XTGRID live: Online spectral analyses with TLUSTY models

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Properties of XTGRID

XTGRID is a general purpose stellar spectral analysis procedure to fit multi-wavelength observations. It is a chi-square minimizing program that attempts to reproduce diverse spectral observations of a target using a single model.
We have been developing XTGRID for a decade in the domain encompassing hot, evolved, compact stars, peculiar objects, and binaries. The work has started with the motivation to do quantitative X-ray spectral analyses for the hottest known stellar objects: super-soft sources. Later the stream of development has shifted toward hot compact objects such as white dwarfs and hot subdwarfs. Many of these objects are in binaries with cool companions, which added spectral disentangling procedures for non-interacting binaries and irradiation spectroscopy for reflection effect binaries to the development.
XTGRID wraps around the non-LTE model atmosphere suite TLUSTY/SYNSPEC (Hubeny & Lanz 2017, http://nova.astro.umd.edu/) and serves as an interface to utilize these models in automated spectral analyses. All models are calculated by the iterative procedure in the direction of decreasing chi-squares, seeking for a global minimum. In addition, auxiliary spectral models of different kinds (ATLAS, PHOENIX, OWENS, etc.) can be included depending on the objective of the analysis.
XTGRID was designed to carry out fully automated data analyses. This feature inspired us further to build a web-service, which allows for the operation of the procedure online. The user needs only to upload their observed spectrum, set a few data parameters, like resolution and signal-to-noise, and the calculations are performed on our servers within a day, assuming H, He, C, N, and O model composition and a sufficient convergence rate. An interactive mode (supervised modeling) is also available, which allows users to change parameters and guide the fit procedure in real time.

Precision spectroscopy of individual objects

The complexity of flux redistribution due to non-LTE radiative transfer in metal rich atmospheres needs lengthy calculations with all major opacity sources present. The partially burnt supernova remnant LP40-365 (Vennes et al. 2017) is an extremely metal rich low mass cool white dwarf and a good example for complex applications of XTGRID.

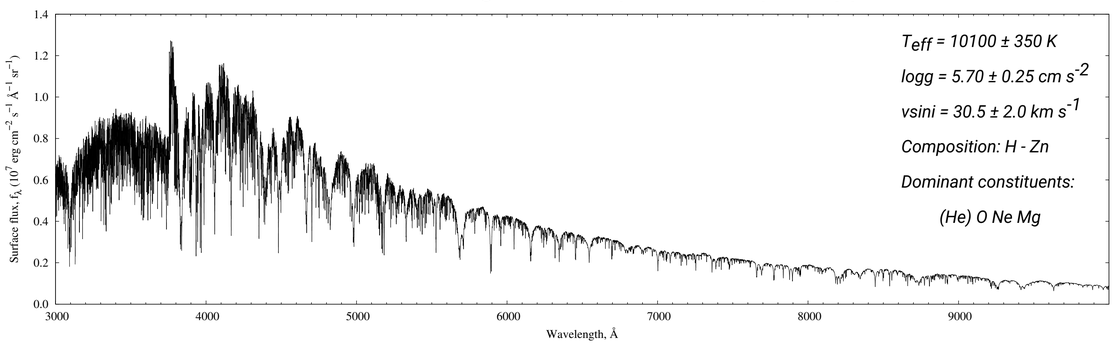

Figure: TLUSTY model for LP40-365. The atmosphere of the hypervelocity supernova remnant is dominated by metals.

Spectroscopy of large samples

Large spectroscopic surveys are excellent resources to search for homogeneous observational data for any stellar types. Such data sets are best analysed with global methods to exploit their homogeneity and reduce systematics in the results.

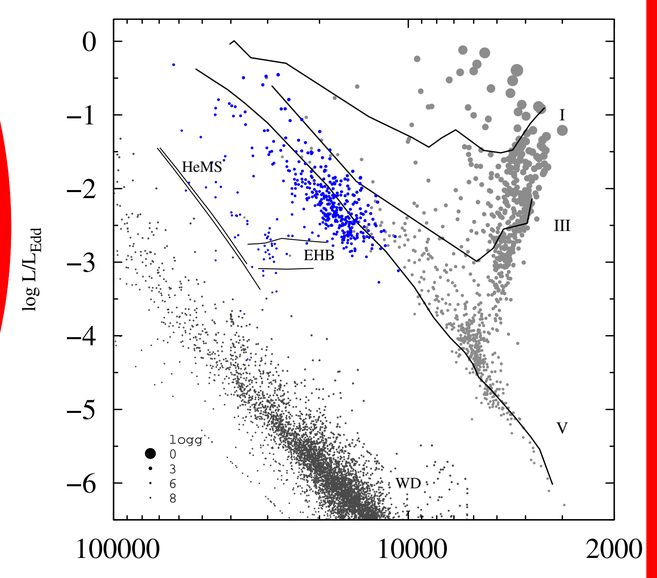

Figure:
The blue data points are upper main-sequence stars from LAMOST.

Binary spectral decomposition

The spectra of non-interacting binaries can be relatively easily analysed by co-adding two stellar models. Such a spectral decomposition has been included in XTGRID and applies two TLUSTY models for hot star binaries, or a TLUSTY model and an LTE spectrum for hot stars with cool companions. The LTE spectra are extracted from public libraries of synthetic spectra.
The high level of degeneracy among the stellar and binary parameters is a major problem in decomposition. To overcome these, we use a combination of flux calibrated low-resolution spectra and high-resolution data to infer the individual stellar properties and their contribution to the composite spectrum.

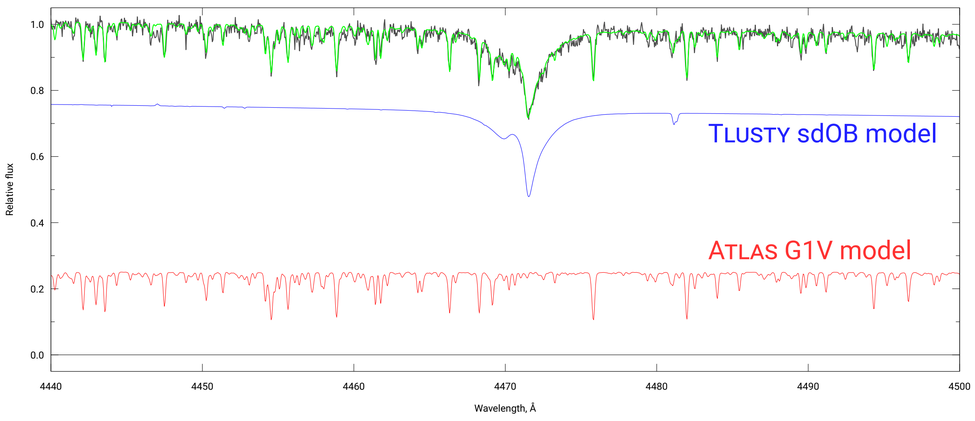

Figure: XTGRID spectral decomposition of the sdOB+G1V type binary SB 744 (MCT 0146-2651) by Vos et al. (2018). The sum (green line) of the TLUSTY sdOB model (blue line) and the ATLAS G1V model (red line) fits the VLT/UVES observation (dark-grey line) well.

Simultaneous Ultraviolet-Optical-Infrared (UVOIR) spectral modeling

A precise parameter determination requires the knowledge of the radiation field as well as the composition and structure of the stellar atmosphere. Because the spectral energy distributions of the majority of stars peak in the UVOIR spectral range, a combination of data from different instruments are necessary to derive their accurate surface parameters.

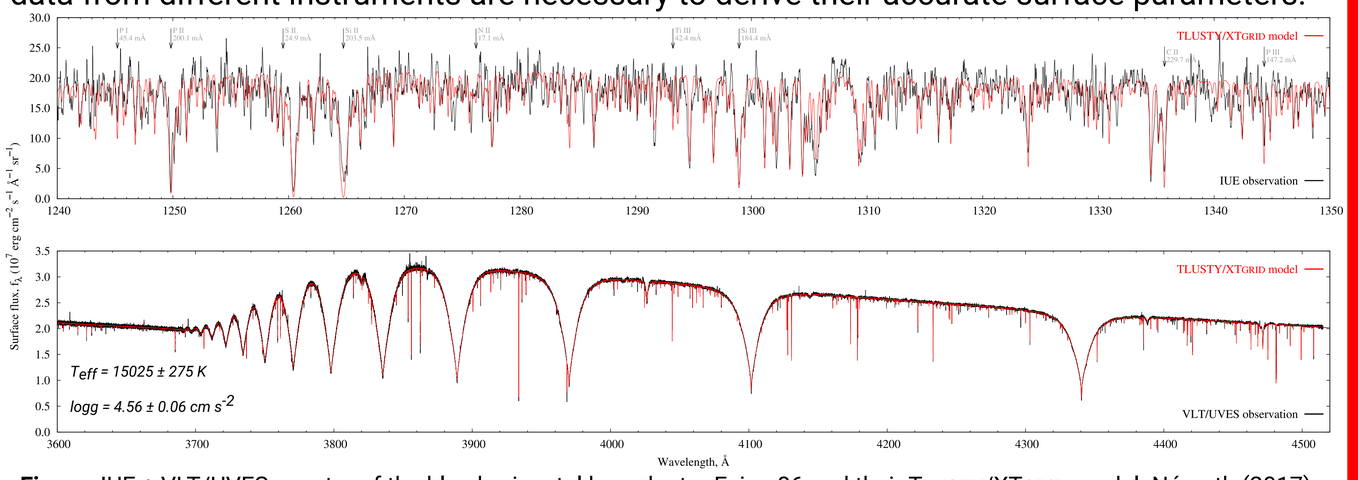

Figure: IUE + VLT/UVES spectra of the blue horizontal branch star Feige 86 and their TLUSTY/XTGRID model. Németh (2017)

Availability and Acknowledgements

The current production version of XTGRID (v32) is actively maintained and made available through the online Sandbox services of Astroserver.org at: **www.xtgrid.astroserver.org/sandbox**
Our goal is to improve XTGRID and fully integrate it with the capabilities of TLUSTY. Along this line, future developments will include a revision of the atomic data input (model atoms and line list), new analysis techniques for stratified atmospheres and accretion disks. Such new methods will be added to the web-service as they become available.
Browse the Astroserver web site for news, more examples and further references.

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References

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◦ XTGRID - Németh, Kawka, Vennes 2012, MNRAS 427, 2180
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