FUV Spectroscopy of the Central Star of Sh 2-216

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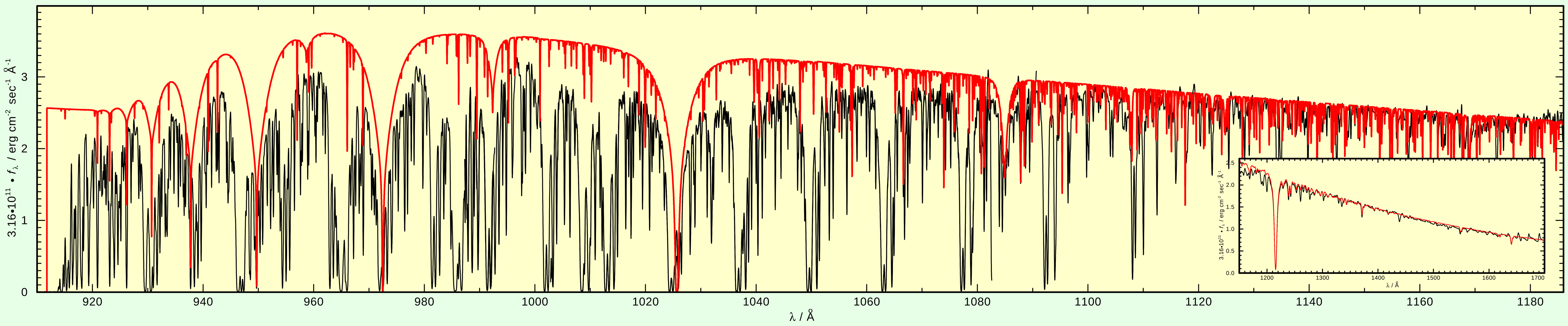

Fig. 1. FUSE observation of LS V +46°21 compared with a NLTE model-atmosphere spectrum which is normalized to match the flux level of a HST STIS observation (see the window on the right). The neutral hydrogen density is log n_{HI} = 19.93, and a reddening of E_{B-V} = 0.065 is applied. Note that the deviation between observation and photospheric spectrum is due to ISM line absorption.

Abstract

We present preliminary results of a NLTE spectral analysis of the FUV spectrum of LS V +46°21, the central star (CS) of the planetary nebula (PN) Sh 2-216. The FUSE spectrum is strongly contaminated by interstellar absorption and thus, we have to simultaneously model both, the stellar as well as the interstellar spectrum in order to identify strategic metal lines which are only accessible in the FUV wavelength range and necessary to determine the photospheric parameters reliably.

Introduction

Sh 2-216 (Fig. 2) is the closest (d = 129 pc, Harris et al. 2007) PN known. It is also amongst the most extended and, thus, oldest PNe. In a recent spectral analysis (see Rauch et al. 2007 for details), we aimed to identify individual iron-group lines, and determine their abundances as well as the effective temperature (T_{eff}), and the surface gravity. For this purpose we used high-resolution UV spectra obtained with FUSE and HST/STIS, respectively, because all strategic iron-group lines are located in this wavelength range.
It turned out that the FUSE observation (914 - 1187 Å, Fig. 1), is highly contaminated by interstellar absorption and, thus, modeling of the absorption of interstellar lines was necessary (cf. Oliveira et al. 2007 for details) in order to identify photospheric lines.

Fig. 2. Composite H α (600 min, red) and [O III] 5007 Å (180 min, green) image of the PN Sharpless 2-216 (Dean Salman, www.galaxies.com).

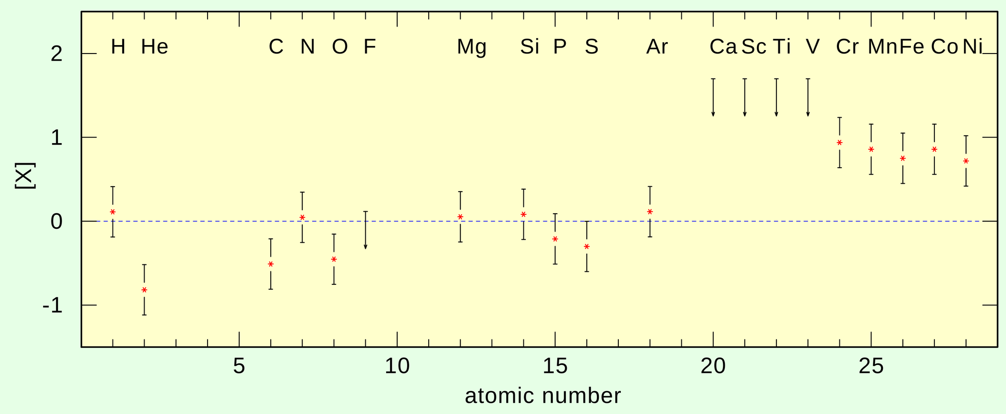

Fig. 3. Photospheric abundances of LS V +46°21 (T_{eff} = 95.0 +/− 2.0 kK, log g = 6.9 +/− 0.2 (cgs)). [X] denotes log (abundance / solar abundance). For Ca, Sc, Ti, and V only upper limits have been determined because no Kurucz's POS lines (Kurucz 1996) can be identified in the STIS observation while the FUSE observation is too-strongly contaminated by ISM absorption.

TMAP: The stellar photospheric model

We used the Tübingen Model Atmosphere Package (TMAP, Werner et al. 2003) to calculate plane-parallel, hydrostatic NLTE model atmospheres in radiative equilibrium. These consider the opacities of the elements H, He, C, N, O, F, Mg, Si, P, S and Ar, as well as the so-called iron-group elements (Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni). For H – Ar "classical" model atoms are used, whereas the iron group had to be treated with a statistical approach (cf. Rauch & Deetjen 2003), in order to handle the large number of atomic levels and line transitions.
We are able to reproduce about 95 % of all photospheric lines in the STIS wavelength range as well as all identified isolated photospheric lines in the FUSE range (Fig. 4).

OWENS: The ISM absorption model

We used the OWENS program, to calculate the interstellar absorption. This program allows to model different interstellar clouds taking into account different radial and turbulent velocities, temperatures, chemical compositions, as well as column densities for each element included (cf. Oliveira et al. 2007 for details).
We have calculated a normalized ISM absorption spectrum which is multiplied with the model-atmosphere spectrum. We are able to reproduce almost all parts of the FUSE observation and can unambiguously identify the pure photospheric absorptions (e.g. Fe VII 1073.9 Å, Fig. 4). These are used then to fine-tune the parameters of our model-atmosphere calculations.

Results and conclusions

With TMAP and OWENS, we can precisely model both, the photospheric spectrum of LS V +46°21 (see Fig. 3 for its photospheric parameters) as well as the interstellar absorption in the line of sight (Fig. 4, Oliveira et al. 2007), respectively.

The inclusion of the ISM absorption model in the FUV spectral analysis of hot stars further improves the reliability of the determination of photospheric parameters and vice versa.
It is highly desirable to establish this procedure as a standard tool in future spectral analyses.

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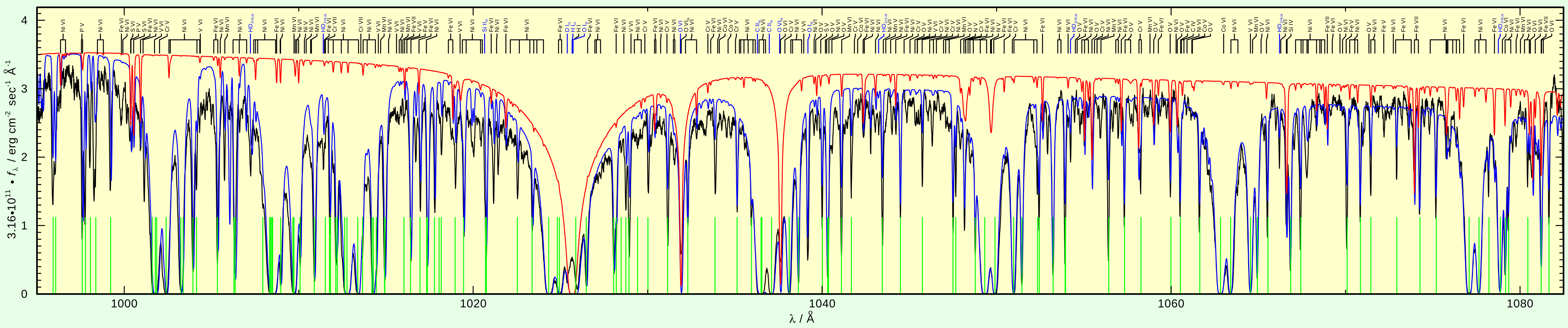

Fig. 4. Comparison of a section of the FUSE observation (black) with spectra of the pure photospheric model (red) and of the combined ISM + photospheric model (blue). Photospheric lines and interstellar lines are indicated at the top. The green marks at the bottom indicate interstellar H_2 absorption lines.

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