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Towards a better determination of stellar parameters in the pre-main sequence phase

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Abstract

Large scale spectroscopic surveys are providing, for the first time, robust samples of young stars spectra, which may allow us to understand the origin of current Galactic disk populations and to increase the precision with which we study the pre-main sequence stage of stellar evolution.

Resumen

Los sondeos masivos de espectroscopía proveen, por vez primera, muestras robustas de espectros de estrellas jóvenes, que podrían ayudarnos a entender el origen de las poblaciones actuales en el disco Galáctico, asi como mejorar la precisión con la cual entendemos la fase de pre-secuencia principal de la evolución estelar.

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In the last 10 years, large-scale multi-object fiber spectroscopic surveys (e.g. Gaia-ESO, GALAH, SDSS APOGEE-2), combined with Gaia parameters have allowed us to study the detailed properties of stellar populations. Young stars in our Galaxy allow us to understand the origin population of the galactic disk. Was it similar to what we currently find in nearby star-forming regions? More important: Can these databases help us to characterize the Pre-Main Sequence (PMS) stage of stellar evolution? How robust are the samples we need to allocate the precision to understand parameter variations in terms of complex physical processes like accretion, variability and others?

SDSS APOGEE spectrographs (R$\sim$22500, $1.5 < \lambda < 1.7$ μm) provide radial velocities near 0.1 km/s precision, can penetrate through dusty regions, and allow to map relatively crowded population using multiple visit schemes. The SDSS Milky Way Mapper (MWM) survey now also includes BOSS R$\sim$3000 $0.3 < \lambda < 0.9$ μm optical observations, which improve spectral type classification and provide stronger accretion features. By SDSS DR17-18, a number of important star-forming regions and young cluster regions were explored, yielding a few thousand of YSO spectra Román-Zúñiga et al. (2023). The MWM will increase the sample by one order of magnitude in the next few years.

State of the art software makes use of powerful neural networks (Sprague et al., 2022) to determine the best sets of spectral parameters (T_{eff}, $\log g$, v_{rot}, v_R, [Fe/H]) using spectral label compilations. While this approach is powerful, the direct comparison of spectra and synthetic models allows more precision, specially towards the determination of detailed chemical abundances and the characterization of effects like extinction and circumstellar veiling.

Our code `TONALLI` (Adame et al., 2024) uses the Asexual Genetic Algorithm of Cantó et al. (2009) to locate and interpolate the best possible model from a grid that provides a set of parameters from an APOGEE spectra. Our approach includes a machine learning routine to assign spectro-photometric priors from PMS evolutionary models, which reduces model dependencies, especially for $\log g$.

Our work with `TONALLI` is currently allowing us to determine chemical abundances in young stars of the solar neighborhood. Our calibration sample is composed of main sequence stars within 100 pc from the Sun (López-Valdivia et al., 2024). Our main goal is to be able to produce a catalog of chemical abundances in nearby (up to 2 kpc from the Sun) star-forming regions and understand how they deviate (or not) from Solar abundances.

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