THE H. R.- DIAGRAM OF CENTRAL STARS OF PLANETARY NEBULAE

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During the last years some progress has been made in the determination of temperatures of central stars of planetary nebulae (CPN). The main reasons are the successful deployment of space crafts which made the more temperature sensitive spectral region in the UV accessible, and the application of NLTE-spectral analyses (e.g.Mendez et al.,1981). Therefore, a re-examination of the H.R.-diagram of CPN's seems to be in order.

We collected informations about the temperatures of central stars from different sources (see references in the Table) and accepted only objects with at least two independent determinations. We discarded all objects with too discrepant temperatures. WC-type nuclei have also been omitted. The selected objects are listed in the Table, and the quoted temperatures represent mean values, the error of which seems to be in most cases much less than ± 25%. For the distances, we used the recent calibration of Daub (1982), upscaled to the (revised) distances of Cahn and Kaler (1971). We did not consider objects with $R_{Neb} < 0.05$ pc because of the uncertainty of their distances. The resulting absolute magnitude are also given in the Table (interstellar absorption has been taken into account). Fig. 1a shows all objects of the Table in a H.R.-diagram, i.e. M_V vs. T_{eff}. They occupy a well defined strip, ranging from $M_V = -1$ to 9 and log T_{eff} from 4.5 to 5.2. Superimposed are the evolutionary tracks of post-AGB models with different masses as they follow from Paczynski (1971) and Schönberner (1979, 1983). The latter are burning hydrogen in a shell under quiet conditions. Within the errors ($\Delta M_V \approx \pm 0.5$, $\Delta \log T_{eff} \approx \pm 0.1$), we find an excellent agreement between the observed loci of CPN and those of post-AGB models with $M \lesssim 0.65\ M_\odot$. Only the two faintest CPN ($M_V \gtrsim 8$) seem to have higher masses ($\sim 0.9 - 1.0\ M_\odot$).

Fig. 1b shows the (M_V, age)-diagram for the same objects and the same evolutionary tracks. We have used a nebular expansion velocity of 20 km/s in those cases where an individual velocity is not available. Both figures are consistent with each other, in that the CPN studied are confined (with only a few exceptions already mentioned above) within the 0.55 and 0.65 $M_\odot$ post-AGB tracks, and the theoretical predicted temperatures (read off from Fig.1b) are in reasonable agreement with the ob-

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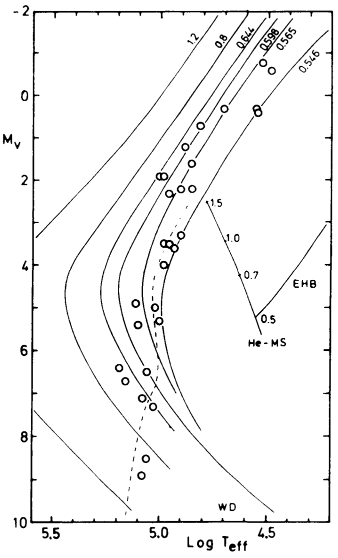

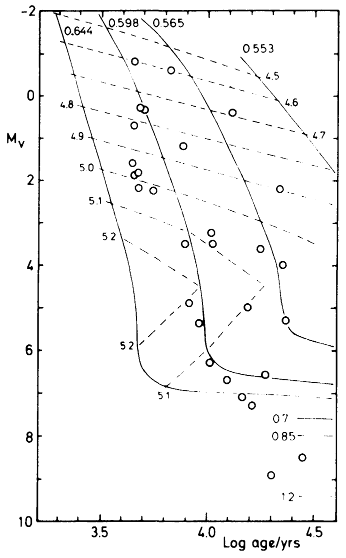

1a: H.R.-diagram for CPN and post-AGB evolutionary tracks from Paczynski (1.2, 0.8 $M_\odot$) and Schönberner (0.644, 0.598, 0.565, 0.546 $M_\odot$). On the dashed line 40 000 years are spent since the models left the AGB (zero age is at $T_{eff} = 10^{3.7}$ K).

1b: M_V vs. age of the models (zero point defined as in Fig. 1a) and CPN. The 0.553 $M_\odot$ track has been interpolated. Dashed lines connect points of equal effective temperatures as predicted by these models. The ages of observed CPN are given by nebular radius devided by the expansion verlocity.

Object	$T_{eff}/10^3K$	M_V	$T_{eff}(pred)/T_{eff}$	Object	$T_{eff}/10^3K$	M_V	$T_{eff}(pred)/T_{eff}$
NGC 650	150 (3,7)	6.4	0.79	NGC 6891	35 (2,3,6)	0.4	1.38
1535	50 (2,4)	0.3	1.13	7293	110 (1,2,3,4,7)	7.3	~1
2022	100 (6,8)	1.8	0.94	IC 2448	75 (2,6,8)	1.6	1.17
2392	30 (2,5)	-0.6	1.33	4593	33 (3,8)	-0.8	1.21
2610	90 (3,9)	3.5	1.22	A 15	82 (2,3,4,7)	3.3	1.45
3242	70 (2,6)	2.2	1.50	20	105 (2,3)	5.0	1.22
3587	120 (2,3,6,7)	7.1	~1	31	115 (3,7,9)	8.5	-
4361	95 (2,3,4,6)	3.5	1.26	33	95 (3,4,7)	5.3	~1
6058	75 (3,7,8)	1.2	0.92	36	85 (2,3,4,7)	3.6	1.32
6326	90 (3,8)	2.3	1.14	43	85 (2,3)	2.2	0.93
6720	130 (3,6,7)	4.9	1.20	84	115 (3,7)	6.5	~1
6772	125 (6,7)	5.4	1.13	K 1-16	93 (3,9)	4.0	1.21
6818	100 (3,8)	1.9	1.03	J 320	65 (3,8)	0.7	1.00
6826	37 (2,3,5,6,8)	0.3	1.60	YM 29	120 (3,7,9)	8.9	-
6853	135 (1,3,6)	6.7	~1				

1) Bohlin et al. (1982)
2) Clegg and Seaton (1983 b)
3) Cahn (1983)
4) Mendêz et al. (1983)
5) Natta et al. (1983)
6) Pottasch (1983)
7) Kaler (1983)
8) Martin (1981)
9) Schönberner (unpublished)

served ones (see Table). We found, however, a systematic difference between the two sets of temperatures because Fig. 1b predicts CPN-temperatures which are, on the average, 15% larger than those which follow from the observations (see Table).

This difference can be accounted for by an average distance increase of, say, 15% (see also Schönberner, 1981). This would be in line with other arguments favouring an increase of the Cahn/Kaler distances (Weidemann, 1977; Schneider et al., 1983). Alternatively, this discrepancy might also indicate a faster fading of real nuclei by a factor of about two compared to the models. This would imply that actual mass loss rates are larger than those used in the computations of Schönberner (1979, 1983).

In conclusion we can say that post-AGB models with quiescent hydrogen burning as shown in Fig 1a give in all respects a very satisfactory description of the evolution of at least those central stars which have been studied in this work.

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DISCUSSION

Conti: Are any of your central stars WC-type and if so, where do they sit in the HR-diagram?

Schönberner: No.

Mould: Looking at your final diagram, one gets the impression that the selection criterion on nebula size may have depopulated the $M > 0.6$ side of the diagram. Could this selection effect influence the derived mass distribution?

Schönberner: Theoretically we don't expect CPN on the left side of the $M = 0.644\ M_\odot$ track because the fading times are too short. Rather, they should show up at $M_V \gtrsim 7$. Of course this ensemble is too highly biased by selection as to make any statement about a general CPN mass distribution.