

Spectroscopic Analysis of B and Be Stars in the open Cluster NGC 3766

Silva Soares, M.F. ; Daflon, S. and the Gaia – ESO Survey team



MINISTÉRIO DA
CIÊNCIA, TECNOLOGIA
E INOVAÇÃO

Introduction

Gaia-ESO Survey (GES; Randich et al. 2013) is a public spectroscopic survey that observed ~100.000 stars in the Galaxy from 2011 to 2019, using the VLT 8m @ESO. One of the clusters observed by GES is the open cluster NGC 3766, known for presenting a large number of Be stars. Be stars are main sequence B stars presenting emission lines in their spectra, produced by a disk of ejected material and ionized by the star. Observations show that Be stars generally rotate faster than normal B stars, so rotation may play an important role in disc production.

The objective of this work is to study the distributions of rotational velocity and chemical abundances in NGC 3766. We determined the atmospheric parameters T_{eff} , $\log g$, $v \sin i$, the microturbulence and macroturbulence velocities, and the abundances of Si, C, N and O for a sample of B stars from this cluster using non-LTE synthesis.

Temperature

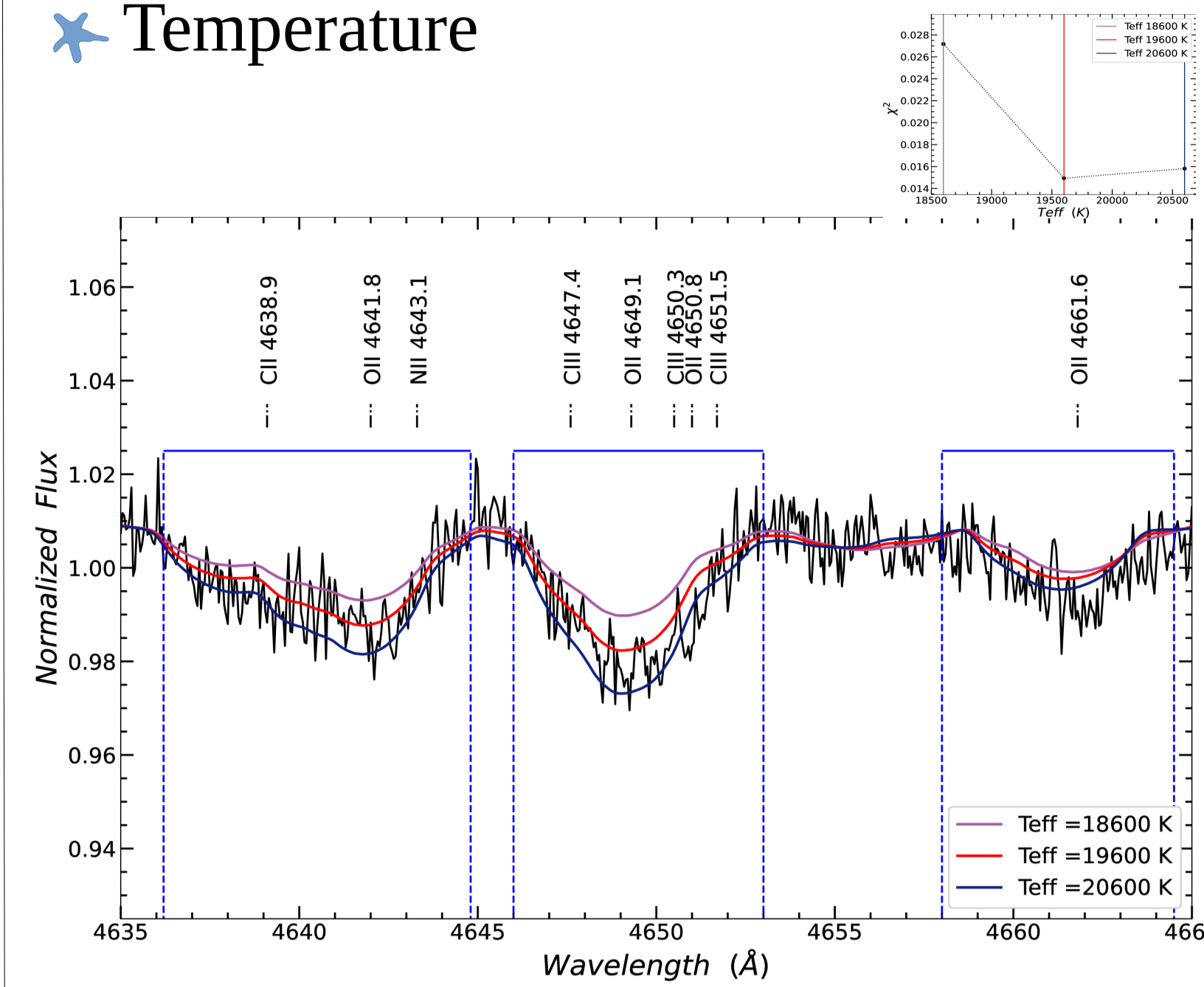


Fig. 6: T_{eff} determined from CNO synthesis for NGC 3766 239 star.

$v \sin i$

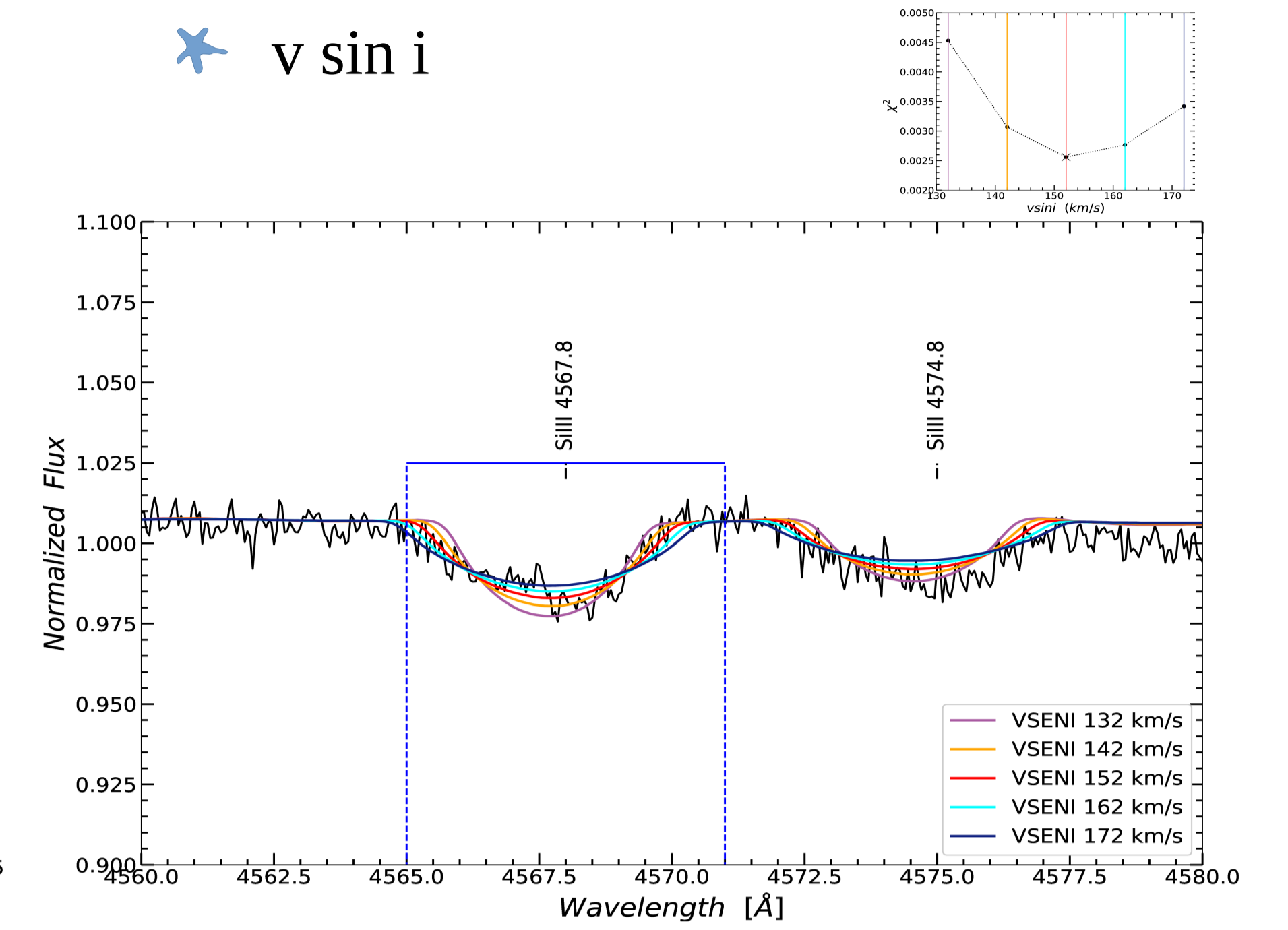


Fig. 7: $v \sin i$ determined from Si III lines for NGC 3766 239 star.

Silicon Abundance

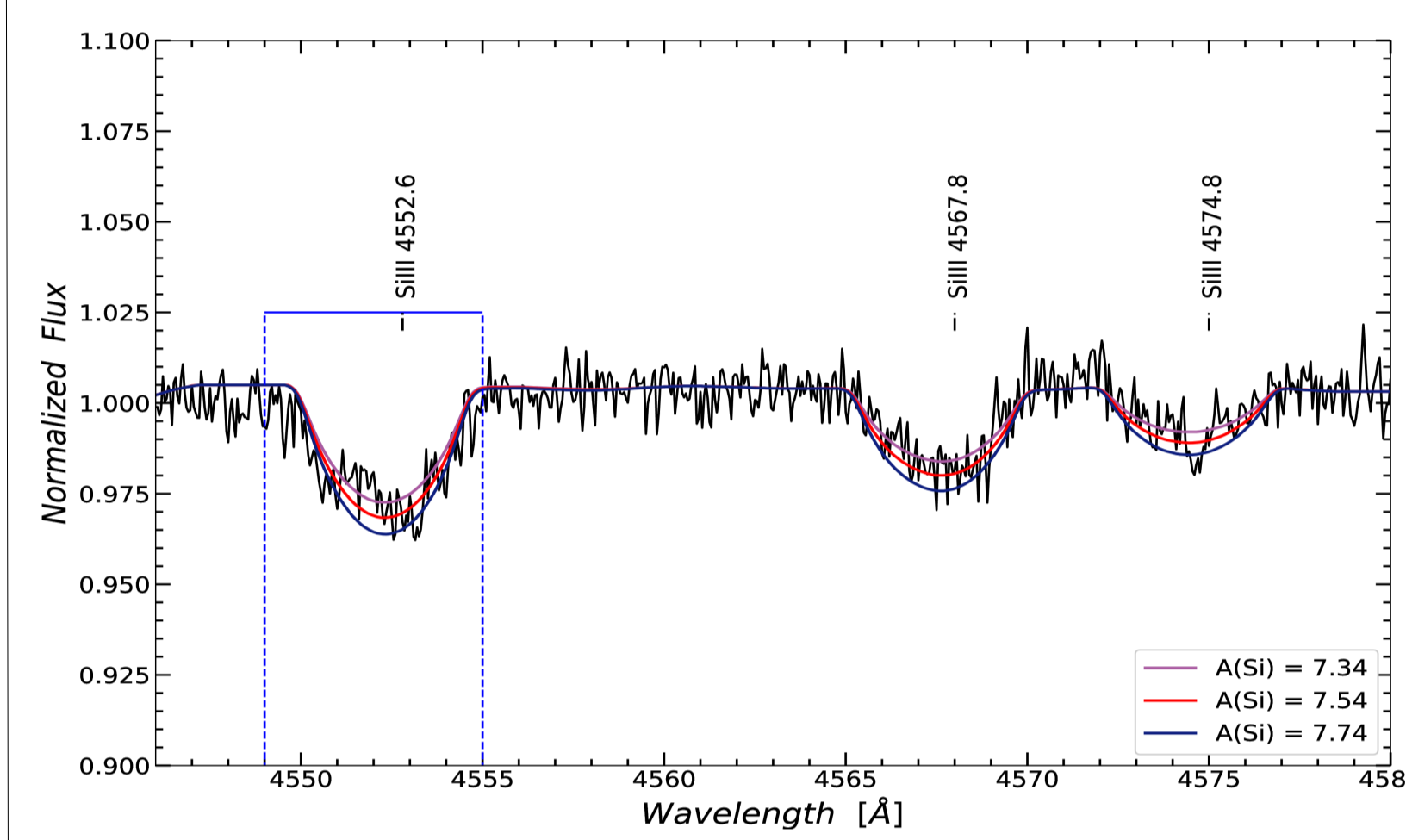


Fig. 8 : Abundance determined by Si III lines fitting for NGC 3766 239 star.

Microturbulence

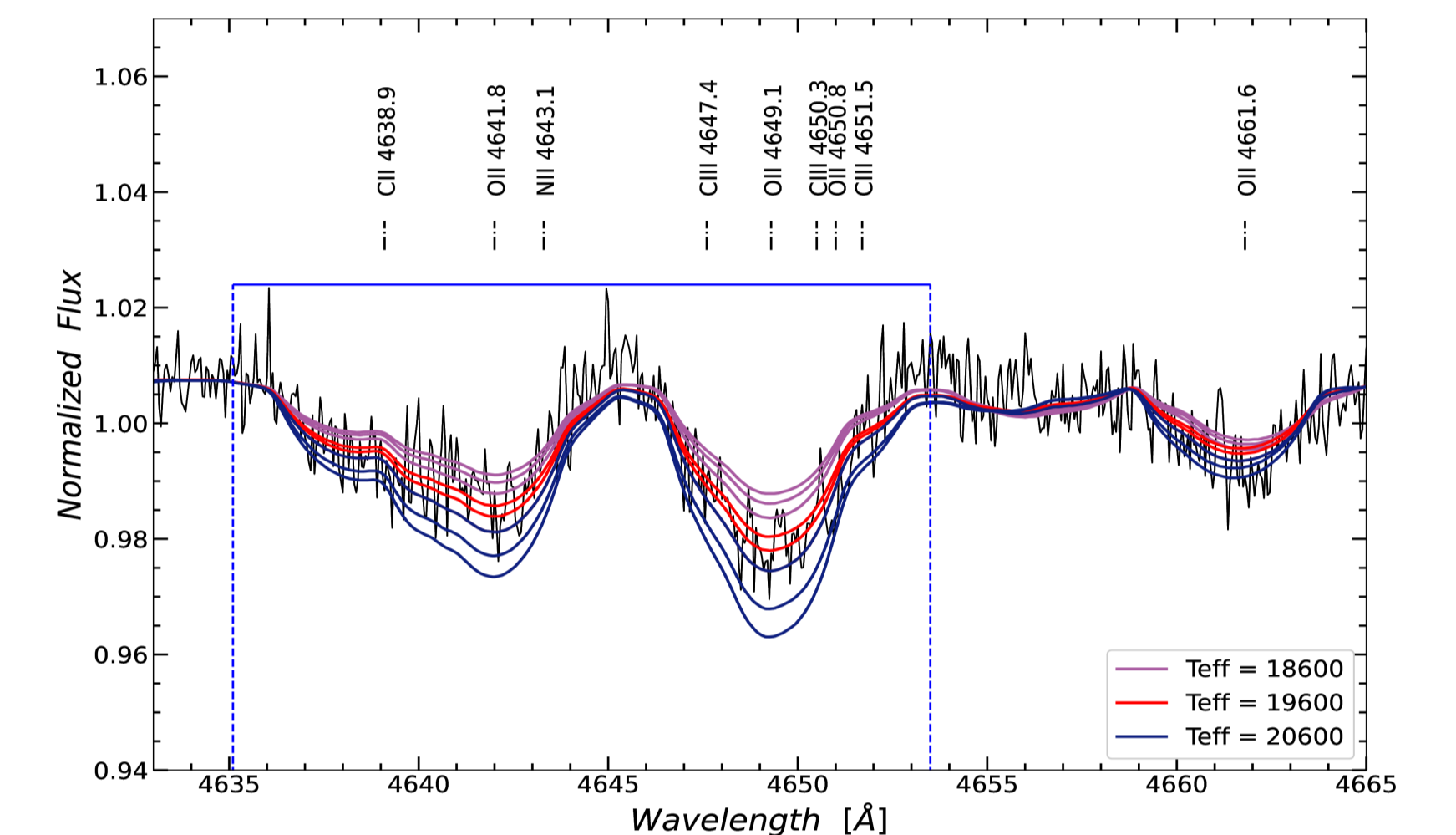


Fig. 9: Microturbulence and T_{eff} fitting for NGC 3766 239 star.

Results

Kiel Diagram

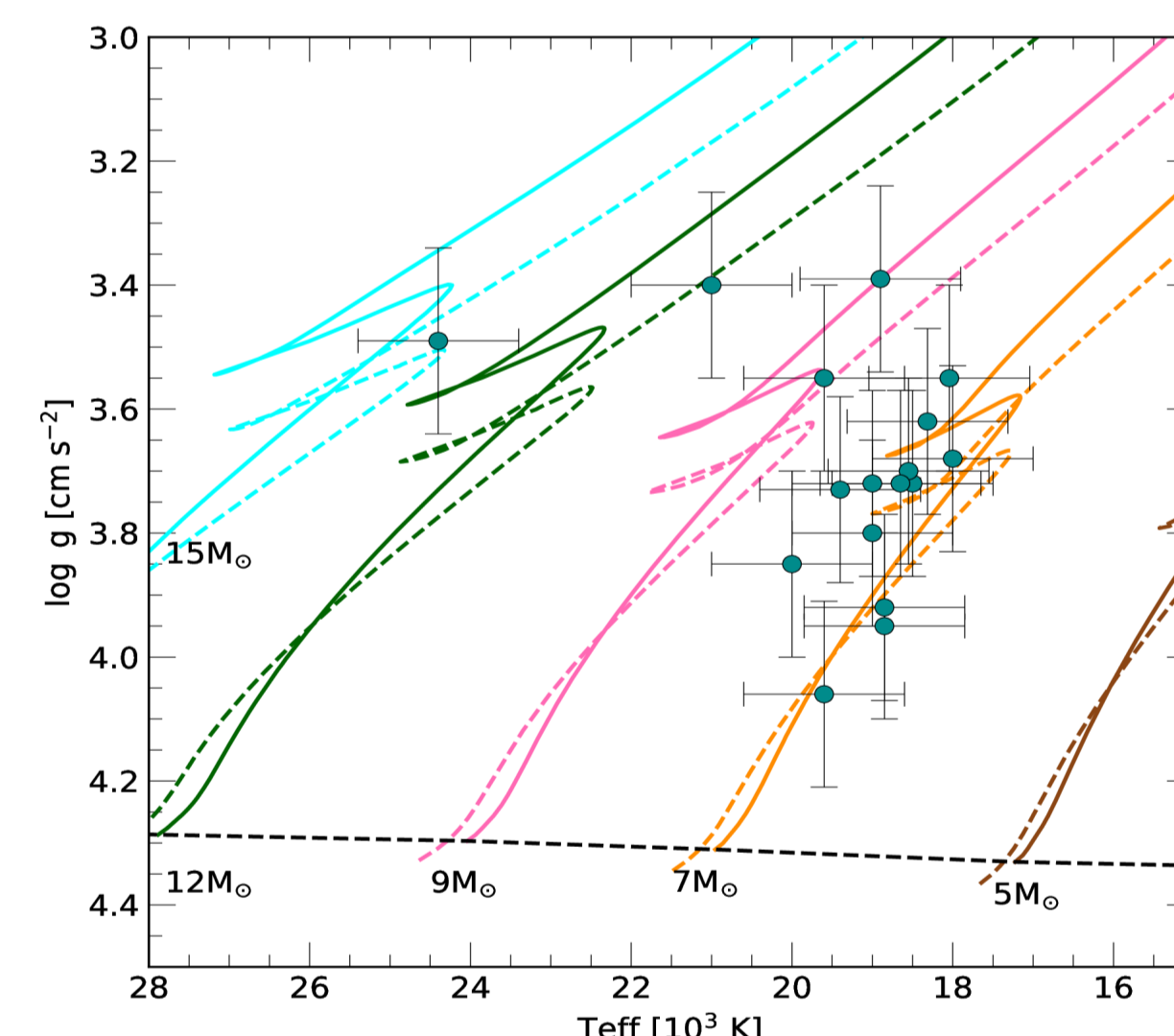


Fig. 10: Kiel diagram for the sample stars of NGC 3766. Colored lines represent evolutionary tracks of Ekström et al. (2012) for $M = 5 - 15 M_{\odot}$, calculated without rotation (dashed lines) and with rotation $v/v_{\text{crit}} = 0.4$ (solid lines)

Abundances

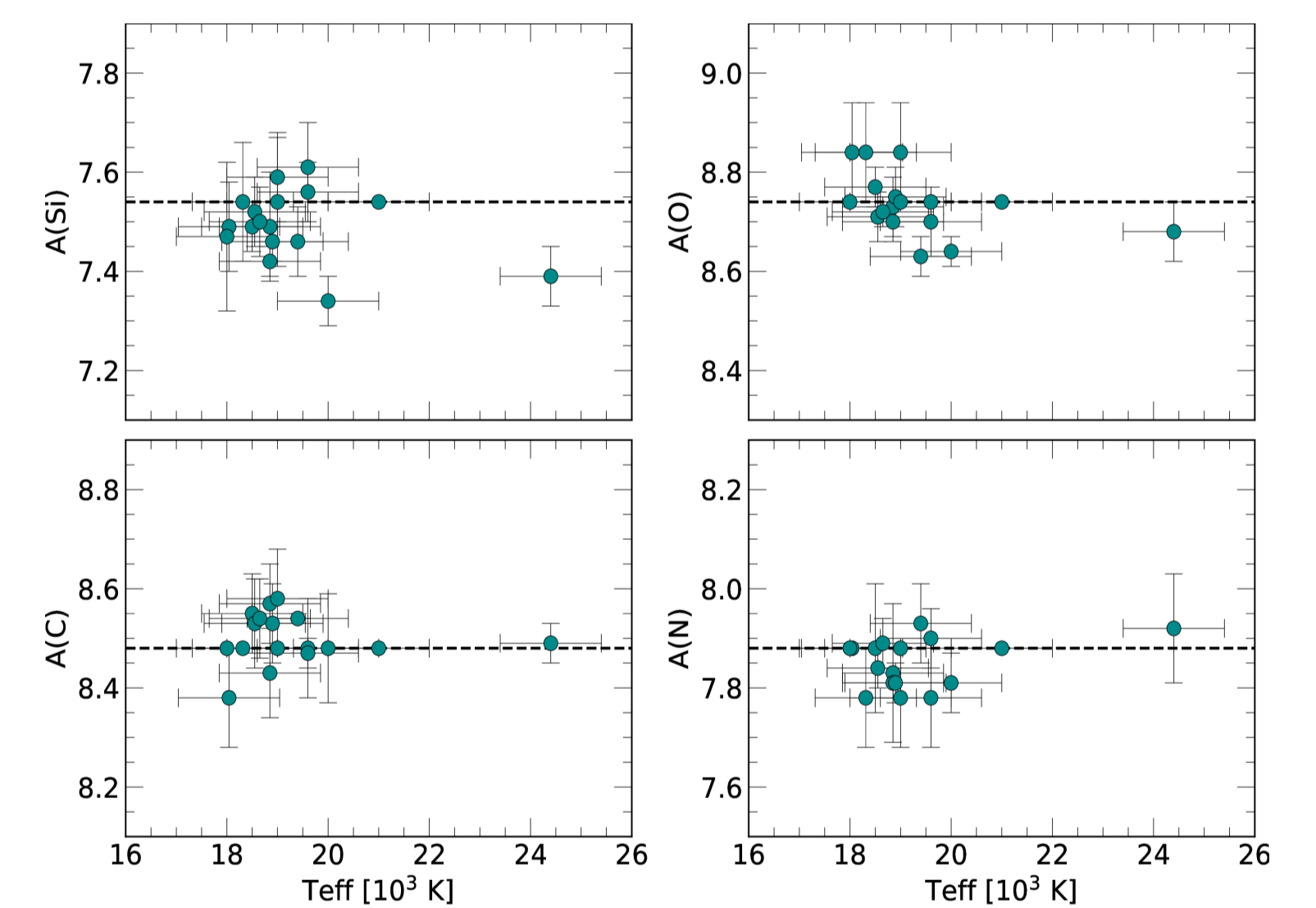


Fig. 11: Derived abundances of C, N, O and Si as a function of T_{eff} . The stellar abundances are consistent with the solar values (MAGG et al., 2022), represented by the dashed lines.

Radial Abundance Gradient

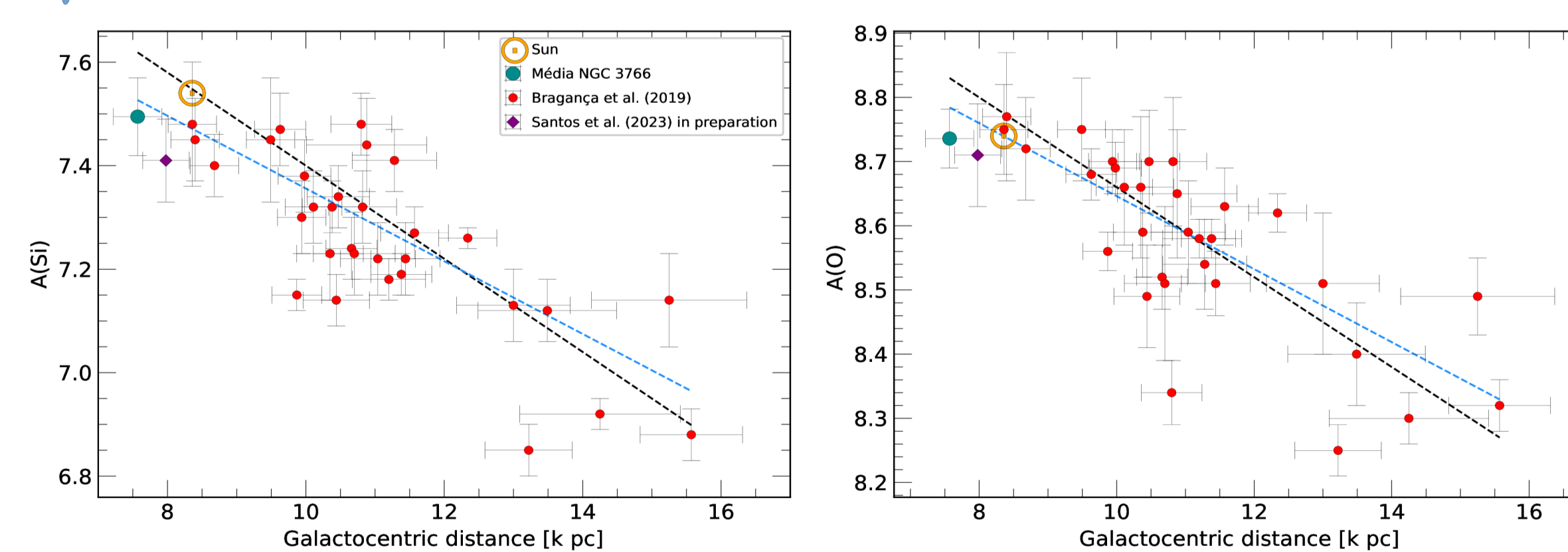


Fig. 12: Average abundances of Si and O of NGC 3766 are consistent with the cluster position on the Galactic plane, according to the radial gradients of Si and O abundances obtained by Braganca et al (2019). The yellow circles represent the solar abundances (Magg et al. 2022).

CMD and stellar rotation

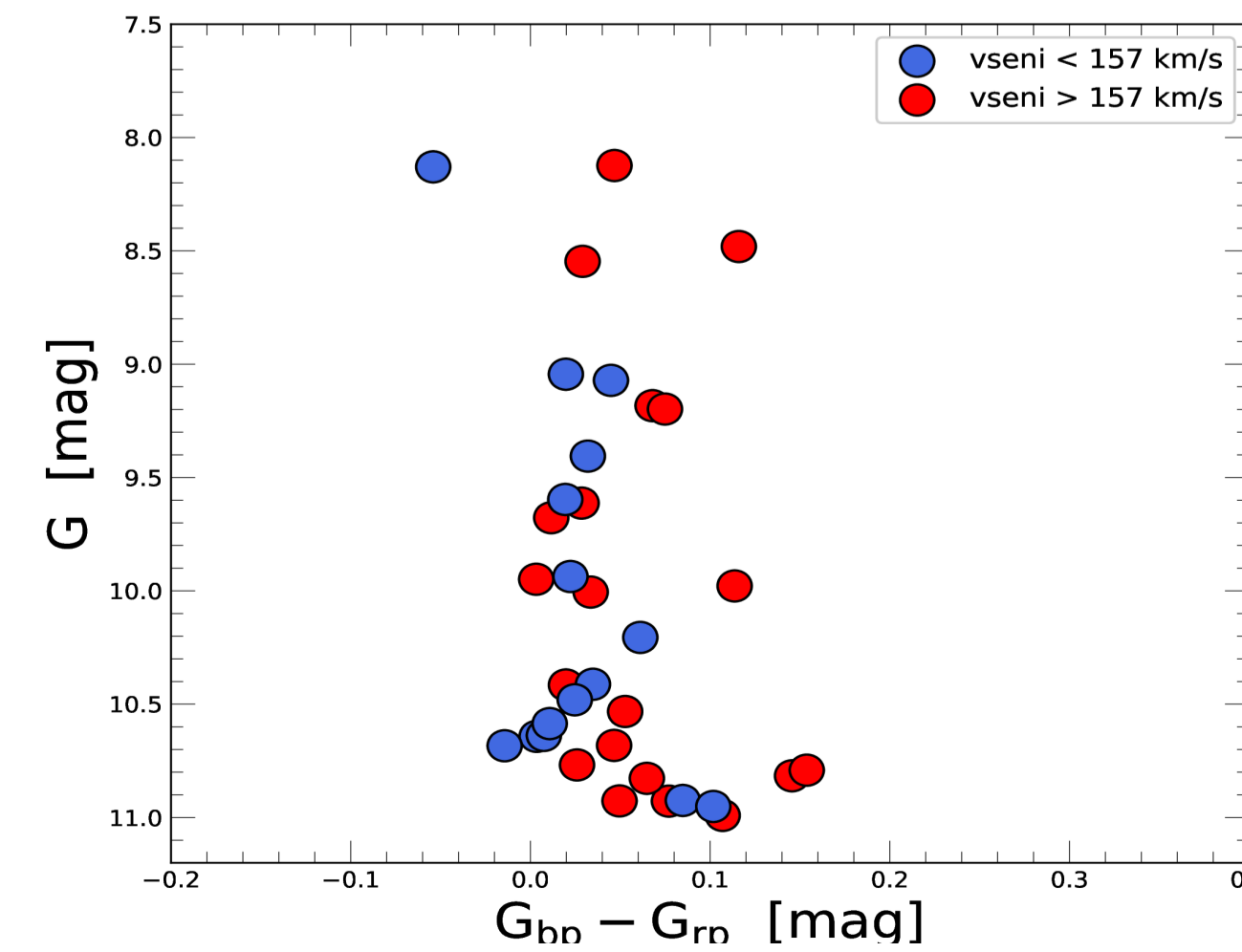


Fig. 13: CMD for B stars of NGC 3766 with $8 < G < 11$, color-coded according to the $v \sin i$: blue for stars with $v \sin i < 157$ km/s (average value for the sample) and red for $v \sin i > 157$ km/s. Note that the main sequence (MS) of the NGC 3766 cluster is broadened and that the lower part of the MS (bluer) contains both blue and red dots, that is, it contains low and high $v \sin i$ stars. On the other hand, the upper part of the main sequence (redder) contains only red dots, suggesting that a bimodality may exist in the MS of NGC 3766 due to rotation. This result is in line with the observational result obtained by Wang et al. 2022 for open clusters of the Magellanic Clouds.

Sample Selection

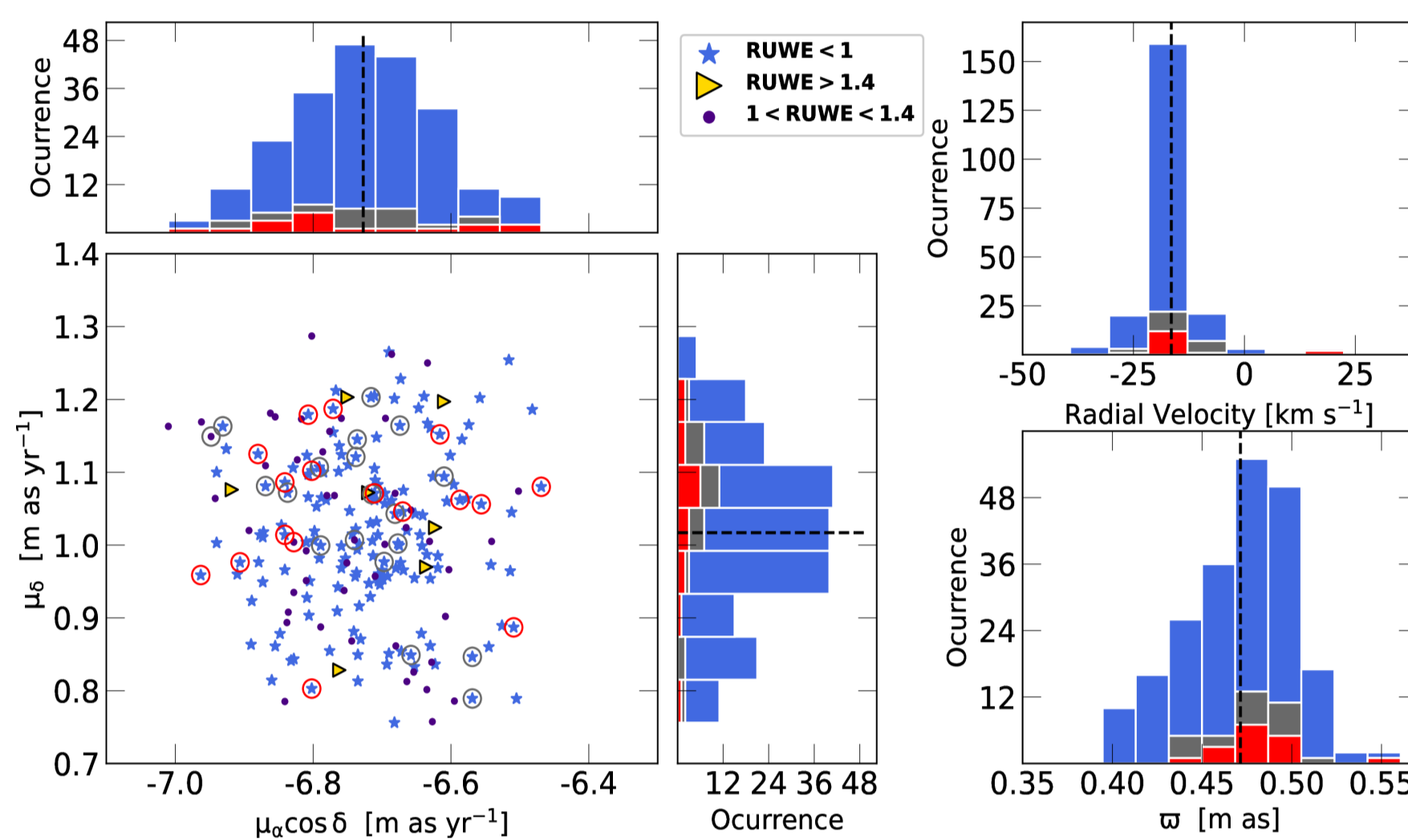


Fig. 1: Gaia astrometric and photometric data of NGC 3766. The left panel shows the distribution of proper motion, the upper middle panel shows the radial velocity histogram for the sample of 214 stars members in NGC 3766. The lower middle panel shows a histogram of the parallax. Full sample observed by GES is blue and our sample of B stars is in red and grey circles.

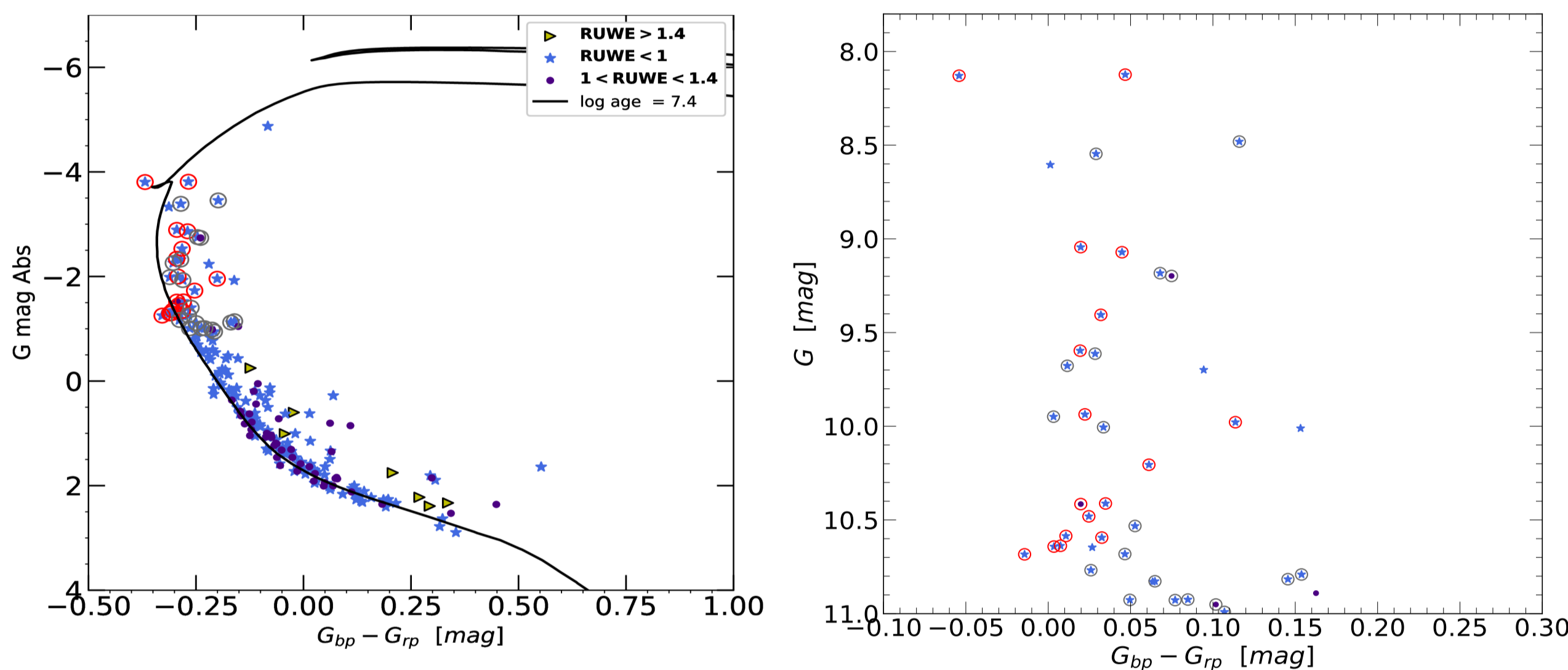


Fig. 2: The Gaia CMD of NGC 3766. PARSEC evolutionary track from Bressan et al. 2012 with age ~ 25 My is shown in black. The selected sample of B and Be stars is the red and grey circles.

Fig. 3: A cutted sample for the color magnitude diagram (CMD) using the G, GRP and GBP bands from GES. The selected sample is the red and grey circles.

Be Identification

Approximately 100 Be stars have been reported in NGC 3766 by McSwain & Gies (2005); McSwain et al. (2008, 2009).

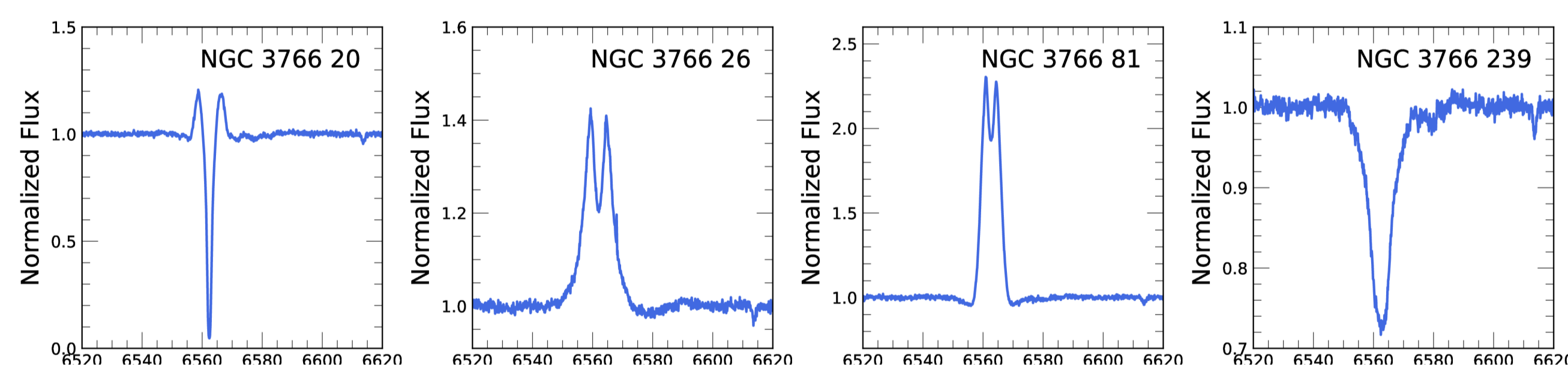


Fig. 4: Example of emission H α lines in the spectra of 4 Be stars of NGC 3766.

Methodology

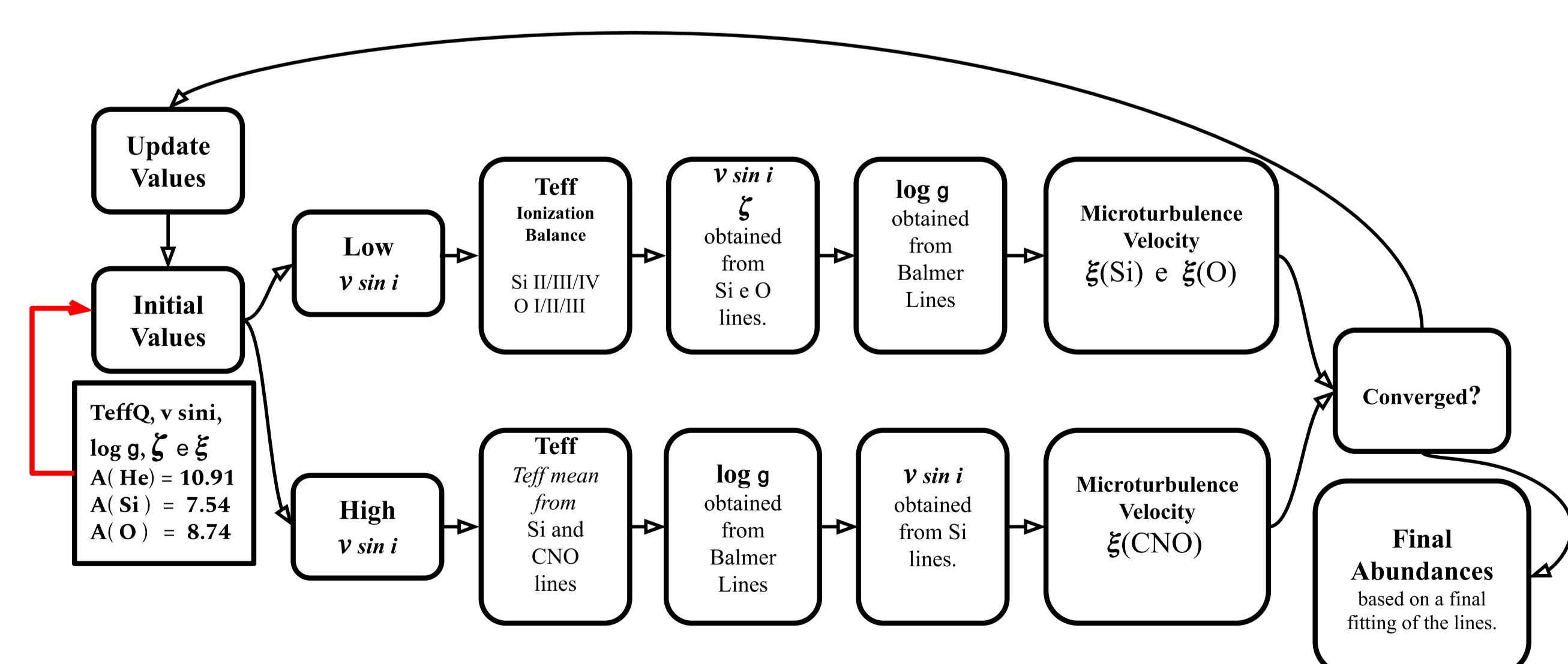


Fig. 5: Steps of the iterative scheme used to derive the stellar parameters and abundances: S4 (Braganca et al 2019), based on TLUSTY/SYNPEC

Initial estimates :

Teff : from photometric calibration for Q index

Vsini: from the widths of He I lines

Fixed values: $\log g = 4$, $V_{\text{mic}} = 2$ km/s, $V_{\text{mac}} = 20$ km/s