THE FINAL FATE OF MASSIVE STARS

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PROCEDURE

The cluster membership of Wolf-Rayet stars, supernova remnants and pulsars is used to study the late stages of stellar evolution of massive stars.

In a hypothetical stellar cluster with strictly coeval members, we find only those stars in these evolutionary stages for which the lifetime ℓ roughly equals the cluster age t. The evolved cluster members must therefore originate from a small range of initial mass M_i for which $\ell (M_i) \approx t$. We have calculated this relation between the initial mass of cluster members near the SN explosion and the cluster age (Schild and Maeder, 1984).

Information on the cluster membership of individual WR stars, SNR's and pulsars can be found in the literature (e.g. Lundström and Stenholm, 1984; Allakhverdiyev et al.,1983; Schild and Maeder, 1985). The age of the parent associations can be obtained e.g. by isochrone-fitting. Clearly, an age spread present in the parent clusters leads to increasing error bars in the initial mass determinations.

RESULTS

The results on the initial mass of WR stars, SNR's and pulsars are summarized in Fig. 1. It should be kept in mind that the emerging picture of the evolution of massive stars is tentative and may be incomplete.

We fistly note that WR stars can form from $M_i \gtrsim 20\ M_\odot$, whereas WC stars originate from $M_i \gtrsim 35\ M_\odot$. We also find that WNL and WCE stars are initially more massive than WNE and WCL stars (Schild and Maeder, 1984). At the present time we know of WR stars with initial mass as high as $\sim 100\ M_\odot$ (Humphreys et al., 1985).

A remarkable feature in Fig. 1 is the presence of both SNR's and neutron stars for initial mass up to $\sim 50\ M_\odot$. There seems to be a tendency for morphological C-type remnants (cf. Weiler, 1983) to originate

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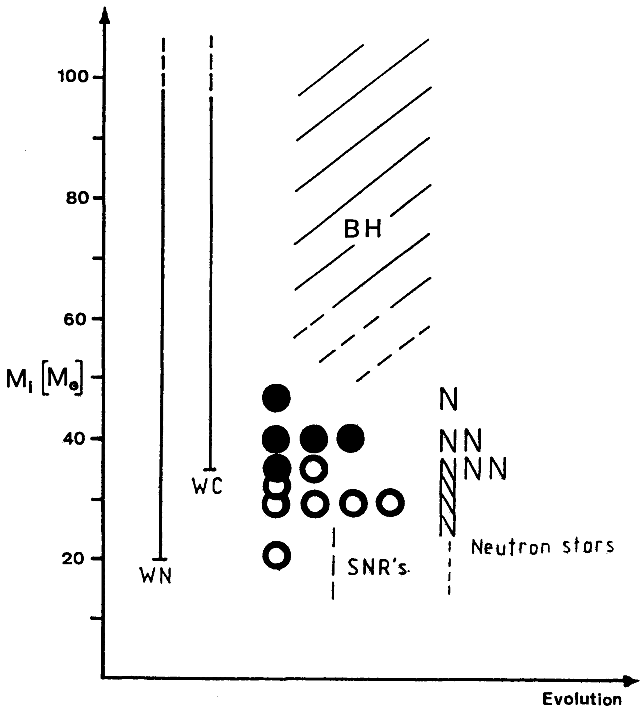

Figure 1:

The initial mass of WR stars, neutron stars and the progenitors of supernova remnants. The filled circles represent C-type remnants, the rings shell-type remnants. The N's stand for neutron stars (pulsars and compact X-ray sources in SNR's). BH indicates the range where possibly black holes are the final outcome of stellar evolution.

from initially more massive progenitors than shell-type remnants (Schild, 1985). It is tempting to speculate that there is an evolutionary connection between WR stars and C-type supernova remnants.

The final phase of stellar evolution for stars with $M_i \gtrsim 50\ M_\odot$ is difficult to establish. From Fig. 1 we see that they do not seem to produce SNR's and neutron stars. Possibly the internal evolution leads them to the formation of a black hole. This is in agreement with the findings of van den Heuvel and Habets (1984) who concluded from the study of two X-ray binaries, that the initial mass limit for black hole formation has to lie between 40 and 80 $M_\odot$.

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