Obtaining accurate parameters of Type IIP progenitors in NGC 6822, IC 10 & WLM

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Motivation

The TiO bands of the optical spectra of red supergiants (RSGs) are widely used to estimate their Teff, but they are now known to form high in the atmosphere, so the Teff this method produces is an underestimation of the real value (Davies et al. 2013). An alternative method is to fit atomic lines in the *J*-band using the NLTE MARCS models (Bergemann et al. 2012, 2013, 2015). This method provides an improved Teff estimation that can be used as an input to SED fitting codes leading to a more robust estimate of mass loss.

Having temperature estimations using both these methods will enable us to calibrate the temperature scale of RSGs with metallicity. This way, we will be able to obtain robust physical parameters and mass-loss estimates for the ASSESS sample (consisting of ~**130** RSGs in total; Bonanos et al. 2024, de Wit et al. 2024), for which IR spectroscopy is not available.

We base our work on the optical spectra of dusty RSG in NGC 6822 and IC 10 obtained within the ASSESS framework using GTC / OSIRIS and we add one target in WLM from Britavskiy et al. (2019).

Target selection

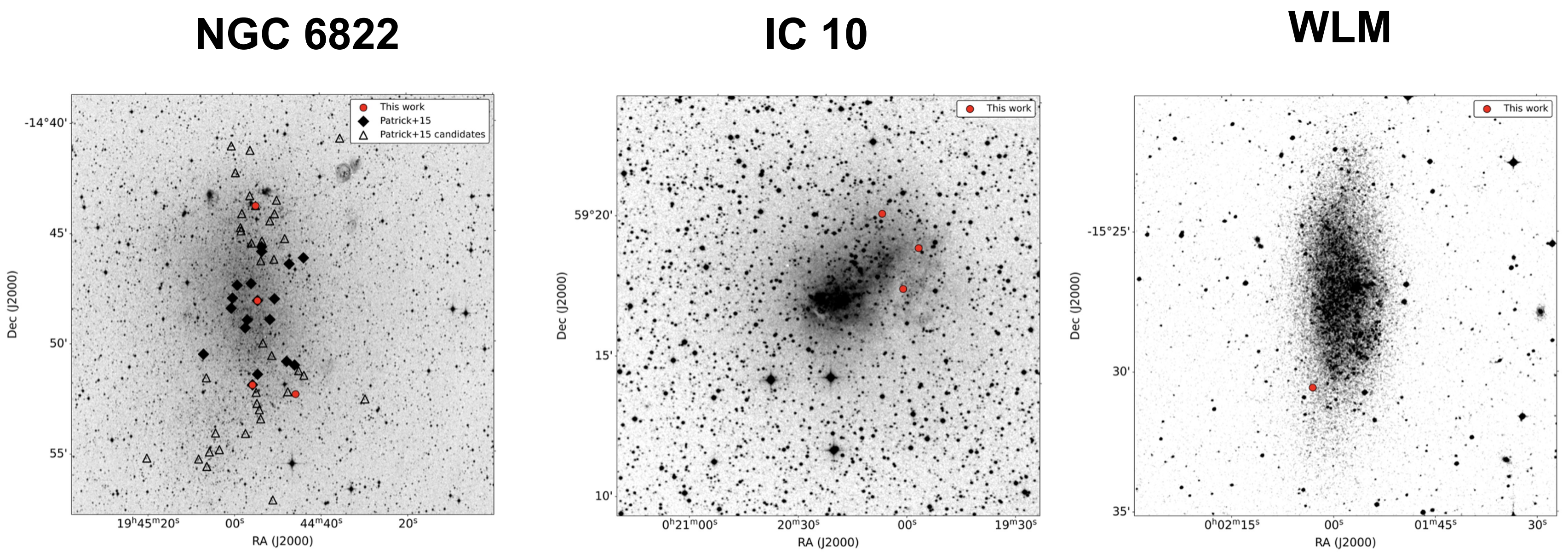

Figure 1: Spatial distribution plots showing the location of the targets within their host galaxies.

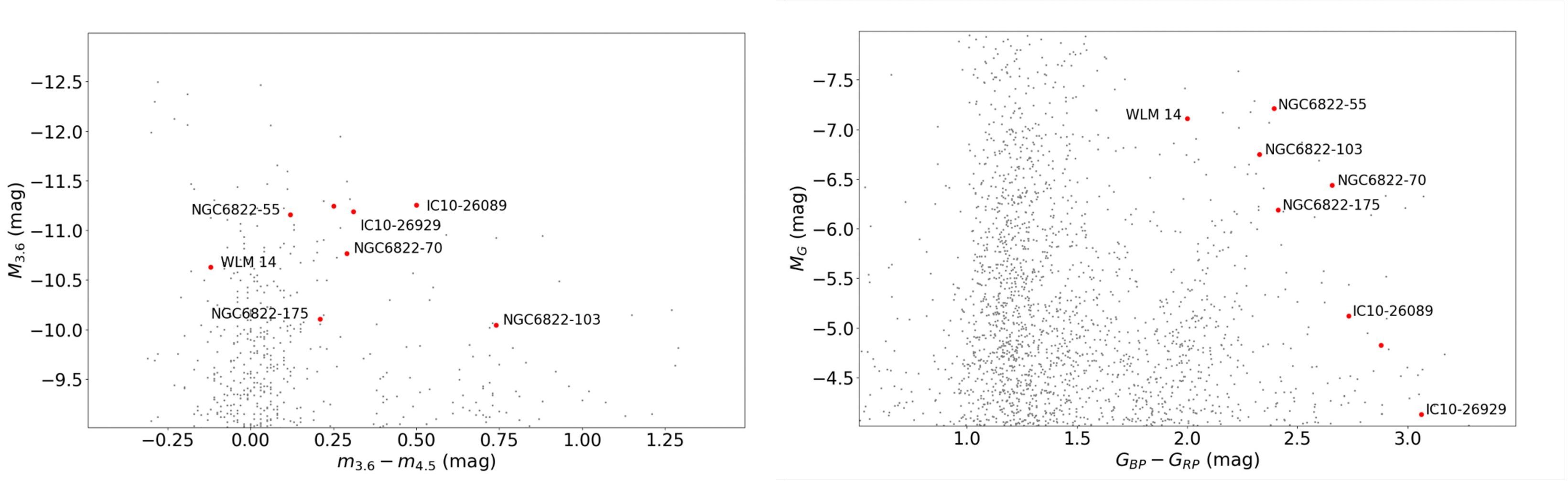

Figure 2: CMDs of our targets using *Spitzer* and *Gaia* photometry, respectively. It is evident that most of our targets show IR excess i.e. those with $m_{3.6} - m_{4.5} > 0.25$ mag, indicating that they lose significant amounts of mass. For the construction of these figures, we assumed a distance of 0.48 Mpc to NGC 6822, 0.74 Mpc to IC 10 and 0.96 Mpc to WLM to obtain the absolute magnitude on the vertical axis.

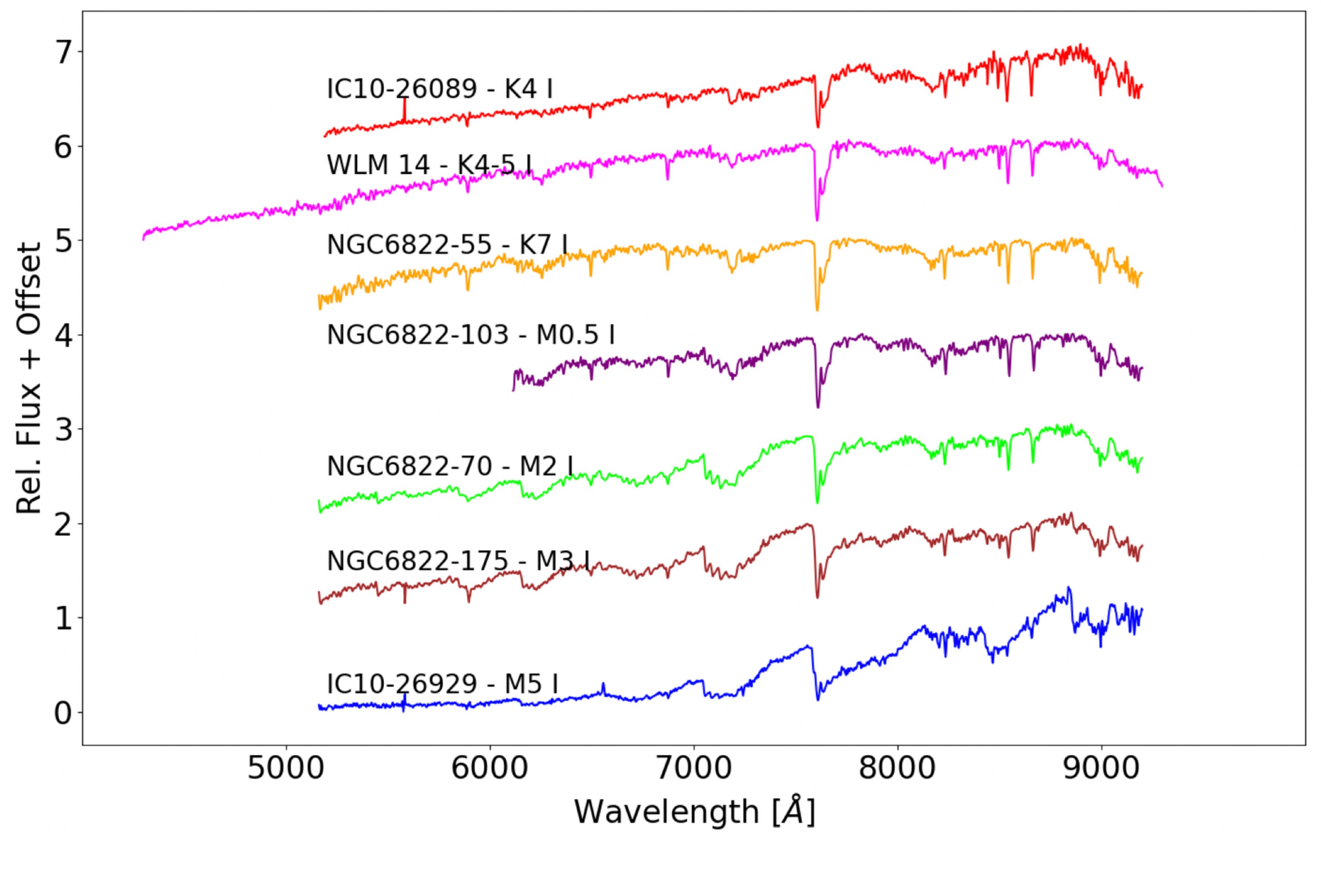

Figure 3: Optical spectra of the sources obtained using GTC/OSIRIS. The spectral type is noted. Characteristic spectral features are indicated.

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Observations

We obtained spectra with a S/N~15 and R~3,200. Targets NGC6822-55 and NGC6822-175 were observed and classified in the near-IR by Patrick et al. (2015; RSG11 and RSG09, respectively). We observed them to search for spectral variability. We used the EMIR dedicated pipeline (Garzon et al. 2022) for the reduction, Molecfit (Smette et al. 2015) for the telluric correction. The observation log is shown below. The observations took place with EMIR at GTC in 2022 using the *J* grism and the *J* filter in long-slit mode (PI: D. Garcia Alvarez).

Name	RA (J2000)	Dec (J2000)	Obs. Date	$m_{3.6}$ (mag)	$m_{4.5}$ (mag)	J (mag)	r (mag)	G (mag)	Texp. (s)	Airmass	S / N	Sp. Type
IC10-26089	00 20 03.687	+59 18 13.91	2022-09-09	13.1	12.6	15.5	19.7	19.2	2280	1.30	4	K4 I
IC10-26929	00 20 10.622	+59 20 53.10	2022-09-10	13.2	12.9	15.8	21.3	20.2	3360	1.17	6	M5 I
NGC6822-103	19 44 46.666	−14 52 25.35	2022-09-10	13.4	12.6	13.8	16.8	16.7	960	1.39	17	M0.5 I
NGC6822-55	19 44 56.616	−14 51 58.71	2022-10-11	12.2	12.1	13.3	16.5	16.2	960	1.40	32	K7 I
NGC6822-70	19 44 55.558	−14 43 50.53	2022-10-12	12.6	12.4	13.9	17.4	17.0	960	1.56	15	M2 I
NGC6822-175	19 44 55.412	−14 48 10.11	2022-10-11	13.3	13.1	14.4	17.4	17.3	960	1.60	14	M3 I
WLM 14	00 02 03.043	−15 30 34.20	2022-12-19	14.3	14.4	15.3	17.9	17.8	3360	1.40	11	K4-5 I

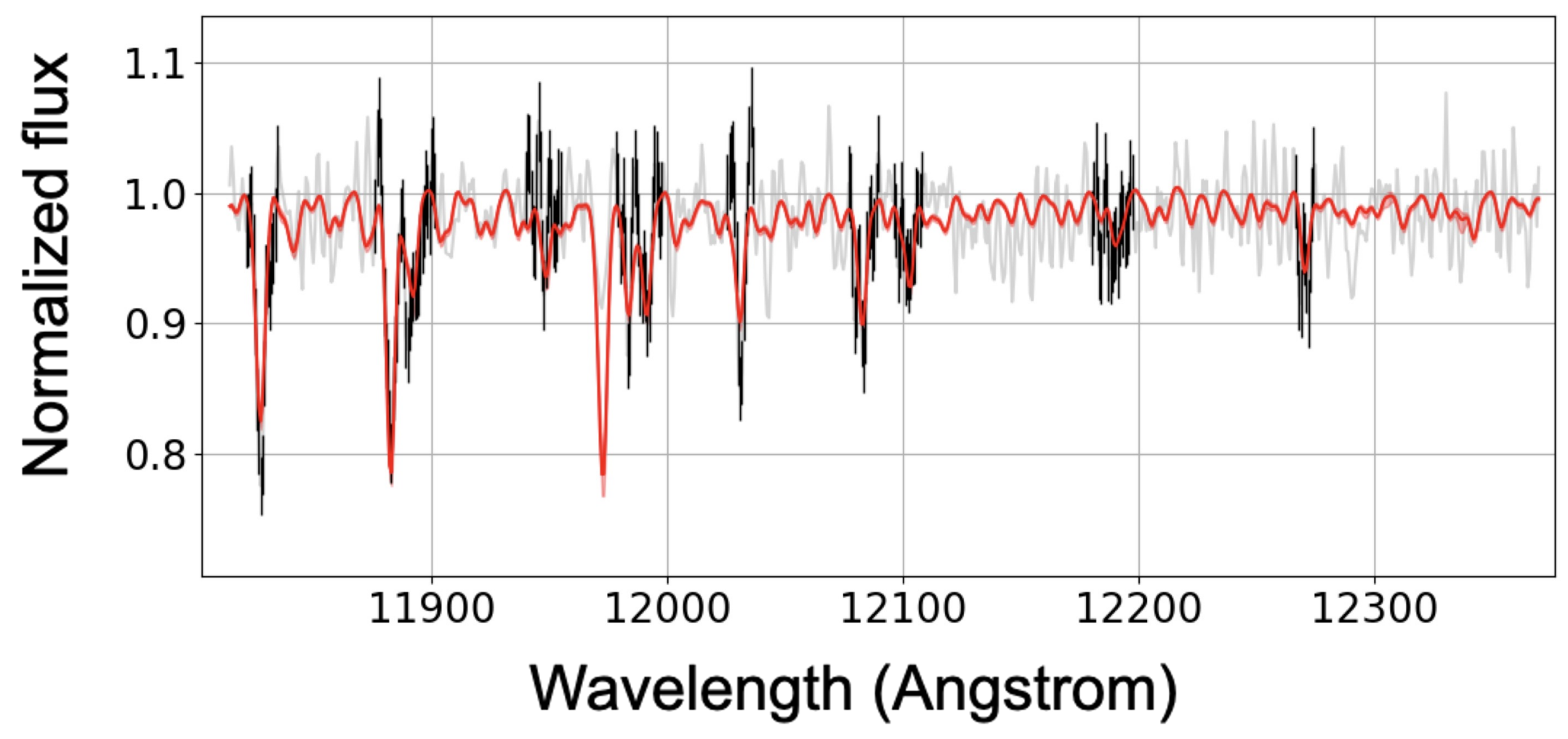
Modeling

We use the NLTE MARCS models to obtain the atmospheric parameters. Our grid consists of around 14,000 models. We fit for six parameters: Teff, log g, [Fe/H], ξ, RV and amplitude. The range in the parameters used span:

- 3300 ≤ Teff ≤ 4500 K with a step of 100 K,
- -0.5 ≤ log g ≤ 0.5 dex with a step of 0.1 dex,
- -1.0 ≤ [Fe/H] ≤ 0.0 dex with a step of 0.1 dex,
- 2.0 ≤ ξ ≤ 6.0 km/s with a step of 0.5 km/s

The range of the RV depends on the location of the target within the host galaxy and range of amplitude depends on the correction to the normalization needed per spectrum.

We select spectral windows around the crucial spectral diagnostics. We use UltraNest (Buchner et al. 2021) to obtain best fit physical properties. An example spectrum, reduced and corrected for telluric line absorption and modelled using NLTE MARCS models is shown below.



Results

We present some first results of the NLTE MARCS modeling. The dominant spectral features, due to metallic lines of Fe I, Mg I, Si I and Ti I, are indicated. The shaded band indicates the one sigma uncertainty. We model these lines to obtain the effective temperature (Teff), surface gravity (log g), [Fe/H], ξ, RV and amplitude.

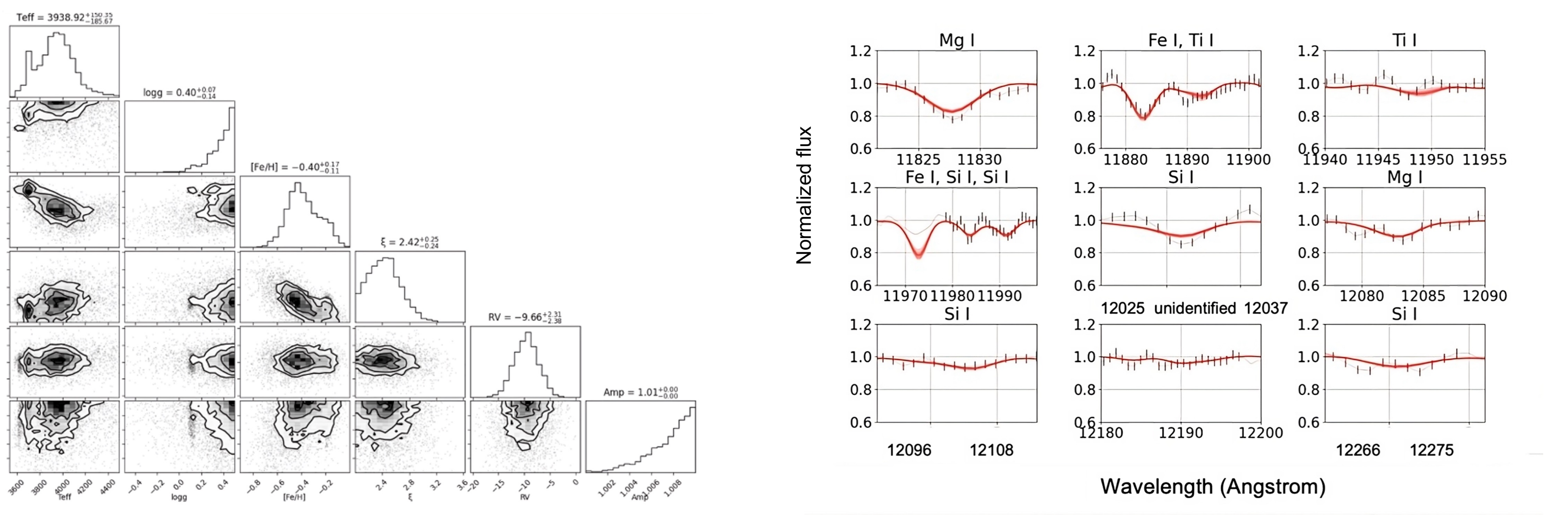


Figure 4: *Left:* Corner plot containing the best fit parameters and the statistical relation between them. *Right*: Spectral line fit showing the quality of the fit per line.

References

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