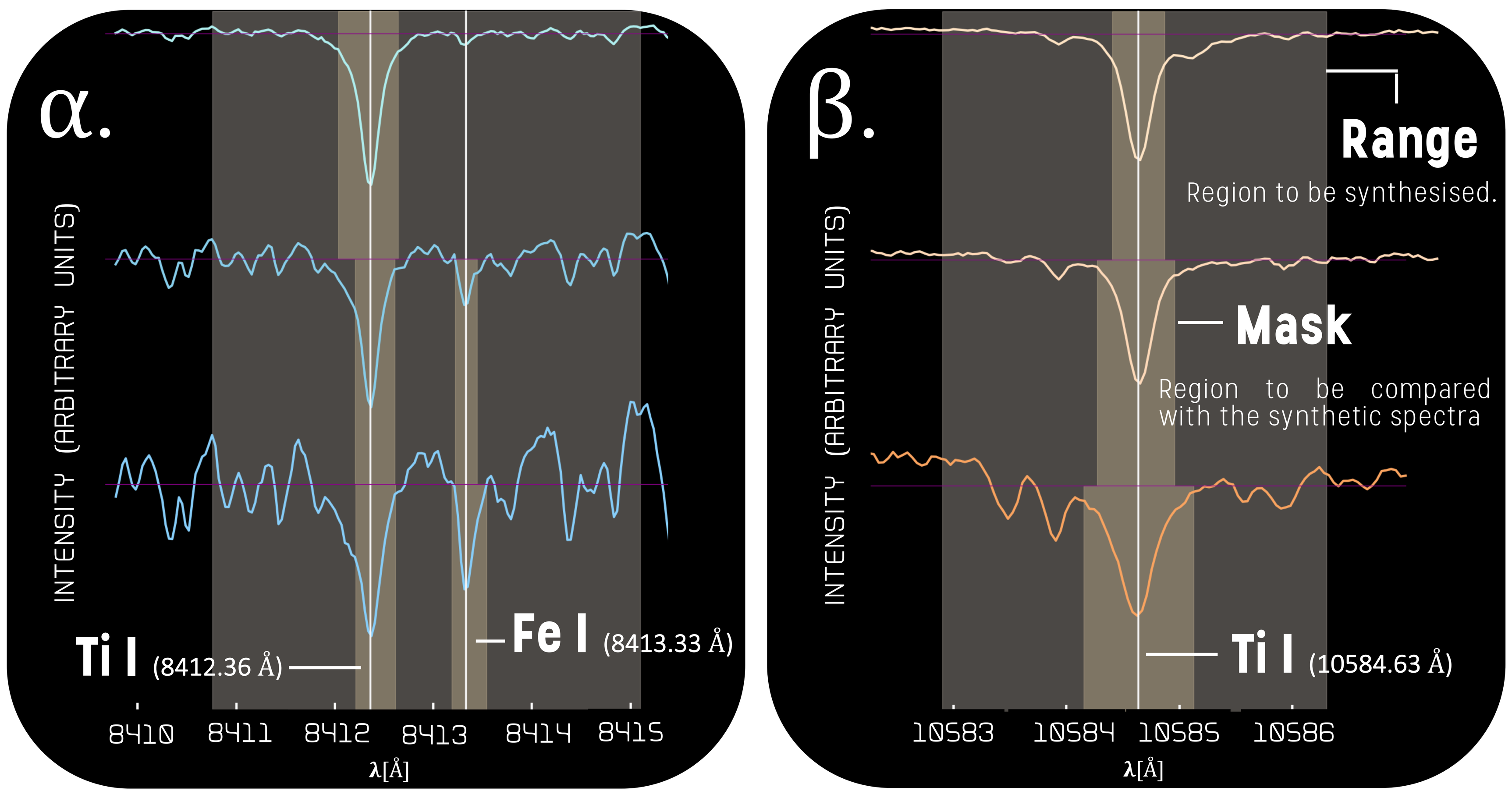

Figure 2. Example of two line selections, ranges and masks (close-up view of α. and β. zones of fig. 1).

[2] Spectral synthesis around the selected ranges requires careful consideration of the following aspects:

- **Model atmospheres:** We opted for BT-Settl model atmospheres (Allard et al. 2012) after trying out both MARCS and PHOENIX model atmospheres.
- **Radiative transfer code:** TurboSpectrum (Alvarez & Plez 1998, Plez 2012), capable of handling large atomic and molecular data at high speed.
- **Atomic line data:** VALD3, *extract all* option (Ryabchikova et al. 2015).
  Molecular line data: Mostly from B. Plez and ExoMol line lists, including:
  TiO SiH MgH CaH CrH FeH C_2 ZrO H_2O OH CN CO VO and **their isotopes**

Synthetic grid	T_{eff} [K]	log g [dex]	[Fe/H] [dex]
Lower limit	2600	4.00	-1.00
Upper limit	4500	5.50/6.00*	+1.00
Step	100	0.5	0.5*

Table 1: Parameter space of our synthetic grid obtained using BT-Settl model atmospheres. *Steps and limits may vary slightly depending on the actual effective temperature considered.

[3]

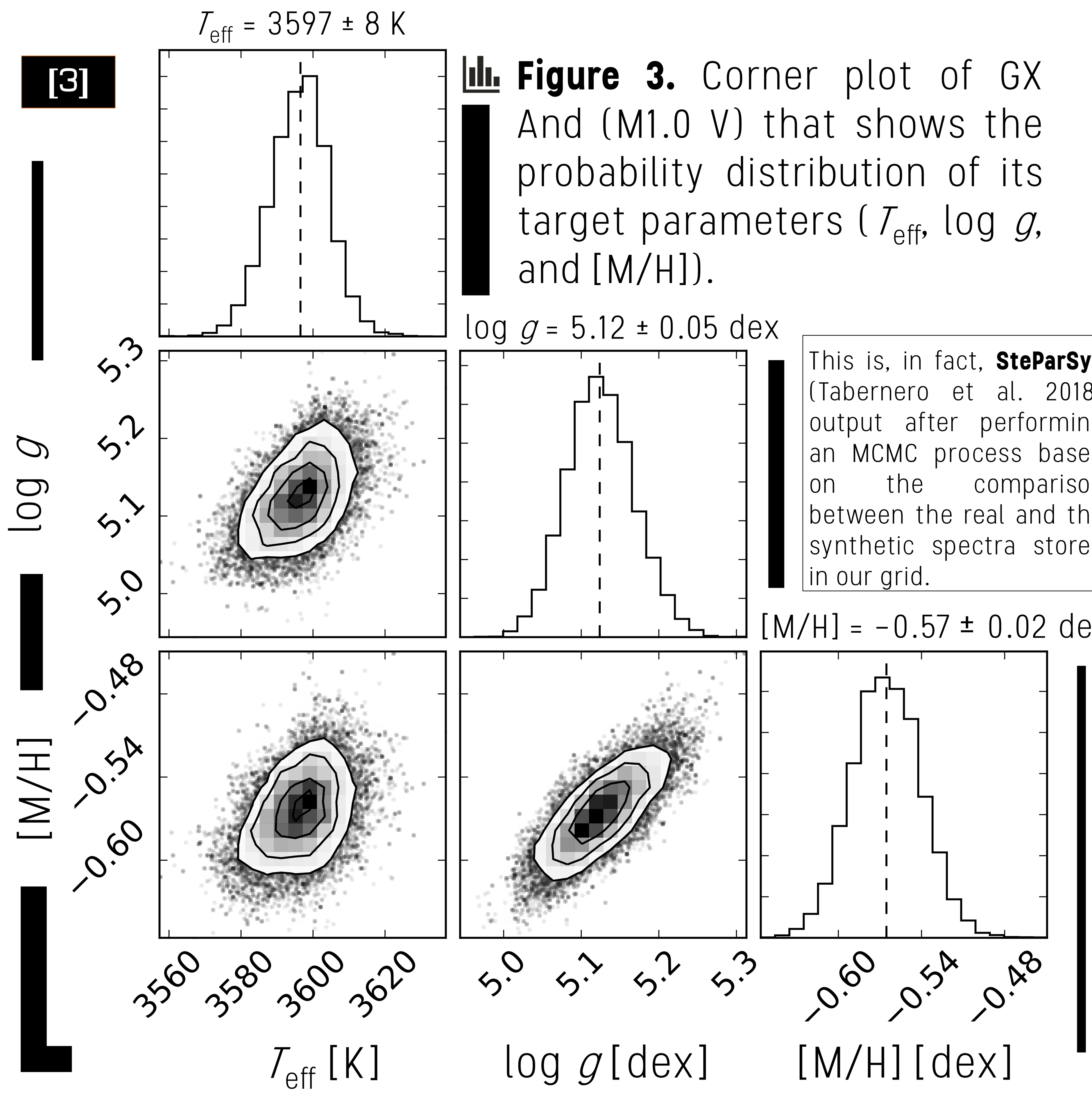

Figure 3. Corner plot of GX And (M1.0 V) that shows the probability distribution of its target parameters (T_{eff}, log g, and [M/H]).

This is, in fact, **SteParSyn** (Tabernero et al. 2018) output after performing an MCMC process based on the comparison between the real and the synthetic spectra stored in our grid.

References:
Allard et al. 2012
Alvarez & Plez 1998
Blanco-Cuaresma et al. 2014
Gustafsson et al. 2008
Husser et al. 2013
Lázaro Barrasa, MSc thesis, 2018
Plez 2012
Quirrenbach et al. 2018, SPIE
Ryabchikova et al. 2015
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