銀河の化学進化

Relative frequencies of Type Ia and Type II supernovae in the chemical evolution of the Galaxy, LMC and SMC

(T. Tsujimoto, K. Nomoto, Y. Yoshii, M. Hashimoto, S. Yanagida and F.-K. Thielemann 1995, MNRAS, 277, 945)

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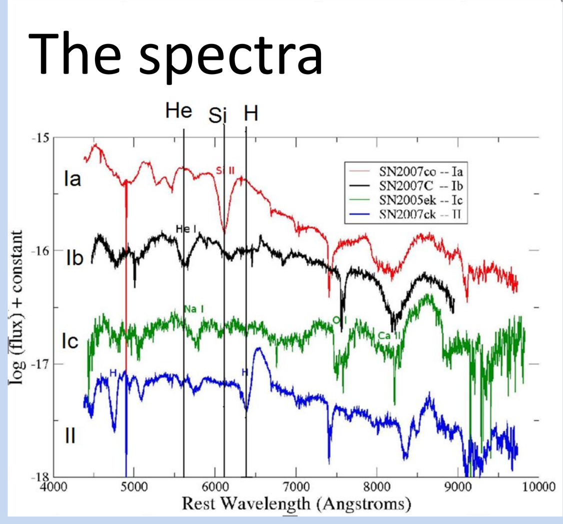
1.Introduction

The spectra



Timescale

SNe II $10^{6\sim7}$yr

SNe Ia 1.5×10^{9}yr

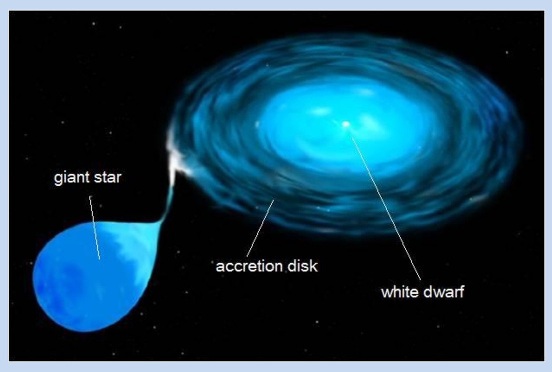
The productions of supernovae

SNe Ia Fe, Ni etc.

SNe II(SNe Ibc) O, Ne, Mg etc.

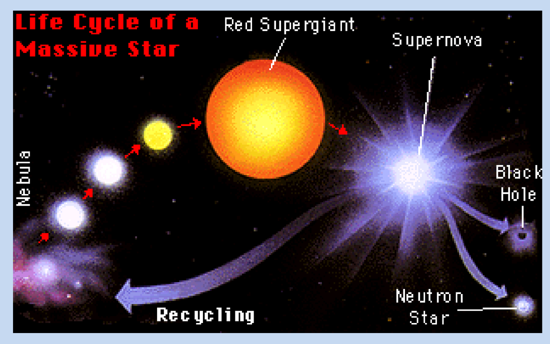
⇒The heavy-element rate shows the relative frequency of SNeIa and SNe II (including SNe Ibc)supernovae (N_{Ia}/N_{II}).

SNe Ia (mass accretion to white dwarf)



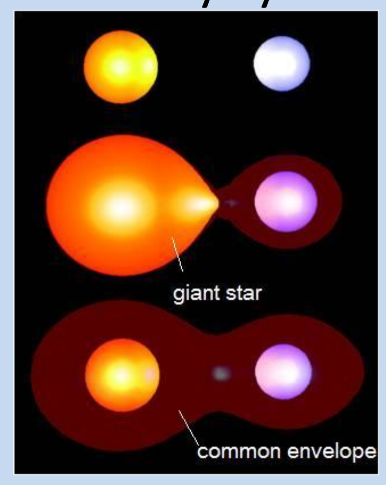
(NASA)

SNe II (massive star $10\sim50M_{\odot}$)



(NASA)

SNe Ibc (mass transfer in close binary system)



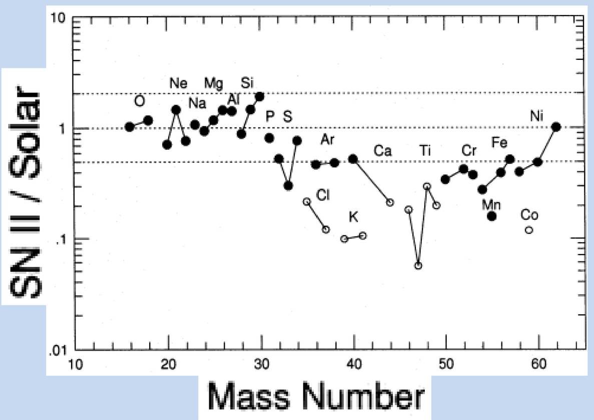
(Wolfram Demonstration project)

*Wolf-Rayet star>$25M_{\odot}$ causes SNe Ibc.

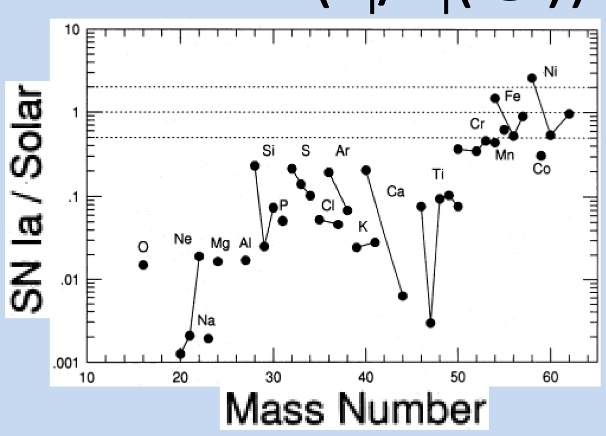
The purpose of this study is to determine the value of N_{Ia}/N_{II}.

2.The proportion of SNe

nucleosynthesis products of SNe II ($x_i/x_i(◎)$)



nucleosynthesis products of SNe Ia ($x_i/x_i(◎)$)



NOTE : open circles show the elements not calculated.

The number of SNe II is calculated from IMF. (M_i is taken from Hashimoto et al. 1995)

$M_{i,Ia}$ is determined to the W7 model (Nomoto, Thielemann & Yokoi 1984) .

$$\frac{d\phi}{dm}\propto m^{-(1+x)}\rightarrow M_{i,II}\equiv\frac{\int M_i d\phi}{\int d\phi}$$

The solar neighbourhood patterns can be reproduced by overlapping these patterns by just proportions.

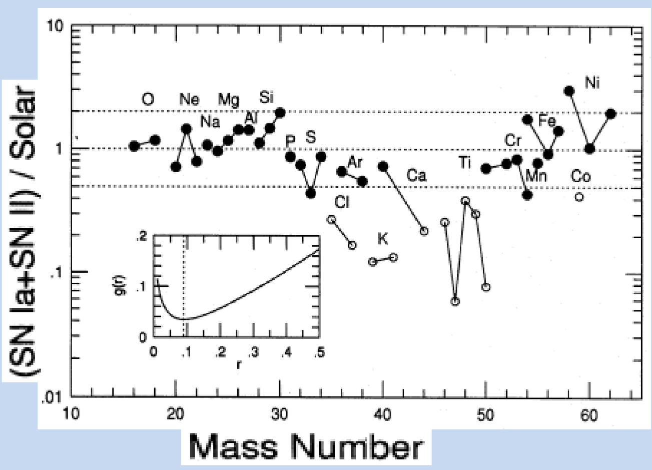
$$r\equiv\frac{w_{Ia}M_{Ia}N_{Ia}}{w_{Ia}M_{Ia}N_{Ia}+w_{II}M_{II}N_{II}}$$

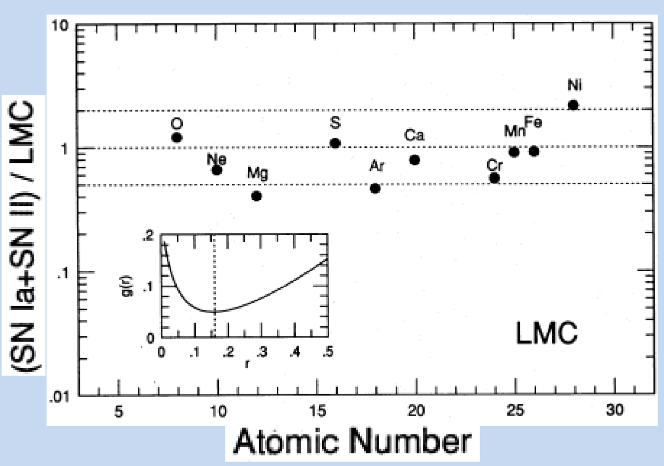
$$(M_{Ia}=\sum_i M_{i,Ia},M_{II}=\sum_i M_{i,II})$$

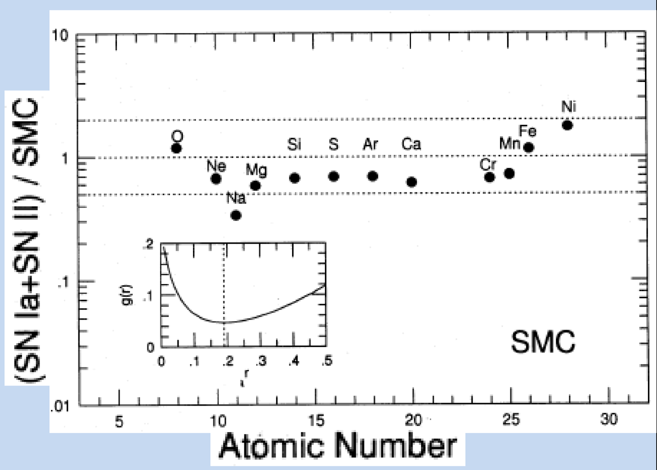
$$x_i\equiv r\frac{M_{i,Ia}}{M_{Ia}}+(1-r)\frac{M_{i,II}}{M_{II}}\qquad g(r)=\sum_{i=1}^{n}\frac{(\log x_i-\log x_{i,\Theta})^2}{n}$$

The most probable value of r, determined by minimizing g(r), shows the proportion of SNe.

The results ($x_i/x_i(◎)$) using r







NOTE : open circles show the elements not calculated.

We can see the success of standardization on these graphs. The most probable r is 0.09 in the solar neighbourhood. By adding isotopes, r = 0.08. 0.16 for LMC, 0.19 for SMC.

$$w_{II}=\frac{f_g Z_{g,o}}{(1-f_g)Z_{s,o}+f_g Z_{g,o}}\qquad c_g=1-10^{-[O/Fe]_{II}}\frac{(Z_O/Z_{Fe})_g}{(Z_O/Z_{Fe})_\Theta}$$

$$w_{Ia}=\frac{f_g c_g Z_{g,Fe}}{(1-f_g)c_s Z_{s,Fe}+f_g c_g Z_{g,Fe}}\qquad c_s=1-10^{-[O/Fe]_{II}}\frac{(Z_O/Z_{Fe})_s}{(Z_O/Z_{Fe})_\Theta}$$

w_{II} and w_{Ia} are determined to calculations of the model. $[O/Fe]_{II}$ is taken from the observation of metal-poor stars.

3.The chemical evolution

3.1.Models

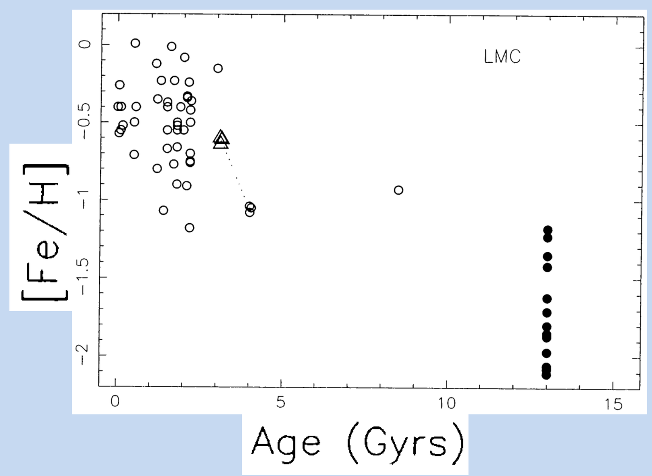
They used the model by Yoshii et al. 1996 (based on the infall model (cf. Tinsley 1980) has IRA and IMA).

$$\frac{df_{gas}}{dt}=-\alpha\psi(t)+A(t)$$

$$\frac{d(Z_i f_{gas})}{dt}=-\alpha Z_i(t)\psi(t)+Z_{A,i}(t)A(t)+y_{II,i}\psi(t)+y_{Ia,i}\int_0^t\psi(t-\tau_{Ia})g(\tau_{Ia})d\tau_{Ia}$$

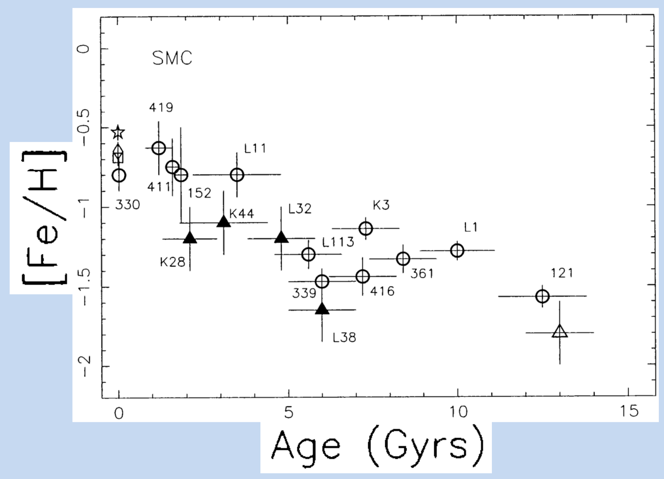
① The lack of cluster in the age-metallicity relation provides two phases of star formation in LMC.

⇒a burst model for LMC



② The age-metallicity relation for SMC is continuous.

⇒a continuous model for SMC



Initial Mass Function and Star Formation Rate follow the power law and the Schmidt law respectively.

The smaller timescale of infall (t_{fall}) causes the larger infall.

input parameters

	continuous model Solar Neighborhood	LMC	SMC	burst model LMC	SMC
t_{fall}	5	5	5	0.3	0.3
t_{Ia}	1.5	1.5	1.5	1.5	1.5
k	1	1	1	1	1
f_g	0.15	0.15	0.36	0.15	0.36
$[O/Fe]_{II}$	0.41	0.31	0.27	0.34	0.28
$[O/H]_g$	0.0	-0.58	-0.90	-0.58	-0.90
$[Fe/H]_g$	0.1	-0.28	-0.67	-0.28	-0.67
t_1-t_2	...	...	...	1–12	1–12

NOTE : t_{fall}, t_{Ia}, t_1 and t_2 are in units of Gyr. In the burst models, star formation between t_1 and t_2 has been stopped.

3.2.Results

	continuous model Solar Neighborhood	LMC	SMC	burst model LMC	SMC
$[O/H]_s$	-0.20	-0.78	-1.16	-1.44	-1.64
$[Fe/H]_s$	-0.17	-0.56	-0.98	-1.52	-1.71
w_{Ia}	0.27	0.26	0.55	0.82	0.90
w_{II}	0.22	0.22	0.50	0.56	0.76
x	1.35*	1.73	1.88	1.62	1.84
N_{Ia}/N_{II}	0.15	0.24	0.30	0.21	0.28

The observed $\dot{N}_{Ia}/\dot{N}_{II/Ib/Ic}$ is ~ 0.15 in the Galaxy (van den Bergh & Tammann 1991) and ~0.10 in Sbc-Sc galaxies (Tammann 1993).

4.Summary

In MCs, the frequencies of SNe Ia relative to SNe II is larger than that of the solar neighbourhood.

It is seen from the abundance pattern of the galaxy.

5.References

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