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The Initial/Final Mass Relation for Stars with Different Initial Chemical Compositions

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Abstract.

The initial/final mass relation (M_i–M_f) for small and intermediate mass stars depends strongly on the initial chemical composition (Z). Two factors play an important role in this effect: the dependence on Z of mass loss rates and the carbon-oxygen core initial mass. For heavy element abundances $Z = 0.001$ and $Z = 0.02$ the greatest differences of M_f and M_i are found between $1.5 < M_i/M_\odot < 4$ and may be as great as 0.1 $M_\odot$.

The M_i–M_f relation for stars is important because:

1. The amount of matter returned to the interstellar medium by mass loss depends on this relation. This matter is enriched by the products of the stellar thermonuclear reactions. An accurate estimate of this relationship is crucial for the modeling of the chemical evolution of galaxies.

2. The determination of the mass distribution of white dwarfs (WD) depends on this relation. According to some models, such phenomena as SN Ia and millisecond pulsars in globular clusters depend on this mass distribution.

To estimate an accurate M_i–M_f relation, we must carefully choose accurate analytical expressions which will allow us to calculate the initial mass of the C–O core, the stellar luminosity, and the mass loss rate as a function of chemical composition.

In our calculations the mass loss was represented by Reimers (1975) law. The observations, however, show that apart from the conventional stellar wind, some other mechanism (apart from the planetary nebulae ejection) also operates during the AGB phase, substantially increasing the mass loss. In our calculations, an abrupt tenfold jump in the mass loss rate for the AGB stars reaching a certain luminosity is suggested (α=1 for $M_{\rm bol} > -5\overset{\rm m}{.}5$ and α=10 for $M_{\rm bol} < -5\overset{\rm m}{.}5$).

Table 1 contains the numerical results of the M_i–M_f calculations. A notable feature is a significant dependence of these relations on the metallicity in the region between $M_i = 1.5M_\odot$ and $M_i = 4M_\odot$. Between $1M_\odot$ and $2.5M_\odot$ our results are similar to the results of Weidemann (1987). For larger (M_i, M_f) values, we find that Weidemann's results are significantly smaller than ours.

The strong dependence of M_i–M_f relation on the initial chemical composition must significantly influence the mass distributions of the WDs. Such distributions were calculated by the population simulation method using a Salpeter initial mass function and constant stellar birth rate. These distributions strongly

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depend on the initial chemical composition. In case of small metallicities the distribution is shifted to the greater masses, significantly raising the number of WDs with masses greater than 0.7 $M_{\odot}$. This fact may be very important in considering the sub-Chandrasekhar WD explosions as the mechanism of SN Ia phenomenon.

Table 1. The initial/final mass relation for different initial chemical compositions and mass loss rates

M_i	M_f^a	M_f^b	M_f^c
1	0.57	0.56	0.56
2	0.65	0.62	0.71
3	0.69	0.65	0.82
4	0.81	0.79	0.87
5	0.94	0.91	0.95
6	1.01	0.98	1.03
7	1.10	1.05	1.11

[a] Z=0.02, α=1 if $M_{bol} > -5\overset{m}{.}2$ and α=10 if $M_{bol} < -5\overset{m}{.}2$
[b] Z=0.02, α=1 if $M_{bol} > -5\overset{m}{.}0$ and α=10 if $M_{bol} < -5\overset{m}{.}0$
[c] Z=0.001, α=1 if $M_{bol} > -5\overset{m}{.}2$ and α=10 if $M_{bol} < -5\overset{m}{.}2$

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