Ejected vs Accreted mass in novae

Nova models : general properties

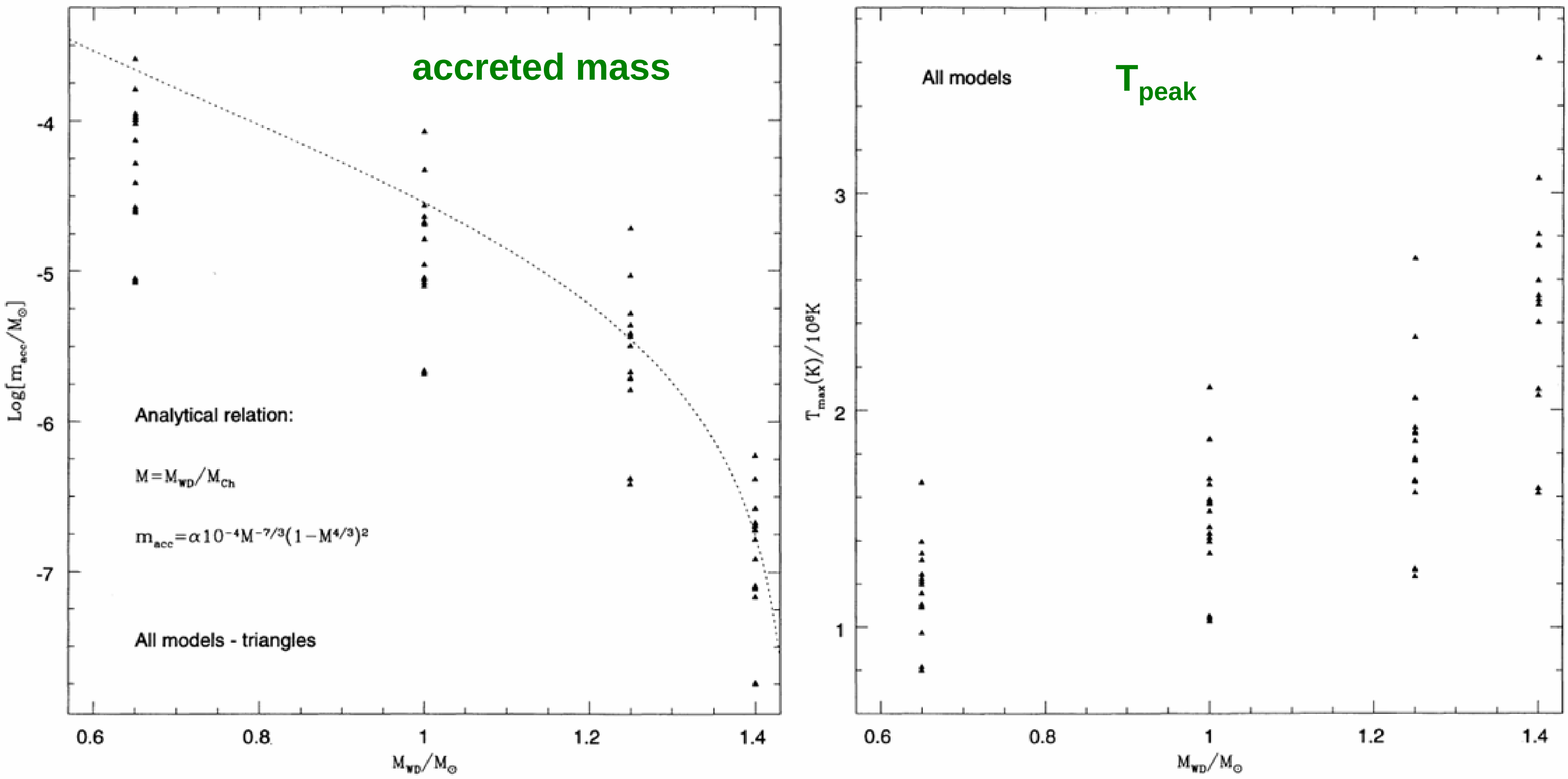


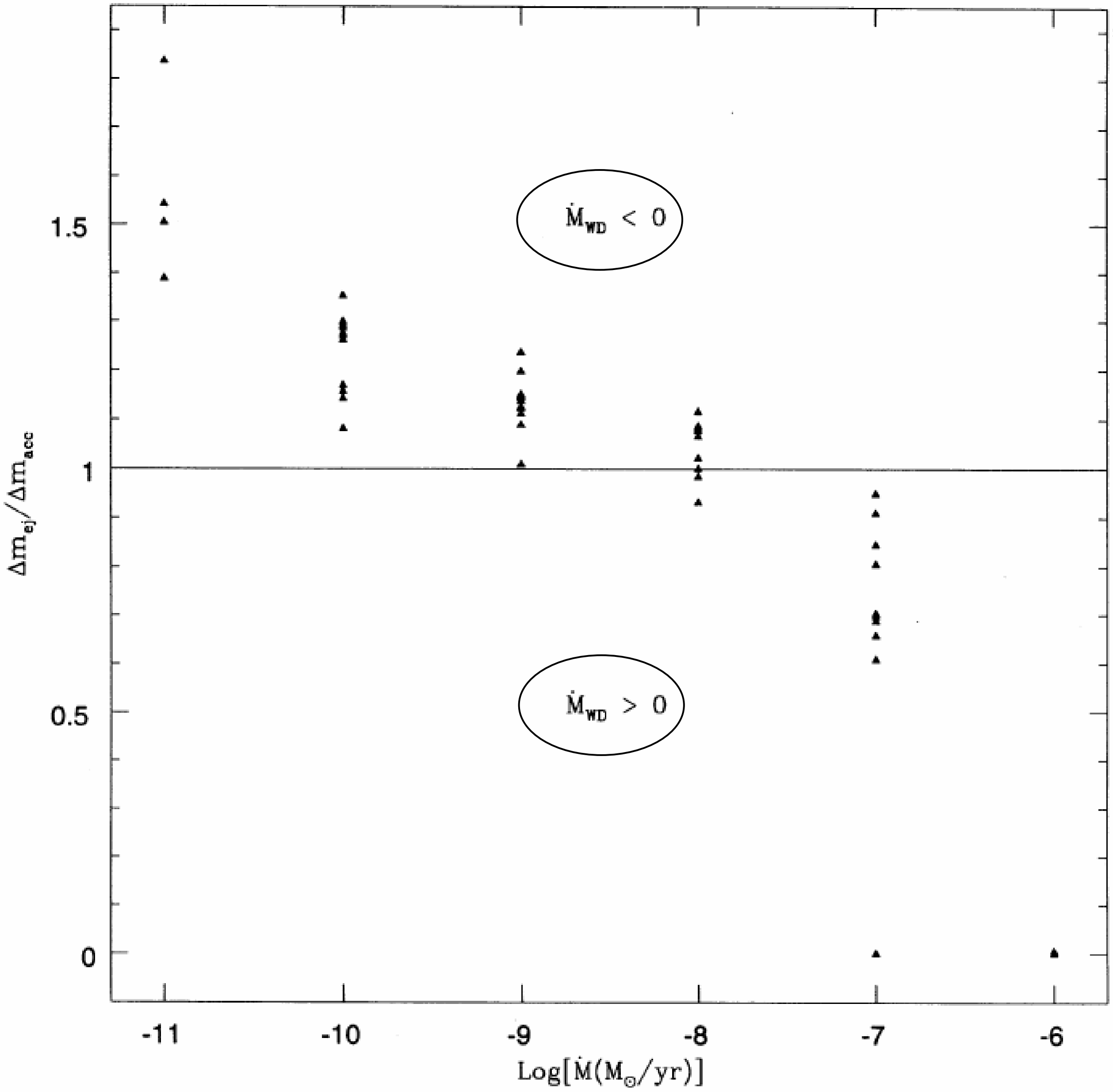
FIG. 1*a*

FIG. 1*b*

FIG. 1.—(*a*) Accreted mass—on a logarithmic scale—as a function of the WD mass for all models. The vertical spread in calculated points is due to the effect of different T_{WD} and $\dot{M}$. The analytical relation is shown by a dotted line; α is a fudge factor of order unity. (*b*) Peak temperature attained at outburst (in units of 10^8 K) as a function of the WD mass for all models. (*c*) Maximal bolometric luminosity (see comments in text)—on a logarithmic scale—as a function of the WD mass for all models. The (nominal) Eddington luminosity, calculated assuming a constant electron-scattering opacity, is given by the dotted line. (*d*) Time of decline of the bolometric luminosity by 3 magnitudes as a function of the WD mass for all models.

Prialnik & Kovetz, 1995, ApJ

Ratio of ejected to accreted mass



Prialnik & Kovetz, 1995, ApJ

Observed abundances in novae: a proof of mixing

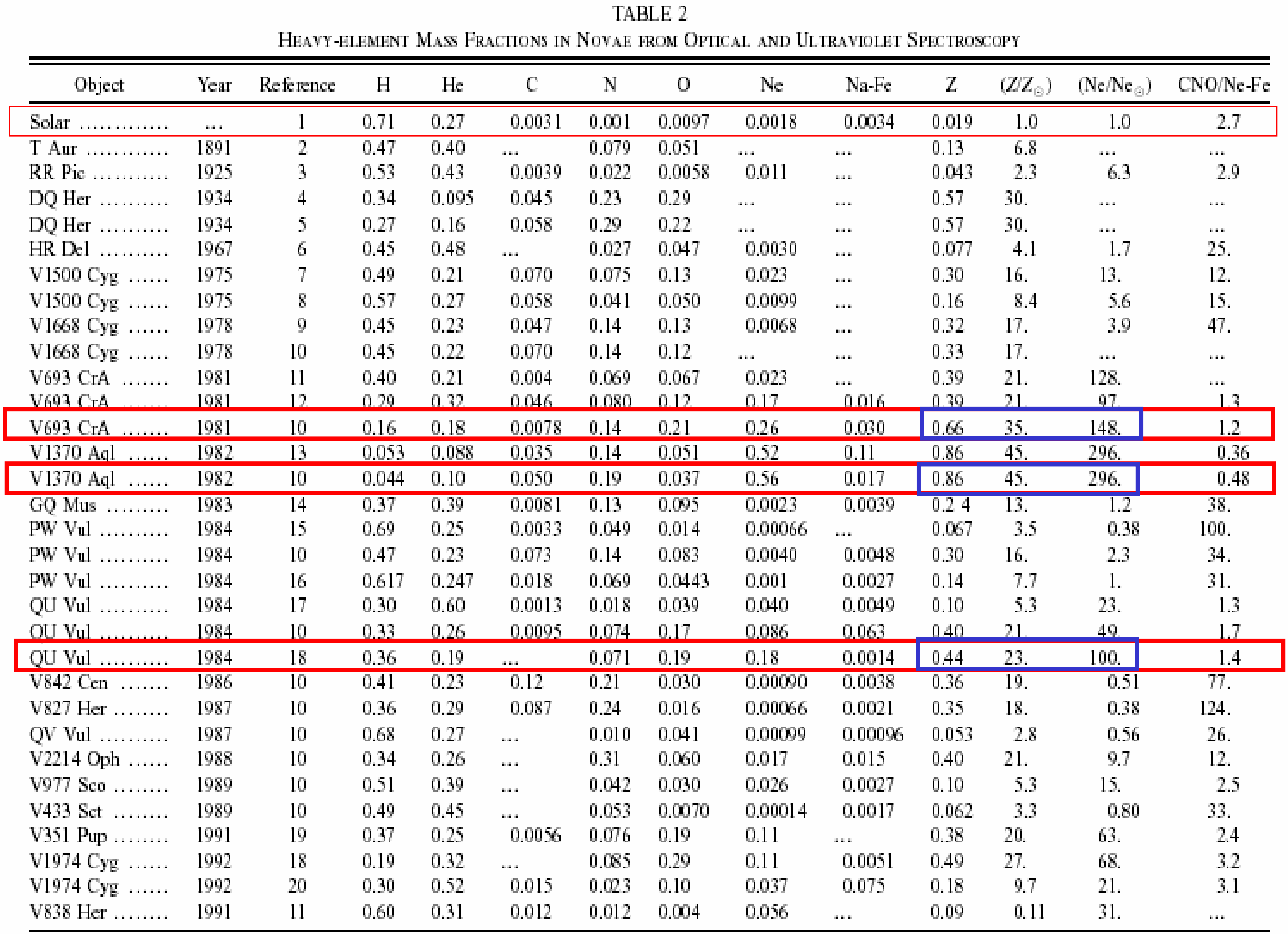


TABLE 2

HEAVY-ELEMENT MASS FRACTIONS IN NOVAE FROM OPTICAL AND ULTRAVIOLET SPECTROSCOPY

Object	Year	Reference	H	He	C	N	O	Ne	Na-Fe	Z	$(Z/Z_\odot)$	$(Ne/Ne_\odot)$	CNO/Ne-Fe
Solar	...	1	0.71	0.27	0.0031	0.001	0.0097	0.0018	0.0034	0.019	1.0	1.0	2.7
T Aur	1891	2	0.47	0.40	...	0.079	0.051	...	...	0.13	6.8	...	...
RR Pic	1925	3	0.53	0.43	0.0039	0.022	0.0058	0.011	...	0.043	2.3	6.3	2.9
DQ Her	1934	4	0.34	0.095	0.045	0.23	0.29	...	...	0.57	30.	...	...
DQ Her	1934	5	0.27	0.16	0.058	0.29	0.22	...	...	0.57	30.	...	...
HR Del	1967	6	0.45	0.48	...	0.027	0.047	0.0030	...	0.077	4.1	1.7	25.
V1500 Cyg	1975	7	0.49	0.21	0.070	0.075	0.13	0.023	...	0.30	16.	13.	12.
V1500 Cyg	1975	8	0.57	0.27	0.058	0.041	0.050	0.0099	...	0.16	8.4	5.6	15.
V1668 Cyg	1978	9	0.45	0.23	0.047	0.14	0.13	0.0068	...	0.32	17.	3.9	47.
V1668 Cyg	1978	10	0.45	0.22	0.070	0.14	0.12	...	...	0.33	17.	...	...
V693 CrA	1981	11	0.40	0.21	0.004	0.069	0.067	0.023	...	0.39	21.	128.	...
V693 CrA	1981	12	0.29	0.32	0.046	0.080	0.12	0.17	0.016	0.39	21.	97.	1.3
V693 CrA	1981	10	0.16	0.18	0.0078	0.14	0.21	0.26	0.030	0.66	35.	148.	1.2
V1370 Aql	1982	13	0.053	0.088	0.035	0.14	0.051	0.52	0.11	0.86	45.	296.	0.36
V1370 Aql	1982	10	0.044	0.10	0.050	0.19	0.037	0.56	0.017	0.86	45.	296.	0.48
GQ Mus	1983	14	0.37	0.39	0.0081	0.13	0.095	0.0023	0.0039	0.2 4	13.	1.2	38.
PW Vul	1984	15	0.69	0.25	0.0033	0.049	0.014	0.00066	...	0.067	3.5	0.38	100.
PW Vul	1984	10	0.47	0.23	0.073	0.14	0.083	0.0040	0.0048	0.30	16.	2.3	34.
PW Vul	1984	16	0.617	0.247	0.018	0.069	0.0443	0.001	0.0027	0.14	7.7	1.	31.
QU Vul	1984	17	0.30	0.60	0.0013	0.018	0.039	0.040	0.0049	0.10	5.3	23.	1.3
QU Vul	1984	10	0.33	0.26	0.0095	0.074	0.17	0.086	0.063	0.40	21.	49.	1.7
QU Vul	1984	18	0.36	0.19	...	0.071	0.19	0.18	0.0014	0.44	23.	100.	1.4
V842 Cen	1986	10	0.41	0.23	0.12	0.21	0.030	0.00090	0.0038	0.36	19.	0.51	77.
V827 Her	1987	10	0.36	0.29	0.087	0.24	0.016	0.00066	0.0021	0.35	18.	0.38	124.
QV Vul	1987	10	0.68	0.27	...	0.010	0.041	0.00099	0.00096	0.053	2.8	0.56	26.
V2214 Oph	1988	10	0.34	0.26	...	0.31	0.060	0.017	0.015	0.40	21.	9.7	12.
V977 Sco	1989	10	0.51	0.39	...	0.042	0.030	0.026	0.0027	0.10	5.3	15.	2.5
V433 Sct	1989	10	0.49	0.45	...	0.053	0.0070	0.00014	0.0017	0.062	3.3	0.80	33.
V351 Pup	1991	19	0.37	0.25	0.0056	0.076	0.19	0.11	...	0.38	20.	63.	2.4
V1974 Cyg	1992	18	0.19	0.32	...	0.085	0.29	0.11	0.0051	0.49	27.	68.	3.2
V1974 Cyg	1992	20	0.30	0.52	0.015	0.023	0.10	0.037	0.075	0.18	9.7	21.	3.1
V838 Her	1991	11	0.60	0.31	0.012	0.012	0.004	0.056	...	0.09	0.11	31.	...

Gehrz et al 1998, PASP

The underlying WD in classical novae:

- Massive WDs are not CO WDs
- ONe vs. CO - Mass frontier (1.1 $M_{\odot}$)
- Binary vs. single star evolution: harder to get high mass (ONe) WDs

The underlying white dwarf

White dwarfs are the endpoints of the stellar evolution of stars with masses below 11-12 $M_\odot$.

- $M \leq$ 8-10 $M_\odot$ → CO white dwarfs (He burning)
- 8-10 $M_\odot \leq M \leq 12\ M_\odot$ → ONe white dwarfs (C burning)

10 $M_\odot$ → 1.2 $M_\odot$ ONe core

-- CAUTION: single star evolution --

Classical novae: the underlying white dwarf

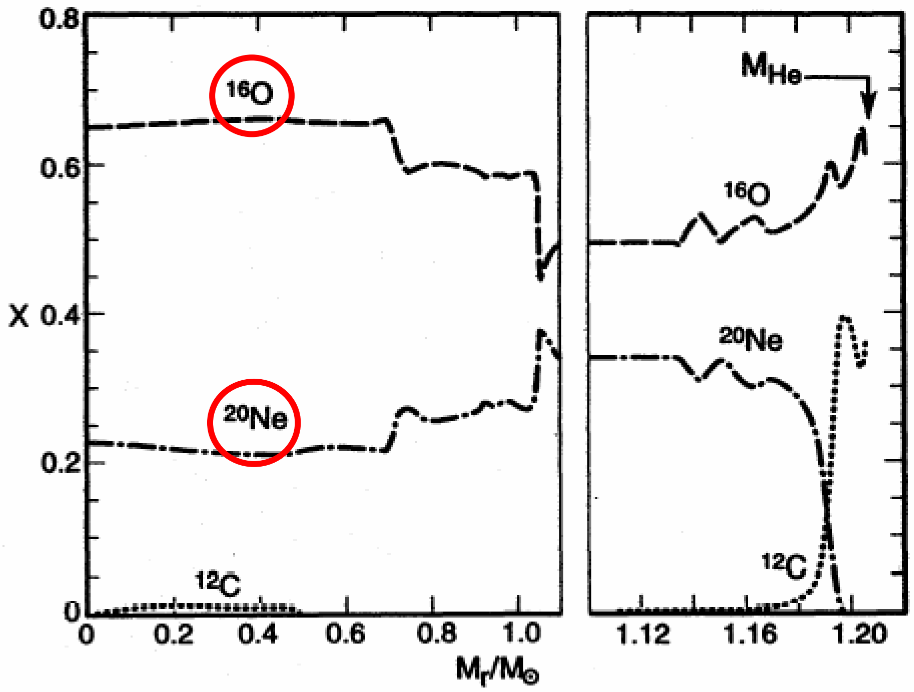


FIG. 7.—Abundances by mass of the major isotopes in the helium-exhausted interior at the end of the carbon-burning phase ($t = 7.1895212 \times 10^{14}$ s).

10$M_\odot$ mass Population I star evolved from the H-burning main sequence through C-burning

↓

1.2$M_\odot$ ***ONe*** core

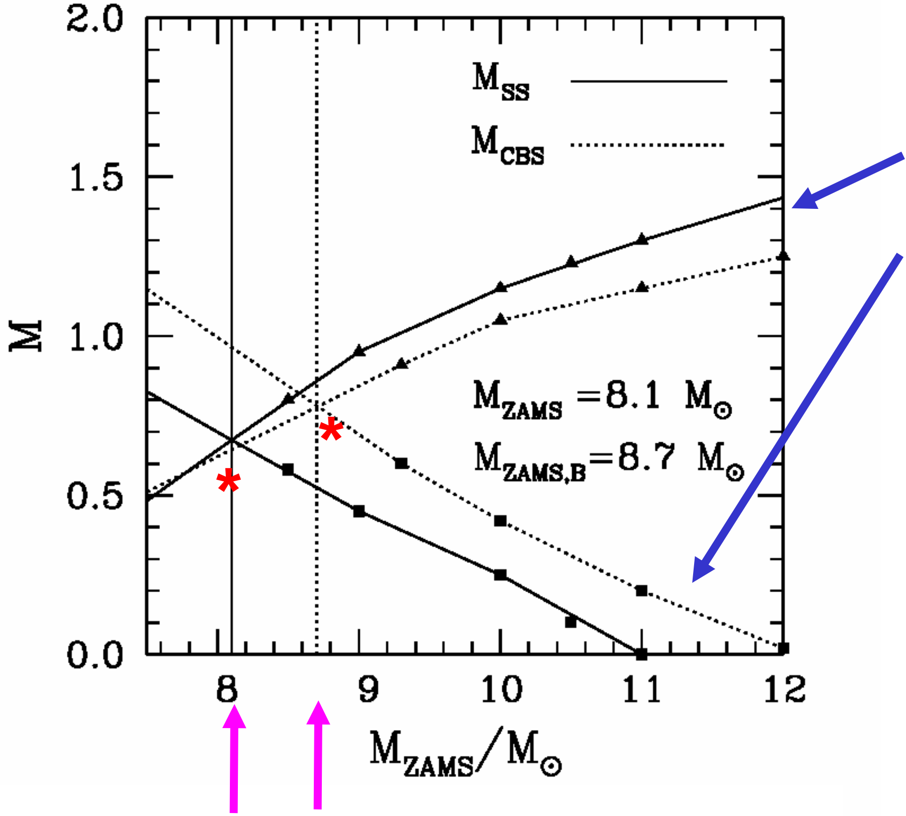
≠

ONeMg core predicted by hydrostatic C-burning (Arnett & Truran, 1969)

Ritossa, García-Berro & Iben, 1996, ApJ

see also Domínguez, Tornambè & Isern 1993

The underlying white dwarf: single versus binary evolution



Size of the CO core at the beginning of C burning, for single and binary evolution

Mass point at which C is ignited

Minimum mass required for C-ignition to take place (*): 8.1 $M_\odot$ (single) and 8.7 $M_\odot$ (binary)

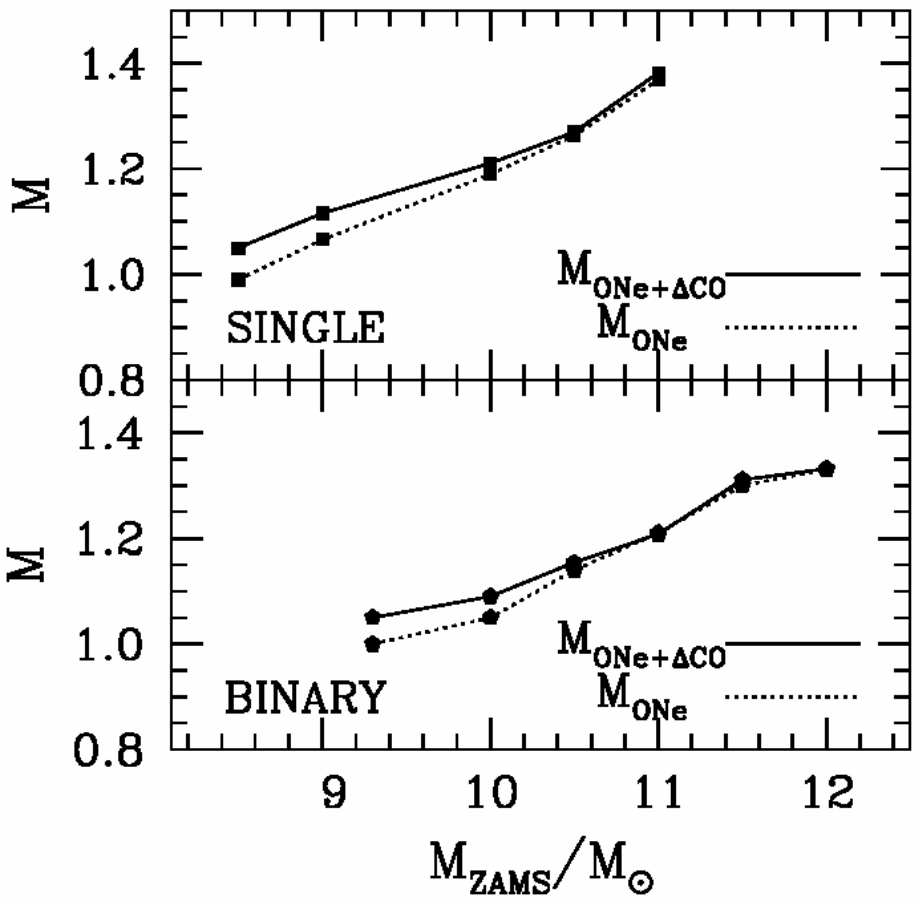
Off-center C-ignition => ONe WD

Gil Pons, García-Berro, José, Hernanz & Truran, 2003, A&A

Central C ignition:

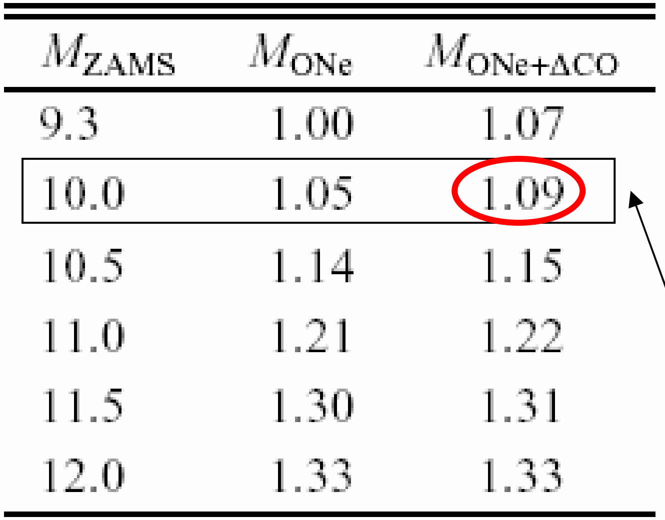
- 11 $M_\odot$ for single evolution
- 12 $M_\odot$ for binary evolution

The underlying white dwarf: single vs. binary evolution



ig. 3. Size of the final cores as a function of the ZAMS mass for ingle and binary star evolution.

ONe core mass with a "CO buffer" (binary evolution)



M_{ZAMS}	M_{ONe}	$M_{ONe+\Delta CO}$
9.3	1.00	1.07
10.0	1.05	1.09
10.5	1.14	1.15
11.0	1.21	1.22
11.5	1.30	1.31
12.0	1.33	1.33

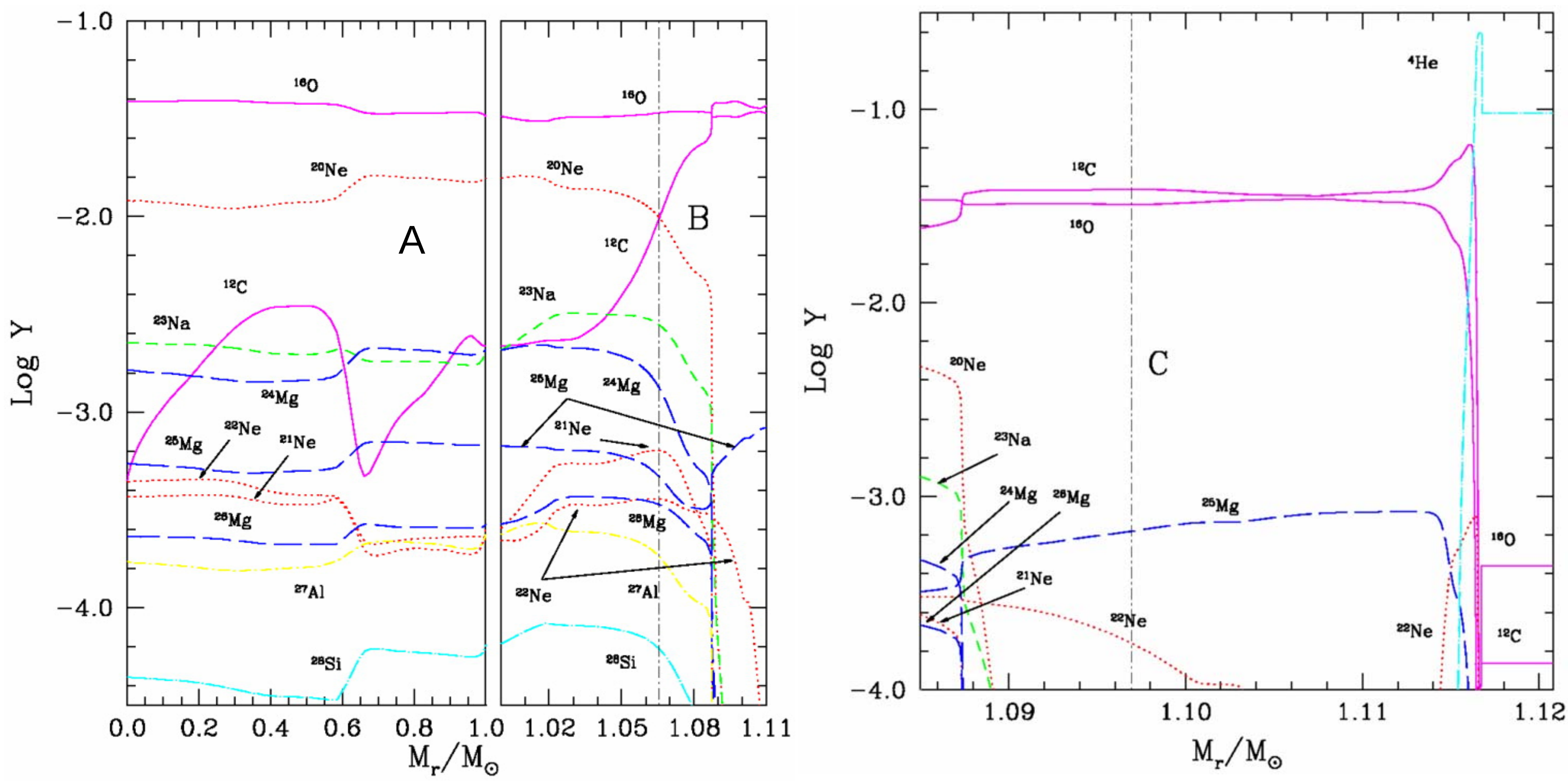
instead of
$1.2M_\odot$

Gil-Pons, García-Berro, José, Hernanz, Truran, 2003, A&A

Size of the final core for single and binary evolution: relevance of new $M_{initial}$-M_{final} mass relation for the fraction of novae hosting ONe white dwarfs: smaller number but still around 30%

The underlying White Dwarf

CO buffer on top of ONe core: weird nuclesoynthesis potentially leading to missclassification of novae



José, Hernanz, García-Berro, Gil-Pons, 2003, ApJL