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SYNTHETIC IONIZING SPECTRA FOR PLANETARY NEBULAE: A NEW GRID OF METAL-LINE BLANKETED NLTE MODEL ATMOSPHERES

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RESUMEN

Presentamos una tabla de flujos de atmósferas estelares basadas en modelos de atmósferas "Fuera de Equilibrio Termodinámico Local" (NLTE) que consideran el encubrimiento por líneas metálicas de todos los elementos desde el hidrógeno al grupo del hierro. El uso de estos flujos como espectros de ionización es altamente recomendado para análisis nebulares confiables.

ABSTRACT

We present a grid of stellar model atmosphere fluxes which is calculated from state-of-the-art NLTE model atmospheres which consider the metal-line blanketing of all elements from hydrogen to the iron-group. The use of these fluxes as ionizing spectra is highly recommended for reliable nebula analysis.

Key Words: **PLANETARY NEBULAE: GENERAL — STARS: ATMOSPHERES**

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1. INTRODUCTION

The precise analysis of properties of planetary nebulae is strongly dependent on the ionizing spectrum (Armsdorfer et al. 2002). Observations as well as NLTE model atmosphere calculations have shown that spectra of their exciting stars neither are well-approximated by blackbody spectra nor can be modeled sufficiently well with NLTE models which consider only H and He: Strong differences between synthetic spectra from these compared to the observed spectra at energies higher than 54 eV (He II ground state) can be ascribed to the neglected metal-line blanketing (Rauch 1997).

2. NLTE MODEL ATMOSPHERES AND FLUXES

For a reliable calculation of the stellar ionizing spectrum for planetary nebulae the consideration of opacities from all elements from hydrogen up to the iron-group elements is required. The accelerated lambda iteration (ALI) method represents a powerful tool to calculate metal-line blanketed atmospheres with more than 300 atomic levels treated consistently in NLTE.

Our NLTE model atmospheres (plane-parallel, hydrostatic and radiative equilibrium) are calculated using the code of Werner & Dreizler (1999). All elements from hydrogen to the iron group can be considered (Rauch 1997; Dreizler & Werner 1993; Deetjen et al. 1999).

2.1. *H–Ca Models*

The impact of the elements H–Ca was studied in detail by Rauch (1997). Since the EUV / X-ray fluxes are strongly dependent on the inclusion of "light metals" F–Ca in the model atmosphere calculations (Fig. 1), a first grid of models and fluxes ($T_{\rm eff}$ = 50–1000 kK, $\log g$ = 5–9 in cgs, solar and halo abundance ratios) had been calculated in order to provide more realistic ionizing spectra for photoionization models of PN. The grid is available on the WWW: http://astro.uni-tuebingen.de/~rauch/flux_H-Ca.html. Fluxes are given for the range 5–2000 Å (0.1 Å steps). The flux conservation of the models is fulfilled better that 2%.

2.2. *Metal-line blanketing*

In the first model grid only about 1000 individual lines had been considered. In order to investigate the influence of extensive metal-line blanketing, firstly a line-formation calculation has been performed in which all Ca lines given by Kurucz (1991) had been considered. Strong deviations are obvious (Fig. 2) and thus, we decided to include the iron-group opacities in our calculations. The elements Ca–Ni are represented by a generic model atom and all Ca–Ni lines (many millions, Kurucz 1991) are considered using an opacity sampling method. In Fig. 3 the drastic changes in the flux level due to the massive line blanketing is shown.

Since we found that the deviation between the old H–Ca and the H–Ni model fluxes are quite large, we started to calculate a new grid which accounts in detail for the metal-line blanketing of Ca–Ni.

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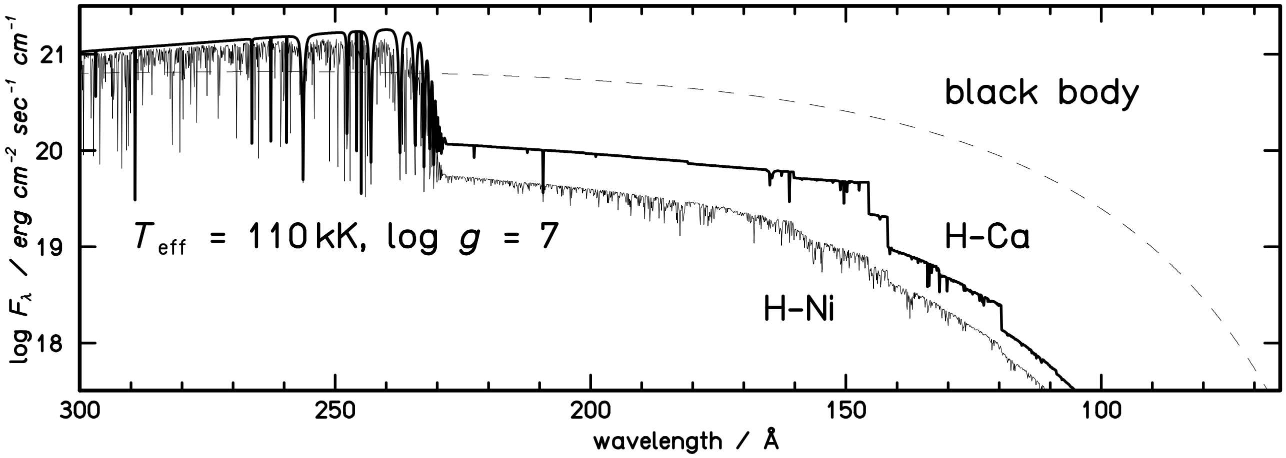

Fig. 1. Comparison of NLTE model atmosphere fluxes with different elemental composition at solar abundances ($T_{\rm eff}$ = 110 kK, $\log g = 7.0$). Note the drastic decrease of the flux level at wavelengths shorter than the He II ground state edge if the metal-line blanketing due to Ca and the iron-group elements (H–Ni) is considered.

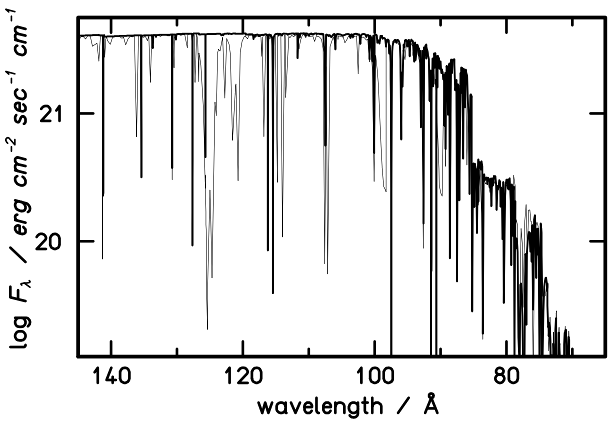

Fig. 2. Comparison of two H–Ca model fluxes ($T_{\rm eff} = 155$kK, $\log g = 6.5$, solar abundances) with (thin line) and without (thick line) consideration of Kurucz's Ca lines.

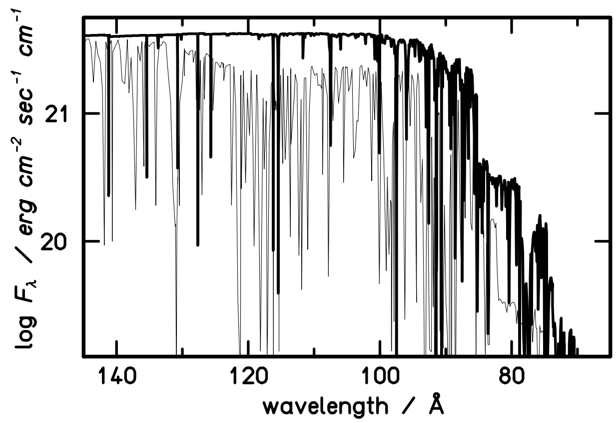

Fig. 3. Comparison of the H–Ca (thick) and H–Ni (thin) model fluxes ($T_{\rm eff} = 155$kK, $\log g = 6.5$, solar abundances).

2.3. *H–Ni Models*

A new grid of model atmosphere fluxes is currently being calculated (estimated completion date: summer 2002) and is also available on the WWW in the same format as the H–Ca flux tables (§2.1): http://astro.uni-tuebingen.de/~rauch/flux_H-IronGroup.html. Some frequency points given within the V band should make a normalization to observed magnitudes possible.

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