12th Hel.A.S Conference
Thessaloniki, 28 June - 2 July, 2015
CONTRIBUTED POSTER

Automated spectroscopic data reduction applied on stellar classification

L. Tzouganatos[1] *and K. Gazeas*[1]
[1] Department of Astrophysics, Astronomy and Mechanics, University of Athens, GR 15784 Zografos, Athens, Greece

Abstract: A spectroscopic program towards a complete atlas of spectroscopic standards is carried out at the University of Athens Observatory. Processing a large amount of data would be both ineffective and time consuming. Therefore, in order to minimize manual interaction and increase effectiveness, an automated spectroscopic data reduction script was developed. For testing the automated reduction procedure, we applied the script on stellar spectral classification. The results are very promising for stellar objects with apparent magnitude down to 9 mag with a 0.4 m telescope.

1 Introduction

The medium resolution stellar spectrograph used in this study was constructed at the Laboratory of Astronomy and Applied Optics at the University of Athens [2] and modified accordingly a few years later, in order to increase its spectral resolution (R=10.000) and be installed on large telescopes [3]. This work aims towards the extension of instrumental capabilities, in terms of software development and automation techniques. The ultimate goal of this study is to create a large database of spectroscopic standard stars in the entire range of luminosity classes and spectral types.

2 Code development and data acquisition

Automated scripts were developed under MATLAB environment (version R2013a). They are written in such a way that the user can process stellar spectra concurrently with their corresponding calibration images in order to reduce, normalize and calibrate the stellar spectrum under process. The code is capable to reduce a raw 2-D spectrum in .fit/.fts format, as well as a scanned 1-D spectrum (spectrophotometric measurements) in ASCII format. It can extract information from image header such as the exposure time and temperature of each raw spectrum and proceed with image reduction. Therefore the reduction process is independent to the instrument or telescope used for obtaining the spectra.

A set of spectroscopic standards was selected, taking into consideration archival database of spectroscopic standard stars [1]. The sample covers the entire MS and a large part of all the remaining luminosity classes, except white dwarfs, due to their very faint magnitude limit. The spectroscopic standards are bright, in order to eliminate noise and increase S/N ratio. Therefore the sample contains spectroscopic standards with apparent magnitude ranging between $0 < m_v < 6$. Spectroscopic observations were carried out from the University of Athens Observatory with a 0.40 m f/8 Cassegrain telescope. A total of 150 stellar spectra were collected over a period of one week in April-May 2015.

3 Data reduction process

Spectra are stored in a single folder, where the script is prompted to look at. Data reduction is taking place in the following steps: The code detects calibration images (utilizing Ne, Xe or Hg calibration lamps) and a specially created database of standard spectral lines, as well as their corresponding dark frames, and proceeds with reduction. The spectrum is isolated, scanned and transformed in a ASCII

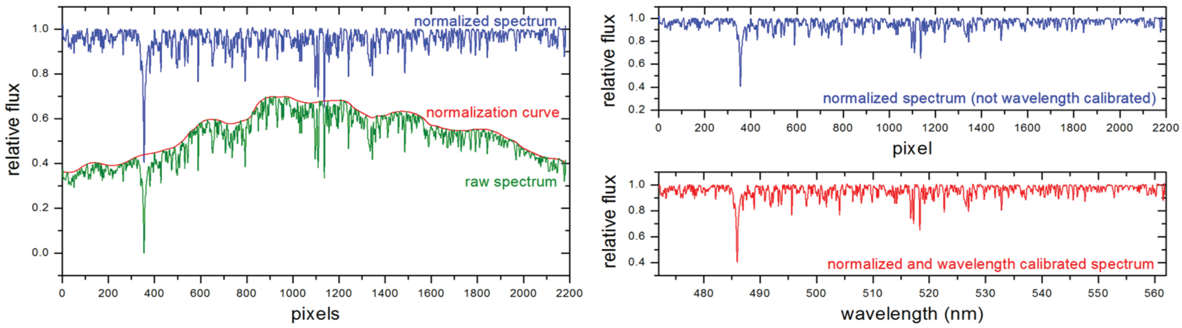

Figure 1: Applying the carefully selected normalization points on the raw scanned spectrum, a smooth curve can be created (bottom-left) and the spectrum can be normalized (top-left). The normalized spectrum (top-right panel) can be therefore wavelength calibrated (bottom-right panel) with the use of the known spectral lines of Ne (or alternatively Hg and Xe) calibration lamps.

file and then it is flux normalized and wavelength calibrated, using the reference calibration lamps. The resulted normalized and calibrated stellar spectrum is stored in ASCII format (.txt) for further use and measurements Fig.1. Flux normalization and reference line detections are obtained interactively by the user. The code asks the user if the current result is acceptable for further analysis. If not, the user can repeat the last step and proceed with the rest accordingly. Processing duration is determined basically from the interactive steps. Depending on the spectrum and line density, normalization point selection can take approximately 1 min. The rest steps follow almost instantly. Adding the loading time of the files in the whole process, the overall processing duration is kept well below 5 min.

4 Conclusion and future plans

The developed code is flexible to reduce, normalize and calibrate all kinds of 2-D or 1-D spectra. It can process a large number of spectra in a short time and perform spectroscopic measurements. The whole process is automatic, interfering with the user only when needed (performing manually some steps or making decisions). With minor modifications the developed scripts can perform automated, pipe-line spectral reduction of wider range of data, obtained with various telescopes in a uniform way. Pipe-line reduction reduces significantly processing time, while minimizes manual interaction and increases effectiveness. The code is tested on spectral classification with very promising results on stellar objects with apparent magnitude down to 9 mag with a 0.4 m telescope. As the observations of standard stars continue, more spectra are added to the atlas, covering eventually the entire range of spectral types and luminosity classes. Stellar classification can also be easily performed by measuring the spectral line-depth ratio and they can be used for scientific purposes. This is a common method used in several applications, where the temperature dependent spectral features are traced. This method expects to provide accurate results of less than half of a spectral type [3]. For example, the F4V spectroscopic standard star HIP 96411 was treated as an unknown in this study and compared with the spectral created database. It was indeed found to be of F4V spectral type (actually F3.98$\pm$0.4), reaching the expected accuracy of our method. Future applications and code developments include radial velocity measurements of single and binary stars, which is currently a by-product of data reduction. The final outcome will be the development of executable software with a user-friendly interface, for performing all the above processes.

References

[1] Corral, L. J., Navarro, S. G., Pea, J. H., Peniche, R., & Hirata, I., 1994, ASPC, 60, 25

[2] Gazeas,K.D., Papathanassoglou,D.A., 2007, HEL.A.S. Conference, Thasos, Greece

[3] Gazeas, K. D., Papathanassoglou, D. A., 2010, ASPC, 424, 433