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ON THE [O/Fe] VERSUS [Fe/H] RELATIONSHIP AND THE PROGENITORS OF TYPE I SUPERNOVAE

C. ABIA,[1,2] R. CANAL,[3,4] AND J. ISERN[4,5]

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ABSTRACT

The new observational [O/Fe] versus [Fe/H] relationship for halo stars is studied in terms of several models of chemical evolution for the solar neighborhood. Nucleosynthesis products from Type I (both Ia and Ib) and Type II SNs are taken into account. The behavior of the [O/Fe] ratio for halo and disk stars is well reproduced by assuming (1) a lower iron production in SN II than in previous theoretical prescriptions, (2) the coalescence by gravitational wave radiation of two CO white dwarfs as the scenario for Type Ia supernovae, and (3) stars in the Wolf-Rayet stage as progenitors of Type Ib supernovae. Nevertheless, the best agreement with the observations is obtained by adopting an IMF favoring massive star formation only at very early epochs in the life of the Galaxy. Model predictions from other plausible scenarios for the origin of Type I supernovae are also discussed as well as the implications of the revised rate for the $^{12}C(\alpha, \gamma)^{16}O$ reaction on the evolution of ^{12}C, ^{16}O, and ^{56}Fe relative abundances.

Subject headings: gravitation — nucleosynthesis — stars: abundances — stars: formation — stars: supernovae

I. INTRODUCTION

The evolutionary scenario usually adopted for the progenitors of SN I is a binary system where a white dwarf produced from an intermediate or low-mass star ($M \leq 8\ M_\odot$) (primary star) is accreting material from its less massive companion (secondary star). However, it is not clear at present what kind of star, in particular, which member of a binary system can evolve to give a SN I. The secondary star might be a red giant, a nondegenerate He star, a star in the main sequence, or even another white dwarf (Iben and Tutukov 1984). The primary star might be a CO, He, or ONeMg white dwarf (see Iben and Tutukov 1984 for a review of the topic). What seems clear is that the large number of possibilities concerning the total mass of the binary system, accretion rates, and orbital characteristics results, in a natural way, in a wide range of evolutionary times previous to explosion.

The supernovae that we have described are currently called Type Ia supernovae or "classical" Type I supernovae. However, observational evidence indicates the existence of at least another class of Type I supernovae, Type Ib, which are fainter than Ia, show different spectral features, and are associated with arms in spiral galaxies. The fainter light curve of SN Ib is interpreted as evidence of a smaller ^{56}Ni production in the explosion ($\sim 0.15\ M_\odot$: Arnett, Branch, and Wheeler 1985) than in SN Ia ($\sim 0.6\ M_\odot$: Nomoto, Thielemann, and Yokoi 1984). On the other hand, their association with spiral arms (there is still strong controversy on this point: see Panagia 1988) seems to hint that SN Ib might originate from core collapse in very massive (Wolf-Rayet) stars which have lost their H-rich envelope (see e.g., Gaskell *et al.* 1986). Nevertheless, since the global spectroscopic and light curve characteristics of SN Ib are similar to those of SN Ia, other authors have claimed that the binary scenario might also be valid for SN Ib, the mechanism being detonation in a surface He-rich shell (Branch and Nomoto 1986; Iben *et al.* 1987). Alternatively, SN Ib might originate from C deflagration in single intermediate mass stars ($7 \leq M \leq 10\ M_\odot$), the previously called Type I 1/2 supernovae (see Iben and Renzini 1983).

Type II supernovae originate from core collapse in massive stars ($M \geq 8$–$10\ M_\odot$). They are responsible for the chemical enrichment of the galaxies, particularly in oxygen (see e.g., Woosley and Weaver 1986) and in intermediate-mass elements ($24 \leq A \leq 60$). Unlike SN I, SN II are not (individually) an important source of iron. In fact, after the interpretation of the light curve of SN 1987A (Woosley 1988), SN II would eject $\sim 0.07\ M_\odot$ of ^{56}Fe per explosion, a significantly lower amount than it was predicted in previous theoretical calculations. Nevertheless, we note on this point that SN 1987A is not a typical SN II and that the iron production in these supernovae is very uncertain (Arnett, Schramm, and Truran 1989).

On the other hand, the fact that SN II are related to the evolution of massive stars implies that the characteristic lifetime of these supernovae is significantly lower than that of Type I (Ia at least). This property makes very interesting the study of the ratios of the abundances of the elements mainly produced in SN II to that of Fe in stars, in particular in the oldest and most metal-poor stars of our Galaxy (Population II stars). Recent observations of halo stars (Abia and Rebolo 1989) point out that the [O/Fe] ratio grows monotonically from $[O/Fe] \simeq 0.0$ at $[Fe/H] \simeq 0.0$ (in agreement with previous observations: Sneden, Lambert, and Whitaker 1979; Clegg, Lambert, and Tomkin 1981) until $[O/Fe] \simeq 1.1$ dex at $[Fe/H] \simeq -2.0$ (which, nonetheless, is in contrast with the trend previously suggested by the authors mentioned above). In stars with $[Fe/H] \leq -2.0$, the [O/Fe] ratio might reach a constant value close to $+1.1$ dex (see Fig. 1).

The aim of theis paper is to calculate detailed models of chemical evolution for the solar vicinity in order to explain this new observational trend, putting particular emphasis on the role played by the different types of supernovae in the chemical enrichment of our Galaxy. We specifically discuss the different alternatives proposed for the progenitors of SN Ia and SN Ib.

[1] Instituto de Astrofísica de Canarias. La Laguna, Tenerife, Spain.
[2] Institut d'Astronomie, d'Astrophysique et de Geophysique, Bruxelles, Belgium.
[3] Departamento de Física de la Atmósfera, Astronomía y Astrofísica, Universidad de Barcelona, Spain.
[4] Grup d'Astrofísica, Societat Catalana de Física, I.E.C., Barcelona, Spain.
[5] Centre d'Estudis Avanças de Blanes, Gerona, Spain.

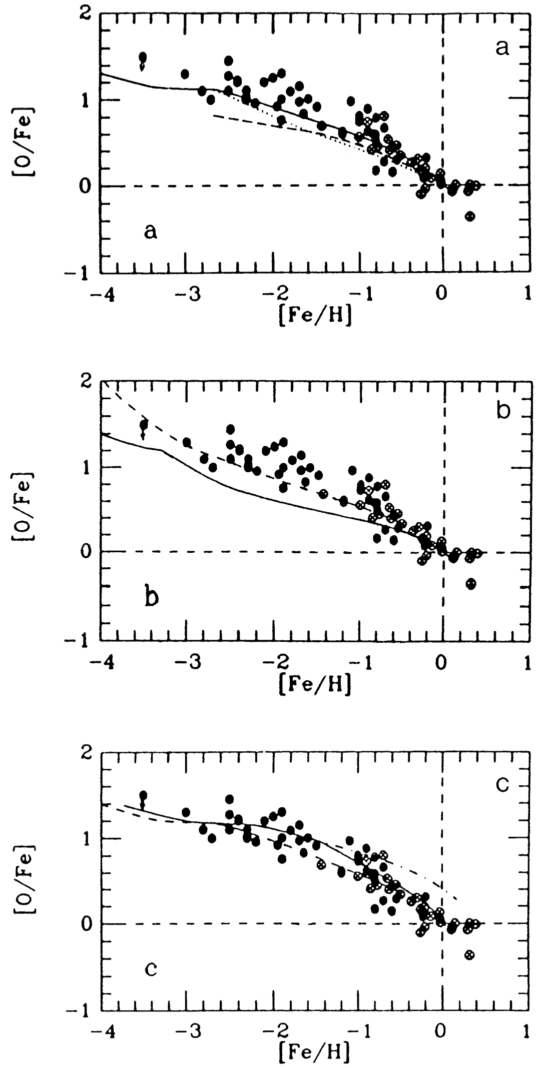

FIG. 1.—Predicted evolution of [O/Fe] versus [Fe/H] in several cases. (*a*) *Continuous line:* prediction for the double degenerate system scenario as progenitors of SN Ia and for Wolf-Rayet stars as progenitors of SN Ib. *Dotted line:* the same for the CO white dwarf + red giant scenario for SN Ia. *Dashed line:* prediction by Matteucci and Greggio (1986). (*b*) *Continuous line:* prediction from "SN I 1/2" for SN Ib. *Dashed line:* same case as the preceding, but without iron production in SN II. (*c*) *Continuous line:* prediction adopting a slope $x = 1.00$ for $t \leq 5 \times 10^8$ yr and $x = 1.35$ for $t > 5 \times 10^8$ yr, in "massive star" scenario for SN Ib and CO + CO scenario for SN Ia. *Dashed line:* prediction allowing formation of "supermassive" ($M \geq 100\ M_\odot$) stars at $t \leq 5 \times 10^8$ yr. *Dash-dotted line:* same as continuous line, but with $x = 1$ during the whole Galaxy lifetime (see text). Observational are indicated as follows: *filled circles*, Abia and Rebolo (1989) and Abia (1989); *crossed circles*, Sneden, Lambert, and Whitaker (1979) and Clegg, Lambert, and Tomkin (1981).

II. THE THEORETICAL MODEL

We make the following approximations:

1. We do not consider the hypothesis of instantaneous recycling, i.e., the star lifetime, τ_m, is taken into account according to Talbot and Arnett (1971).

2. The star formation rate $\psi(t)$ is related to the surface mass gas density $\sigma_g(t)$ via the relation $\psi(t) = \alpha\sigma_g^n(t)$, with $\alpha = 0.6$ Gyr^{-1} and $n = 1$. We include a exponentially decreasing unenriched infall with a e-folding constant of 4.5 Gyr, in such way that the present accretion rate is $f \simeq 0.2\ M_\odot\ \mathrm{pc}^{-2}\ \mathrm{Gyr}^{-1}$ (Mirabel and Morras 1984) and the total mass density $\sigma_T \simeq 70$ $M_\odot\ \mathrm{pc}^{-2}$. With these parameters, the main characteristics of the solar neighborhood are well reproduced (age-metallicity relation, current fraction of gas, etc.).

3. In a first approach we adopt an IMF constant in space and time, given by $\phi(M) \propto M^{-(1+x)}$, with $x = 1.35$ (Salpeter 1955) in the mass range $0.8 \leq M \leq 100\ M_\odot$.

Estimates of the frequencies of appearance of supernovae in spiral galaxies (van den Bergh 1988) indicated that SN II are $\sim$4 times more frequent than SN I. Of the observed Type I supernovae, 30%–60% are Ib. But more recently Evans, van den Bergh, and McClure (1989) suggest that SN Ia rates in spiral galaxies are lower than the previous estimate by van den Bergh (i.e., about one SN Ia every 700 yr for $H_0 \sim 50$ km s^{-1} Mpc^{-1}). The calculation of the theoretical supernova rates, particularly Type I, is a rather complex subject. We must note that it is impossible to calculate the Type I supernova rates in a rigorous way . This is due in part to the numerous parameters which are involved in the computation. These parameters depend on the stellar scenario adopted for the progenitors of this class of supernovae. In our model we have considered the following scenarios:

1. *Type Ia supernovae.*—We use the formulation by Greggio and Renzini (1983) to compute the rates. We consider two different origins for them:

1. The first is a binary system with a CO white dwarf accreting material from a companion red giant star. In this scenario, the time for the explosion is mainly controlled by the lifetime of the secondary star ($\tau^* = \tau_m$).

2. The second one is the scenario proposed by Iben and Tutukov (1984) and by Webbink (1984): two CO white dwarfs. In this latter scenario the characteristic time for the explosion is also determined by the lifetime of the initially less massive star but now to which is added the time elapsed until merging of the system by loss of angular momentum due to gravitational wave radiation (Landau and Lifschitz 1962), $\tau^* = \tau_m + \tau_{\mathrm{gr}}$, where

$$\tau_{\mathrm{gr}} = 1.48 \times 10^8 \gamma^8 m_1^6 m_2^2 \left(\frac{a_0}{M_1^2 M_2}\right)^4 \mathrm{yr}\,, \qquad (1)$$

m_1, m_2, M_1 and M_2 being the white dwarf and original star's masses of the primary and secondary stars, respectively. γ is a parameter coming from the hypothesis that the energy necessary to eject the common envelope is nearly equal $\gamma \approx 1$ to the increase in the gravitational energy of the binary system due to its contraction (see Iben and Tutukov 1984 for details).

In this last scenario, one has to include in the computations of the rates a distribution function for the initial semimajor axis of the binary system a_0. Here we adopt a function $h(a_0) \simeq 1/a_0$ in the range $10 \leq a_0 \leq 10^4\ R_\odot$, according to Tutukov and Yungelson (1980). In both scenarios, we consider that SN Ia originate from intermediate-mass stars, so that the total mass of the binary system is in the range $M_B = 4$–$14\ M_\odot$. In this way, we guarantee that, due to accretion, the primary star will reach Chandrasekhar's limit. In the computation of the SN Ia rate we adopted that only $\sim$2% of the binary systems ever formed in the adequate range of masses and semimajor axes will give a SN Ia. This assumption has to be introduced to fit the present SN Ia rate since we cannot consistently derive how many of those binary systems will actually give a SN Ia. Note finally that in our formulation it is impossible to distinguish between SN Ia and SN Ib if the latter also originate in a binary system (i.e., CO white dwarf + nondegenerate He star; see

Iben *et al.* 1987), although the exploding white dwarf model for SN Ib seems to be ruled out by the large amount of oxygen that is observed in those objects (Fransson and Chevalier 1989).

2. *Type Ib supernovae.*—We assume that their progenitors are individual massive stars and we consider two cases: (1) very massive stars $M \geq 30 M_{\odot}$, in the Wolf-Rayet stage (van den Bergh 1988), and (2) C deflagration in stars in the mass range $7 \leq M \leq 10\ M_{\odot}$ (Iben and Renzini 1983).

3. *Type II supernovae.*—These supernovae are produced by core collapse in stars with $M \geq 10\ M_{\odot}$. If we adopt assumption (1) for SN Ib, the progenitors of SN II will be stars in the mass range $10 \leq M \leq 30\ M_{\odot}$. The formulation for the computation of SN II and SN Ib rates is taken from Matteucci and Tornambè (1988).

The rates derived for the present epoch are 1.4, 0.4, and 0.7 SN per century for SN II, SN Ia, and SN Ib, respectively. These relative rates are in good agreement with the estimate of van den Bergh (1988) for our Galaxy (i.e., SN II/SN Ia/SN Ib $\simeq 3.6/1/1.4$). In the case of the double degenerate system, the maximum SN Ia rate is reached some time later than in the red giant + CO white dwarf scenario. This is because, on average, the characteristic time in which a binary system will give rise to a SN Ia is longer in scenario (2). The difference in the times at which the maximum rate is reached, between both scenarios, is very relevant to the predicted evolution of the [O/Fe] versus [Fe/H] relationship, as we will see below.

As nucleosynthesis prescriptions we have adopted the following:

1. *Individual stars.*—For low- and intermediate-mass stars ($0.8 \leq M \leq 8\ M_{\odot}$), the nucleosynthesis prescriptions of Renzini and Voli (1981), in particular those computed with the parameters $Y = 0.11$, $Z = 0.02$, $\alpha = 1.5$, and $\eta = 0.33$.

2. *Massive stars.*—For massive stars ($M \geq 8$–$10\ M_{\odot}$), we use the ^{16}O yields of Woosley and Weaver (1986), calculated with the $^{12}C(\alpha, \gamma)^{16}O$ reaction rate of Kettner *et al.* (1982). This rate is 3–5 times higher than the older one by Fowler, Caughlan, and Zimmerman (1975). In very massive stars ($M \geq 50\ M_{\odot}$), we also take into account the ^{16}O yield due to stellar mass loss according to Prantzos *et al.* (1986). For iron we have assumed that each SN II ejects $\sim 0.07\ M_{\odot}$. This mass of ^{56}Fe is deduced from the interpretation of the light curve of SN 1987A (Woosley 1988; Hashimoto, Nomoto, and Shigeyama 1989; Arnett, Schramm, and Truran 1989). SN Ib eject $\sim 0.15\ M_{\odot}$ of ^{56}Fe in the two scenarios considered.

3. *Binary stars.*—Concerning binary stars (SN Ia), we take the nucleosynthesis prescriptions from Nomoto, Thielemann, and Yokoi (1984). Therefore, a SN Ia ejects $\sim 0.6\ M_{\odot}$ of ^{56}Fe and $\sim 0.14\ M_{\odot}$ of ^{16}O. This iron production is enough to explain the main observational characteristics of this type of supernova (Branch 1988).

III. RESULTS AND DISCUSSION

In Figure 1*a* we show the predicted evolution of the [O/Fe] versus [Fe/H] relation (*continuous line*) obtained by adopting scenarios (2) and (1) for the progenitors of SN Ia and SN Ib, respectively. The model gives correct absolute abundances of ^{16}O and ^{56}Fe at the time of solar system formation ($t \simeq 8.5$ Gyr) and fits quite well the age-metallicity relation and the current fraction of gas in the solar neighborhood. For comparison, we have drawn in Figure 1*a* (*dashed line*) the prediction of the model by Matteucci and Greggio (1986). We see that at $[Fe/H] \leq -1.0$ our model predicts higher [O/Fe] ratios than those obtained by Matteucci and Greggio (1986). The main reason for this is the lower iron production in SN II adopted here. Due to the short lifetime of the SN II progenitors ($< 10^8$ yr), lowering the iron yield in SN II affects the evolution of the [O/Fe] ratio at very early epochs (i.e., at low metallicity). That seems to be consistent with the observations. An alternative to the reduction of the Fe yield in SN II could be to adopt a different IMF for massive stars during all the Galactic lifetime, in the sense of a flatter slope for them than for lower mass stars. However, we checked that, e.g., by adopting a slope $x = 1.0$ for $M \geq 10\ M_{\odot}$ (keeping the old yield for Fe in SN II from Woosley and Weaver 1986). In this case, the [O/Fe] ratio is not higher than 0.7 dex at $[Fe/H] \leq -1.5$. Any flatter slope of the IMF for massive stars gives an overabundance of oxygen at the time of the solar system formation.

With increasing metallicity, the [O/Fe] ratio goes down with a slope in agreement with the observed one. This is due to the enrichment of the interstellar medium by the nucleosynthesis products from SN Ia, in our case obviously Fe. From the model predictions, when the interstellar medium reached $[Fe/H] \sim -2$, a considerable number of SN Ia had already appeared ($\sim 10\%$ of the total over the Galaxy's lifetime). Since $[Fe/H] \sim -2$ is reached in the model in $\sim 10^8$ yr, this indicates that an important fraction of the progenitor stars of SN Ia must have lifetimes shorter than this, and therefore masses $M \geq 5\ M_{\odot}$ at least.

The characteristic time of appearance of SN Ia in the Galaxy is a critical point for the evolution of the [O/Fe] versus [Fe/H] relationship. This can also be seen in Figure 1*a*, where the dotted line represents the model prediction from scenario (1) for SN Ia progenitors (CO white dwarf + red giant). In this case, the predicted [O/Fe] ratios are below those calculated in scenario (2) at $[Fe/H] \geq -2$, and it is in contrast with the observations between $-3.0 \leq [Fe/H] \leq -1$. This is due to the higher SN Ia rate obtained in scenario (1) at early epochs, as we already pointed out above.

Figure 1*b* (*continuous line*) shows the model prediction from scenario (2) for SN Ib and SN Ia progenitors. The model prediction seems clearly incompatible with the observations. With the same hypothesis for SN Ib, we have considered the alternative of assuming that the Galactic enrichment of iron is due only to Type I supernovae (Ia and Ib) with no iron production by SN II. The result can be seen in Figure 1*b* (*dashed line*). Here the model prediction is better than in the previous case, but there is a strong rise of the [O/Fe] ratio at $[Fe/H] \leq -2.0$, which contradicts the observations. A similar result was obtained by Matteucci and Tornambè (1985) from analogous hypotheses. From this, we can conclude that in order to explain the observed [O/Fe] versus [Fe/H] relationship it seems necessary to include some Fe production in SN II, although in a smaller amount than the current theoretical prescriptions (see, e.g., Woosley and Weaver 1986).

The previous model predictions reproduce well the observed behavior of the [O/Fe] ratio against metallicity, although they underestimate this ratio for halo stars. We have considered other hypotheses in order to solve this problem. First, it has been suggested that the earliest generations of stars formed in the Galaxy could be dominated by the presence of supermassive stars ($M \geq 100\ M_{\odot}$). With regard to O and Fe, these stars have the peculiarity that $\sim 60\%$ of the ejected material (in pair-instability supernovae) is ^{16}O and there is no iron production at all. In Figure 1*c* (*dashed line*) we show the model prediction when one considers the existence of supermassive stars but only during a short period of time in the life of the Galaxy ($t \leq 5 \times 10^8$ yr). The nucleosynthesis prescriptions were taken from Ober, El Eid, and Fricke (1983), for the mass range $100 \leq M \leq 300$ $M_\odot$. In this model we have adopted scenarios (1) and (2) for SN Ib and SN Ia progenitors, respectively. We see that, for halo stars, the predicted [O/Fe] ratios are somewhat higher than those of the previous model (see continuous line in Fig. 1*a*), whereas the result is very similar for disk stars. It is important to note that if we assume formation of supermassive stars during a longer period of time ($t \geq 10^9$ yr), the model predicts oxygen overabundances higher than those observed for disk stars and, at the same time, an incorrect absolute O abundance at the time of formation of the solar system. Note that $\sim 5 \times 10^8$ yr is of the order of the characteristic time for collapse and formation of the Galactic halo (Burkert and Hensler 1988).

On the other hand, it has also been suggested that the IMF has changed in time. There is no clear evidence of this, but it is theoretically possible that in a metal-poor interstellar medium the formation of very massive stars were favored. We have taken into account this idea by adopting a slope $x = 1.0$, again during the first 5×10^8 yr only. The result is shown in Figure 1*c* (*continuous line*). Now the model prediction is in excellent agreement with the observations. Note again that when this hypothesis is adopted for a period longer than $t \geq 10^9$ yr, the model predicts oxygen overabundances higher than the observed ones (see Fig. 1*c*, *dash-dotted line*).

Another possibility is to adopt a lower SN I rate, as it has been recently suggested by Evans, van den Bergh, and McClure (1989). We checked this point by imposing the current SN Ia rate to be about one supernova every 700 yr, according to the estimates of Evans, van den Bergh, and McClure (1989). In this case, however, the iron production rate is so low that the model predicts an absolute abundance of Fe that is lower by a factor ~ 3 than that observed in the solar system.

Finally, we would like to make a few comments on an important point that might change our conclusions. The $^{12}C(\alpha, \gamma)^{16}O$ reaction rate determines, in the presupernova star, the relative abundances of the elements originated in He burning, in particular the C/O ratio: the lower the reaction rate, the higher the production of ^{12}C in SN II, and thus also the higher the $^{12}C/^{16}O$ ratio in the material ejected. Since SN I are not an important source of ^{12}C production, it is expected that the [C/O] ratio observed in very metal-poor halo dwarfs will be representative of the relative production of C and O in SN II. With this idea in mind, we have computed the evolution of the carbon abundance and compared the prediction with the observed [C/O] versus [O/H] relation. The nucleosynthesis prescriptions for ^{12}C were as follows: in low- and intermediate-mass stars, those of Renzini and Voli (1981); in massive stars, those of Woosley and Weaver (1986), obtained with the reaction rate of Kettner *et al.* (1982); and for SN Ia ~ 0.05 $M_\odot$ per explosion, according to Nomoto, Thielemann, and Yokoi (1984).

In Figure 2*a* we show the evolution of [C/Fe] versus [Fe/H] relation, computed with model hypotheses that fit well the [O/Fe] versus [Fe/H] relation. The result is not in agreement with the observations: the predicted [C/Fe] ratios are higher than the observed ones at any metallicity. This result was also obtained by other authors (see e.g., Matteucci 1988; Andreani, Vangioni-Flam and Audouze 1988). They argue that the problem with C comes from incorrect yields in low- and intermediate-mass stars. Our model, however, does reproduce quite well the increase of the [C/Fe] ratios found in stars with $[Fe/H] \leq -1.8$ (see Wheeler, Sneden, and Truran 1989 for a discussion of the [C/Fe] ratios). Also, the model prediction gives a nearly constant [C/Fe] ratio at $[Fe/H] \leq -2.5$, although there are not enough observations at present, for these metallicities, to draw any firm conclusion. These two results were not obtained in previous works. The reason for that is the lower Fe yield in SN II adopted here. Again, this last hypothesis seems to be in agreement with observations.

The [C/O] versus [O/H] evolution is shown in Figure 2*b*. The global behavior is quite well reproduced by the model, although the predicted [C/O] ratio is higher than the observed one. Since at $[O/H] \leq -0.6$ (i.e., at $[Fe/H] \leq -1.5$) the [C/O] ratio is mainly determined by the relative production of carbon and oxygen in SN II (carbon production in SN Ia does not affect the computed [C/O] versus [O/H] relationship), the fact that we obtain a [C/O] ratio higher than the one observed seems to indicate that the $^{12}C(\alpha, \gamma)^{16}O$ reaction rate cannot be

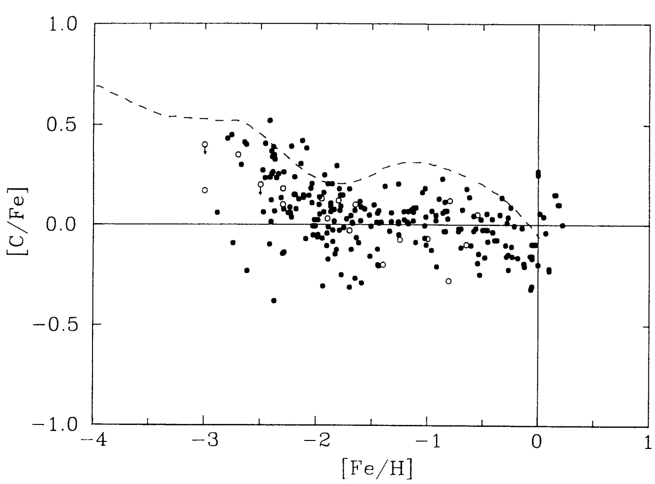

FIG. 2*a*

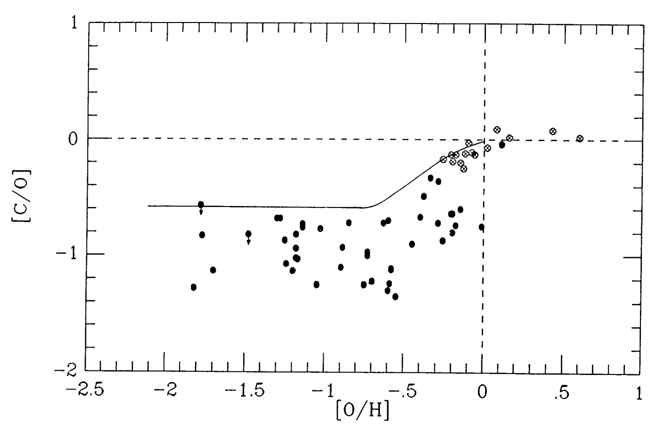

FIG. 2*b*

FIG. 2.—(*a*) Predicted evolution of the [C/Fe] ratio as a function of [Fe/H]. Observational data are indicated as follows: *filled circles*, Laird (1985), Tomkin, Sneden, and Lambert (1986), and Carbon *et al.* (1987) after revision by Wheeler *et al.* (1989); *open circles*, Abia (1989). (*b*) Predicted evolution of the [C/O] ratio as a function of [O/H]. Observational data are indicated as follows: *filled circles*, Abia (1989); *crossed circles*, Clegg, Lambert, and Tomkin (1981) (see text).

much lower than the value given by Kettner *et al.* (1982). Note that if we used the nucleosynthesis prescriptions for C and O obtained from the reaction rate of Fowler *et al.* the predicted [C/O] ratio at $[O/H] \leq -0.6$ would be even higher than those given in Figure 2. Therefore, the observational data, interpreted in the framework of chemical evolution models, might indicate that the $^{12}C(\alpha, \gamma)^{16}O$ reaction rate is even higher than the Kettner *et al.* (1982) one. If that were the case, perhaps it would not be necessary to adopt the above low iron production in SN II and/or an IMF favoring the formation of very high mass stars at early epochs in order to fit the [O/Fe] versus [Fe/H] relationship. At the same time, the computed [C/Fe] versus [Fe/H] relationship could also be improved in the sense that the [C/Fe] ratios would be lower at any metallicity, especially at $[Fe/H] \leq -2$. We checked, however, that even with a IMF variable in time or with a first generation of supermassive stars (using the nucleosynthesis prescriptions for ^{12}C of Ober, El Eid, and Fricke 1983), the model predicts a behavior similar to that shown in Figures 2*a* and 2*b* and does not solve the excessive [C/O] ratio at $[O/H] \leq -0.6$.

A further check of our model would be to confront its predictions with the trends observed for other elements, mainly those produced in SN II (Mg or S), against Fe (note that other α elements, like Si or Ca, could have an important production source in SN I). Unfortunately, there are not enough data at present on the abundances of these elements in dwarf stars with $[Fe/H] \leq -2$ to allow comparison in the metallicity domain where the predictions of our model are sensitive to the hypotheses under discussion. Thus, more observations are needed before definitive conclusions about the early chemical evolution of the solar neighborhood can be drawn.

IV. SUMMARY

Our main conclusions can be summarized as follows:

1. In order to explain the [O/Fe] versus [Fe/H] relationship it seems necessary to assume a very low iron production in Type II supernovae. Nevertheless, the best agreement with the observational data is obtained by adopting an IMF with a flat slope for the very early epochs in the life of the Galaxy. SN Ia are the main producers of Fe in the Galaxy (>80%).

2. The evolutionary scenario for Type Ia supernovae that is most compatible with the evolution of the [O/Fe] ratio in the Galaxy is the double white dwarf degenerate system. For SN Ib, either very massive stars in the Wolf-Rayet stage or simply a fraction of massive stars with distinctive nucleosynthesis yields can do the job.

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CARLOS ABIA: Institut d'Astronomie, d'Astrophysique et de Geophysique CP-165, Ave. F. D. Roosevelt 50, B-1050 Bruxelles, Belgium

RAMON CANAL: Departamento de Física, de la Atmósfera, Astronomía y Astrofísica, Facultad de Física, Avda. Diagonal 647, E-08028 Barcelona, Spain

JORDI ISERN: Centre d'Estudis Avanças de Blanes, Blanes, Gerona, Spain