# NITROGEN ABUNDANCE FROM THE ULTRAVIOLET NH BANDS

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ABSTRACT. Data for NH bands region $\lambda$ 336 nm from CD-ROM's N1 and N18 of Kurucz's database are tested and corrected using the spectrum of the Sun as a star. The nitrogen abundance indicators are selected for spectral resolutions $\delta_g$= 0.0025 nm and 0.02 nm. Using this indicators we derived [N/Fe] = 0 in atmosphere of K0 giant $\gamma^1$ Leo. The accuracy of nitrogen abundance estimations is considered.

**Key words:** cool stars, stellar atmospheres, CNO abundances, synthetic stectra

## Introduction

The nitrogen abundance A(N) in atmospheres of cool stars is usually obtained using spectra of nitrogen-contained molecules. Absorption lines of NH are the most preferable for this goal, because ones do not show a dependence on abundances of carbon and oxygen as well on the C/O ratio. Unfortunately NH bands lie in UV and IR spectral regions which are unconvinient for observations and complicated for theoretical modeling.

Modern databases for the stellar spectroscopy give new possibilities for the more realistic theoretical modeling of cool star spectra even for $\lambda < 450$ nm. If they are used for abundance determinations one must first select suitable spectral features (the indicators of the element abundance). We carried out the study of the nitrogen abundance indicators using Kurucz's data from CD-ROM's for NH bands region near $\lambda$ 336 nm.

## Procedure

We tested the data for region $\lambda$ 336 nm using a comparison of computed synthetic spectra (SS) with the observed spectrum the Sun as a star (Kurucz et al. 1984). Our SS were computed for solar model atmosphere (Kurucz 1995) with microturbulent velocity $V_t$ = 1 km/s (Gurtovenko & Kostik 1989) using WITA2 (Pavlenko et al. 1995) and STARSP (Tsymbal 1994) programs. Abundances A(C)=8.55, A(N)= 7.97, A(O)=8.87 and A(Fe)=7.54 were taken for computations. We adopted the dissociation potential $D_0$(NH)= 3.37 eV. Atomic and molecular line lists were taken from the Kurucz's (1995) database (CD-ROM's N1 (file LOWLINES.DAT) and N18, respectively). Oscillator strengths of NH lines were reduced by factor 2 following Shavrina et al. (1996). Our analysis showed that the contribution of other molecules in the opacity may be ignored in $\lambda$ 336 nm region.

LOWLINES.DAT list was created by Kurucz to realize the statistical treatment of the atomic lines opacity in stellar atmospheres. It contains together with molecular lists 58 millions measured as well theoretically computed lines. Calculated line parameters are often affected by serious errors. Therefore for SS computations in the region $\lambda$ 336 nm we reduced a length of list LOWLINES.DAT using the well-known procedure of the *lines selection.* Then, using a comparison of SS's with Kurucz et al. (1984) atlas of the solar spectrum we excluded from LOWLINES.DAT $\sim$ 100 lines with obviously wrong parameters. Afterwards the subset of LOWLINES.DAT list ($\sim$ 3000 lines) was corrected using VALD atomic lines list (Piskunov et al. 1996).

As was suggested by many authors (see Yakovina & Pavlenko 1997), there are unidentified opacity sources in UV part of cool star spectra. To model their impact on the SS we implemented *an additional continuum absorption* using a parameter $\kappa$ which enhances the continuum opacity by given factor. The best fit of the solar spectrum by SS in region $\lambda\lambda$ 334.6-337.5 nm was obtained for $\kappa$ =1.9 ± 0.1.

Voigt profiles of absorption lines were computed for Kurucz's (1995) $\gamma_2$, $C_4$, $C_6$ damping constants. For atomic lines with unknown dumping constants and molecular lines these parameters were computed following WIDTH6 formulas (see also Pavlenko & Shavrina 1986). Van der Waals broadening in solar SS was computed with a correction factor $E$ =1.5 (Gurtovenko & Kostik, 1989) for all absorption lines.

For a comparison of observed and computed solar spectra we convolved our SS with a gaussian $\delta_g$= 0.0025 nm. To obtain conclusions for lower resolutions both observed and computed spectra were convolved also with $\delta_g$= 0.02nm.

## Results

NH spectrum in region $\lambda$ 336 nm consists of bands with $\Delta v$ =0 of $A^3\Pi$ - $X^3\Sigma^-$ and $c^1\Pi$ - $a^1\Delta$ systems. The spectrum shape is formed mainly by (0-0) (near $\lambda$ 336 nm) and (1-1) (near $\lambda$ 337 nm) bands of A-X system. The fit of the observed solar spectrum by SS for resolution 0.02 nm and the nitrogen abundance indicators are shown in Fig.1. We marked also points used *to bound* computed and observed spectra and demonstrate the sensitivity of SS on A(N) value. Positions of nitrogen abundance indicators for resolutins 0.0025 nm and 0.02 nm are given in Table 1.

Using chosen indicators of A(N) we obtained [N/Fe] = 0 in atmosphere of metal-deficient ([Fe/H] ~ -0.3) K0-giant $\gamma^1$ Leo. We used the same data as Shavrina et al. (1996) and our subset of LOWLINES.DAT list. Note, new estimation [N/Fe] exceeds one in Shavrina et al. (1996) only on 0.1 dex, but this result cancels a qualitative conclusion about the nitrogen deficit in the atmosphere of K-giant $\gamma^1$ Leo.

An influence of uncertainties of values $D_0$(NH), $T_{eff}$, $lg\ g$, $\kappa$ and abundances of any metals on nitrogen abundance in atmosphere of $\gamma^1$ Leo was studied in paper (Shavrina et al. 1996). Authors concluded that the alone parameter $D_0$(NH) can lead to serious uncertainty of A(N). In this work a dependence of our results on completeness of line list was considered. We found:

– the lack of large amount of weak absorption lines in SS can lead to the nitrogen abundance underestimation;

– the effect becomes more strong for lower spectral resolutions;

– for Sun and K0 giant $\gamma^1$ Leo effect is weak, namely $\Delta$ [N/H] ≤ 0.1 dex.

Taking into account all factors discussed above, we estimate the accuracy of our nitrogen abundance determination using UV bands of NH as $\Delta$ [N/H] ≤ 0.2 dex.

Table 1. UV nitrogen abundance indicators in the solar spectrum.

| $\delta_g$= 0.0025nm | | $\delta_g$=0.02 nm | | |
|---|---|---|---|---|
| $\lambda_{min}$ | $r_{min}$ | $\lambda_{min}$ | $r_{min}$ | $\lambda_{max}$ |
| 334.733 | 0.80 | | | 334.63 |
| 335.805 | 0.38 | 335.850 | 0.38 | |
| 336.006 | 0.17 | 336.016 | 0.24 | |
| 336.060 | 0.28 | 336.074 | 0.37 | |
| 336.398 | 0.49 | | | 336.31 |
| 336.518 | 0.65 | | | 336.50 |
| 337.059 | 0.39 | 337.084 | 0.38 | 336.84 |
| 337.111 | 0.39 | 337.142 | 0.45 | |
| 337.171 | 0.39 | | | |

$\lambda_{min}$ - positons of the nitrogen abundance indicators in nm;
$r_{min}$ - residual intensities at $\lambda_{min}$, computed for solar A(N) ($\delta_g$ = 0.02 nm);
$\lambda_{max}$ - positions of the flux maximums which are sensitive to nitrogen abundancen in nm.

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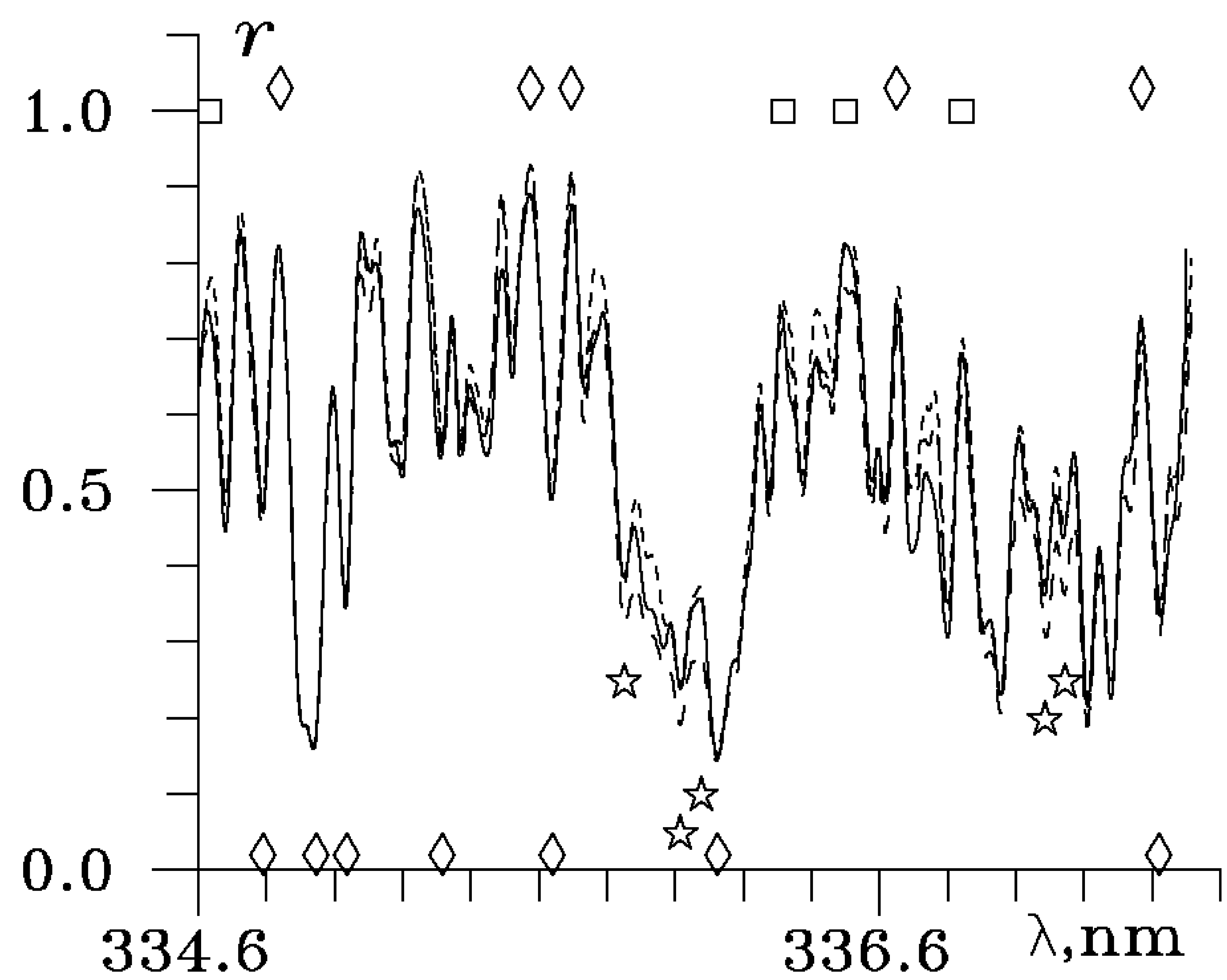


Figure 1. Observed (solid line) and synthetic (dashed lines) solar spectra in region $\lambda$ 336 nm for resolution $\delta_g = 0.02$ nm. Short and long strokes are SS computed for A(N)= 7.97 and 8.27, respectively. Diamonds, stars and squares mark wavelengths of the specral delails used to bond observed and synthetic spectra, the nitrogen abundance indicators and the sensitive on A(N) flux maximums, respectively.