Abstract. By means of 2–D chemodynamical simulations, we study the evolution of dwarf galaxies with structural parameters similar to IZw18 and to tidal dwarf galaxies. Different sets of yields from intermediate-mass stars are tested, in order to discover which one best reproduces the observed chemical compositions (in particular for nitrogen). Different choices of yields from intermediate-mass stars lead to differences of up to 0.3–0.6 dex, depending on the assumptions. It is also shown that, given the dependence of the cooling function on the metallicity, the dynamics of galaxies is also significantly affected by the choice of nucleosynthetic yields.

1. Introduction
From a nucleosynthetic point of view, asymptotic giant branch (AGB) stars are characterized by the nuclear burning of hydrogen and helium in thin shells on top of an electron-degenerate core of carbon and oxygen. Nuclear production from AGB stars is characterized by an important array of elements just above H and He (see contributions of Busso and Lattanzio in this volume), in particular C and N. The importance of AGB stars on the global chemical evolution of galaxies is therefore evident (see also the contribution of Tosi in this volume). As an example, we show in Fig. 1 (left side) a comparison between the evolution of a chemodynamical model with (right panels) and without (left panels) the contribution of ejecta from AGB stars. The model reproduces the main features of the gas-rich dwarf galaxy IZw18 and assumes two bursts of star formation separated by 300 Myr of quiescence. Only the evolution after the second burst is shown. The oxygen is almost unaffected (most of the α-elements are produced by massive stars). Looking at the evolution of C/O and N/O, the difference between the AGB and non-AGB models, and the disagreement between the non-AGB model and the observations (represented by shaded areas in Fig. 1), are striking. Clearly, AGB ejecta are a fundamental ingredient of the chemical evolution of galaxies.

Gas-rich dwarf galaxies are characterized by peculiar chemical compositions, hardly understandable in terms of closed-box models of chemical evolution. In particular, the N/O ratios are puzzling. For $12 + \log \left( \frac{O}{H} \right)$ larger than 7.8, the log (N/O) increases linearly with metallicity, although with large scatter. This is consistent with a secondary production of nitrogen. At lower metallicities, all the galaxies seem to show a constant log (N/O) (of the order of $-1.55$ to $-1.60$), with reduced scatter (Izotov & Thuan 1999). This is a typical behavior of elements produced in a primary way (namely, starting from the C and O
newly formed in the star). Our aim in this contribution is to understand more about the time evolution of particular abundance ratios. We will explore specifically its dependence on the adopted mode of star formation (SF) and on the nucleosynthetic prescriptions. We will show both models aimed at reproducing IZw18 (§ 3.1) and models in which we simulate dark-matter-poor dwarf galaxies resulting from tidal interactions of large galaxies (§ 3.2).

2. The Model

In § 3.1 we present models already published (Recchi et al. 2002, 2004), in which we simulate the main properties of the extremely metal-poor dwarf galaxy IZw18. The adopted numerical code is described in the above-mentioned papers. Here we focus on the effect of nucleosynthetic prescriptions on the chemical and dynamical evolution of the galaxies. In § 3.2 we present preliminary results of new models in which considerable improvements of the code have been implemented. In particular, the self-gravity has been taken into consideration, the release of chemical elements from SNeII and SNeIa has been upgraded in order to take more properly into consideration primary and secondary contributions, SF now depends on the local thermodynamical characteristics of the gas, and the (metallicity-dependent) energy feedback from stellar winds is taken into consideration.

3. Results

3.1. IZw18 Models

We have considered (a) two instantaneous bursts of SF separated by a quiescent period of 300 Myr, and (b) a SF history in which a long episode of SF of
mild intensity is followed (after a short period without SF) by a more vigorous burst, lasting 5 Myr ("gasp" SF; see Recchi et al. 2004). Three sets of yields from intermediate-mass stars (therefore three different prescriptions for the AGB ejecta) have been considered: Renzini & Voli (1981 – RV81); van den Hoek & Groenewegen (1997 – VG97), and Meynet & Maeder (2002 – MM02).

In the first two cases, we combine these yields with the nucleosynthetic prescriptions for massive stars taken from Woosley & Weaver (1995), whereas in the models adopting MM02 yields we adopt for consistency the whole set of masses calculated by those authors, ranging from 2 to 60 \( M_\odot \).

The evolution of \( \log (C/O) \) and \( \log (N/O) \) for the IZw18 gasping models is shown in Fig. 1 (right side). The dependence of \( \log (C/O) \) on the assumed nucleosynthetic prescriptions is rather small (\( \sim 0.1 \) dex at most), whereas the difference in the nitrogen production is very remarkable. In particular, MM02 already produce nitrogen in a primary way in massive stars, so that the predicted N/O is larger than for the other sets of yields in the first tens of Myr. At later times, when AGB stars start to dominate the chemical pollution of the galaxy, the nitrogen predicted assuming MM02 yields is considerably lower than the other models (\( \sim 0.3 \) dex of difference assuming VG97 yields, \( \sim 0.6 \) dex less than what is predicted by the RV81 model). It is however worth recalling that the MM02 models do not take into consideration later phases of the stellar evolution (in particular the third dredge-up and the hot-bottom burning phase), N being mainly produced in a primary way through rotational diffusion of C in the H–burning shell; therefore the predicted N/O should be considered as a lower limit.

Similar differences between various sets of yields are also attained by the bursting models. This is shown for instance in Fig. 5 of Recchi et al. (2002), where it can also be seen how little the different AGB yields affect the oxygen evolution.

The choice of MM02 yields gives better agreement between the model results and the observed abundance ratios, in particular for \( \log (N/O) \). Moreover, assuming a gasping SF regime, the \( \log (N/O) \) attained for the MM02 model reaches \( \sim -1.6 \) in about 120 Myr and then stays almost constant for the rest of the evolution of the object (Fig. 1, right side). This behavior would easily explain the plateau at around this value observed in metal-poor dwarf galaxies. A bursting SF would instead produce large variations of abundance ratios on short timescales which would easily lead to a large scatter in N/O.

### 3.2. Models of Tidal Dwarf Galaxies

Tidal Dwarf Galaxies (TDGs) evolve from self-gravitating structures formed inside tidal tails, thrown out from interacting gas-rich galaxies. Theoretical arguments (Okazaki & Taniguchi 2000) show that this mechanism of galaxy formation can account for most of the present-day dwarf population. However, from basic physical principles and simulations it is clear that TDGs are characterized by a very small dark matter (DM) content, so that a larger impact of the feedback from the ongoing SF is expected. Hence, the survival of TDGs after many Gyrs is questioned. We ran a set of chemodynamical models aimed at simulating DM–poor dwarf galaxies (see Recchi et al. 2007) in order to study under what conditions these objects can sustain the energy released by dying stars without experiencing a blow-away. As we have done in § 3.1, we study here how these models are affected by a different choice of AGB yields.
In Fig. 2 (left side) we show a comparison of the dynamical evolution of two models differing only in the adopted nucleosynthetic prescriptions: MM02 (left panels) and VG97 (right panels), respectively. These models have a SF efficiency $\varepsilon_{\text{SF}} = 0.2$ and a temperature SF threshold $T_{\text{thr}} = 10^4$ K. The superbubble evolution is faster in the MM02 model. Indeed, MM02 produces on average more metals (in particular more $\alpha$-elements), therefore leading to larger cooling rates. On the one hand, it reduces the thermal energy content inside the superbubble, but on the other hand this increased cooling favors the process of star formation, leading to a more powerful feedback. The latter effect prevails, and a larger energy is available in model MM02 to drive the expansion of the supershell. In spite of the quite evident differences, the gross features of the models are the same; after $\sim 100$ Myr a major galactic wind develops and most of the gas is carried out of the galaxy. On the right side of Fig. 2 we compare the evolution of $\text{O/H}$ (left panel) and $\log (\text{N/O})$ (right panel) as a function of time for these two models. The differences in the final oxygen are very small, whereas looking at the evolution of $\text{N/O}$ we notice the same behavior that we pointed out in § 3.1, namely $\log (\text{N/O})$ is larger at the beginning for the MM02 model (due to a larger primary nitrogen production in massive stars), but when the nitrogen production from AGB stars becomes significant, the $\log (\text{N/O})$ in the VG97 model overtakes the MM02 model, attaining in the end a value $\sim 0.2$ dex larger. These differences are therefore mostly due to the variations in the adopted sets of nitrogen yields rather than to the different dynamical behavior of the models.

The SF process in these models lasts $\sim 100$ Myr. Indeed, varying parameters like $\varepsilon_{\text{SF}}$ and $T_{\text{thr}}$, it is possible to produce stars at a milder rate, with less disruptive effects. For instance, a model with $\varepsilon_{\text{SF}} = 0.1$ or a model with a temperature threshold of $T_{\text{thr}} = 10^3$ K can produce stars at a rate of few tenths of a $M_\odot$ yr$^{-1}$ for at least 300 Myr.
4. Conclusions

We have studied the dynamical and chemical evolution of dwarf galaxies assuming different sets of yields from AGB stars. We have focused our study on two model galaxies: the first reproduces the main structural properties of IZw18 while the second is a DM–poor model aimed at studying the early evolution of tidal dwarf galaxies. Our main conclusions can be summarized as follows:

- Different sets of yields can affect the final predicted abundances and abundance ratios up to 0.5–0.6 dex, especially for nitrogen.
- In the framework of gasping models of star formation, the abundance ratios are almost constant over large timescales, explaining the lack of a large spread in the observed log (N/O) of metal-poor dwarf galaxies.
- Due to the dependence of the cooling curve on the metallicity, models with different sets of yields also have different dynamical evolutions.
- Models of DM–poor dwarf galaxies are not necessarily rapidly destroyed and can survive the feedback of the ongoing star formation for more than 300 Myr.

Acknowledgments. The SOC is warmly acknowledged for accepting my contribution and for putting together a very interesting conference. Decisive contributions to the work presented here have come from my collaboration with A. D’Ercole, G. Hensler, P. Kroupa, F. Matteucci, Ch. Theis and M. Tosi. I also acknowledge financial support from the Deutsche Forschungsgemeinschaft (DFG) under grants HE 1487/28 and TH 511/8.

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Discussion

Gustafsson: Could you comment on what would happen, in particular to your short mixing times, if you would allow a third spatial dimension?

Recchi: The third dimension would increase the turbulence in the ISM, therefore allowing for more efficient mixing of the newly produced metals.