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UV Spectroscopy including ISM line absorption: of the Exciting Star of Abell 35

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Reliable spectral analysis that is based on high-resolution UV observations requires an adequate, simultaneous modeling of the interstellar line absorption and reddening. In the case of the central star of the planetary nebula Abell 35, BD–22 3467, we demonstrate our current standard spectral-analysis method that is based on the Tübingen NLTE Model-Atmosphere Package (TMAP). We present an ongoing spectral analysis of FUSE and HST/STIS observations of BD–22 3467.

UV Spectroscopy Including ISM Line Absorption: The Exciting Star of Abell 35

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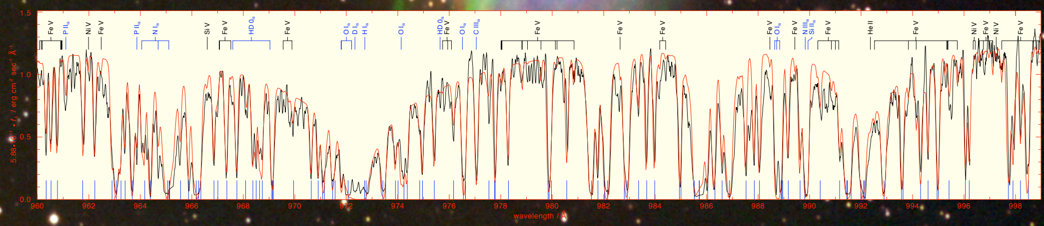

Fig. 1. Section of the FUSE observation (black) of BD−22 3467, the exciting star of A 35. A combined synthetic spectrum (photospheric and ISM, red) shows good agreement with the observation. The blue marks at the bottom indicate interstellar H_2 lines.

Abstract

Reliable spectral analysis that is based on high-resolution UV observations requires an adequate, simultaneous modeling of the interstellar line absorption and reddening.

In the case of the exciting star of Abell 35, BD−22 3467, we demonstrate our current standard spectral-analysis method that is based on the Tübingen NLTE Model-Atmosphere Package (TMAP).

We present preliminary results of an ongoing spectral analysis of FUSE and HST/STIS observations of BD−22 3467.

Abell 35

A 35 was discovered in 1966 (Abell) and was classified as a planetary nebula. Recently it turned out to be a bowshock nebula inside a photoionized Strömgren sphere in the ambient ISM (Frew & Parker 2010; D. Frew, priv. comm.). It is located at a distance of $D = 163^{+96}_{-58}$ pc (HIPPARCOS, Perryman et al. 1997; Gatti et al. 1998). It is a resolved binary system (Jacoby 1981; De Marco 2009) composed of a DAO type exciting star and a G8-type companion dominating the spectrum longward of 2800 Å (Herald & Bianchi 2002). Herald & Bianchi calculated NLTE model atmospheres and derived $T_{\mathrm{eff}} = 80$ kK and $\log g = 7.7$ for the exciting star. They also determined element abundances for H, He, C, N, O, Si, and Fe. Subsolar values of at least 2 orders of magnitude are reported for C, N, O, Si, and Fe. For the companion star they used model atmospheres calculated by Kurucz (1991) and found a best fit for $T_{\mathrm{eff}} = 5$ kK and $\log g = 3.5$.

A new spectral analysis method

In an on-going spectral analysis by means of NLTE model-atmosphere techniques, we aim to determine abundances of individual iron-group elements and to use their ionization equilibria to determine the effective temperature (T_{eff}) precisely. All strategic iron-group lines are located in the far and near ultraviolet and thus, we use FUSE and STIS (Space Telescope Imaging Spectrograph) spectra. Unfortunately, the FUSE wavelength region (904 – 1188 Å) is highly contaminated by interstellar absorption, thus masking the photospheric information. A pure photospheric model atmosphere does not fit the observation satisfactorily (Fig. 2). Therefore modeling the interstellar absorption features is a prerequisite for a reliable analysis of the photospheric parameters.

We employed TMAP (Werner et al. 2003; Rauch et al. 2003) for the calculation of photospheric NLTE model atmospheres. For the calculation of the interstellar features we applied the OWENS programm. OWENS takes into account different radial and turbulent velocities, temperatures, chemical compositions, as well as column densities for each element included (for a detailed description, see Oliveira et al. 2006). Our method of combined photospheric + ISM model atmospheres allows to improve both models iteratively.

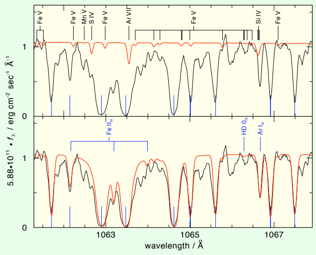

Fig. 2. Section of the FUSE observation (black line) of BD−22 3467 compared with a pure photospheric model spectrum (upper panel) and a combined photospheric + ISM model (bottom). Only a combined spectrum gives a good fit to the observation. The blue marks at the bottom indicate interstellar H_2 absorption lines.

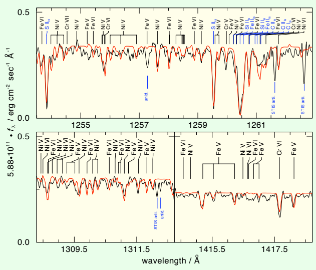

Fig. 3. Three sections of the STIS observation of BD−22 3467. The spectrum is rich in Fe and Ni lines, but also Cr lines can be found. Our preliminary abundance determination gives [Cr] = 1.26, [Fe] = 0.0, and [Ni] = 1.0.

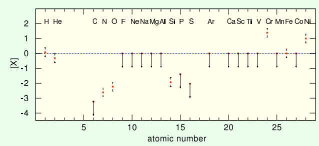

Fig. 4. Preliminary photospheric abundances of BD−22 3467. Arrows indicate upper limits, the blue dashed line indicates solar abundances.

Available Spectra

The FUSE observation (OID: P1330101000) was retrieved from the MAST archive and was performed on May 20, 2000. The observation covers a wavelength range of 915 – 1180 Å with a resolution of ≈ 0.05 Å. The HST/STIS observation (OID: O4GT02010) covers the range from 1140 – 1730 Å with an average resolution of ≈ 0.06 Å.

Results

An evaluation the O IV – VI and Fe V – VII ionization equilibria confirms the parameters derived by Herald & Bianchi (2002, $T_{\mathrm{eff}} = 80.0 +/- 10$ kK, $\log g = 7.7 +/- 0.3$). In contrast to Herald & Bianchi, who found Fe to be $0.1 < X_{\mathrm{Fe}} < 0.5$ with respect to the solar values, we find Fe to have a solar abundance. A difficult task is the determination of the C abundance. In the FUSE and STIS range no C line is visible in the observation. The C IV 1548.2, 1550.8 Å doublet is blended by the ISM and therefore inappropriate for a reliable abundance determination. From the absence of the 1168.8 Å line, an upper limit of roughly [C] < −3.2 can be found ([X] denotes log[mass fraction / solar mass fraction]. The solar abundances are taken from Asplund et al. 2009).

For the first time upper abundance limits for P and S were detemined in this object. We find [P] < −1.4, and [S] < −2. Also Ni ([Ni] = 1.0) and Cr ([Cr] = 1.4) abundances could be determined. Fig. 4 shows our preliminary abundances for BD−22 3467.

Although we have modeled the interstellar absorption as well, we did not find any stellar lines previously hidden behind IS lines in the entire range (915 – 1730 Å). Nevertheless we were able to reproduce nearly all features in the observation. Fig. 1 shows the good agreement between the FUSE spectrum and a combined photospheric + ISM model atmosphere.

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Poster presented at APN5: The Shaping of Stellar Ejecta, Bowness-on-Windermere, England, June 20 – 25, 2010