NON-LTE ANALYSIS OF CENTRAL STARS*

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* Based partly on observations made at the ESO, La Silla, Chile

1. INTRODUCTION

Most of our present knowledge about central stars of planetary nebulae (CPN) is obtained by indirect methods using the emission line spectra of the surrounding nebula. These methods, which apply the beautiful recombination theory, can provide us with information about temperature, distance and radius of the CPN. However, we know that these methods are subject to severe problems, which then lead to strong discrepancies in the parameters of the CPN.

Therefore, we decided to make use of the direct method, which is normally applied to stars, namely, the quantitative analysis of the photospheric line spectrum. This 'model atmosphere approach' has recently become possible after extensive computations of non-LTE model atmospheres (carried out to a large part in our group) and after the development of efficient detectors attached at big telescopes.

The main motivations for this approach are two. The first is to be able to discuss the evolution of CPN without all the uncertainties related to the use of nebular distances; this requires to place our objects

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Table 1

ATMOSPHERIC PARAMETERS OF CENTRAL STARS

Object	T_{eff} (10^3 K)	log g	y = N(He) / (N(He)+N(H))
Longmore 1	65 ±10	5.7 ±0.3	0.10 ±0.03
NGC 1360	60 +15,-5	5.2 ±0.2	0.05 ±0.02
NGC 1535	50 +10,-5	4.5 ±0.3	0.09 ±0.03
Abell 7	75 ±10	7.0 ±0.5	0.01 ±0.005
K1-27	100 ±30	5.7 ±0.5	0.60 ±0.30
Abell 15	65 ±10	6.0 ±0.5	0.09 ±0.04
Abell 33	100 ±30	6.0 ±0.5	0.09 ±0.05
NGC 3242	70 +30,-20	4.5 ±0.5	0.10 ±0.03
NGC 4361	80 ±10	5.5 ±0.3	0.05 ±0.02
Longmore 8	65 ±10	5.0 ±0.5	0.11 ±0.03
Abell 36	65 ±10	5.2 ±0.3	0.13 ±0.04
NGC 7293	90 ±10	6.6 ±0.3	0.01 ±0.005

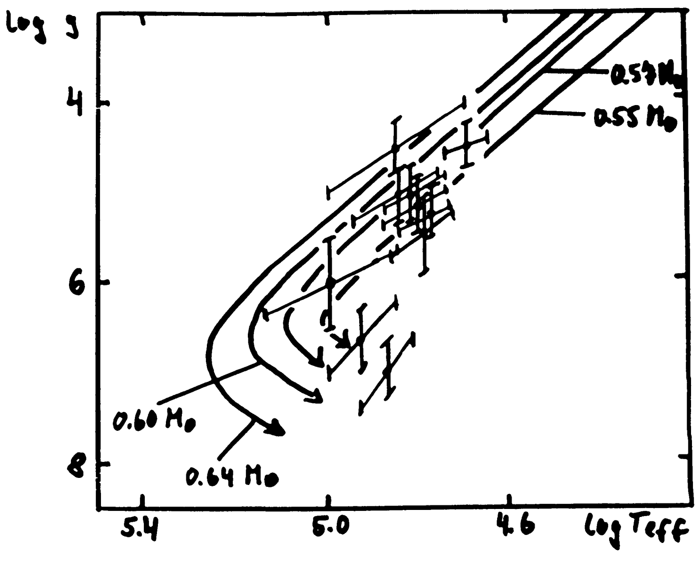

Fig. 1: The log g - log T_{eff} diagram for CPN.
Evolutionary tracks (Schönberner, 1981) descending from the AGB and evolving towards the white dwarfs are also shown (the numbers refer to masses in $M_{\odot}$). For discussion see text.

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on the log g - log T_{eff} diagram instead of the H. R. diagram. The second reason is to explore the surface helium abundance of CPN.

2. METHOD

Cassegrain spectra of moderate dispersion (29 A/mm, 45 A/mm, 58 A/mm) covering the spectral range between 4000 to 5000 A were taken using the IDS at the ESO 3.6 m and the SIT - Vidicon at the CTIO 4 m. The profiles of hydrogen and helium lines were compared with detailed non-LTE model atmosphere and line formation calculations in order to determine simultaneously T_{eff}, log g and helium abundance. Details of the analysis technique are described in Méndez et al. (1981, 1983 a, b) and Kudritzki et al. (1981).

3. RESULTS AND DISCUSSION

Table 1 contains the atmospheric parameters of our program stars, as obtained from our non-LTE analysis. Figure 1 shows their position on the log g, log T_{eff} - plane. A comparison with evolutionary tracks descending from the AGB (Schönberner, 1979, 1981) reveals that our objects form an evolutionary sequence of hot objects with constant luminosity (upper diagonal of the tracks in the log g, log T_{eff} - plane) towards the white dwarf stage. The masses are in a narrow range between 0.5 to 0.6 $M_{\odot}$, which fits nicely with the mass distribution of DA white dwarfs (Koester et al., 1979). Interestingly, the two objects with the highest gravities (NGC 7293 and Abell 7), which are more advanced in their evolution towards the white dwarf stage, have surface helium abundances significantly (a factor of ten) smaller than solar. This implies the onset of gravitational settling and provides a very strong observational connection between these central stars and DA white dwarfs.

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DISCUSSION

Cox: Do any of your stars show strong carbon features in its spectrum?

Kudritzki: Yes, NGC 246 (as already noted by Heap, 1977), Longmore 3 and Longmore 4 show very strong CIV lines at λ4441 and λ4646, respectively. In addition, they are extremely helium-rich. The analysis of these objects, which from the atmospheric models is extremely difficult, is subject to our future work.

Spruit: Can one compare the distribution of number density of the objects along the evolutionary track with predictions?

Kudritzki: For our sample of objects I would guess: no, because it is not statistically complete. However, it appears to be worthwhile to complete the sample in our future work and to carry out an analogous comparison, as has been done by Schönberner with his different method, which does depend on distance scale but not on T_{eff}, whereas our results are independent of distance but use T_{eff}.

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