Continuous star formation in gas-rich dwarf galaxies

Simone Recchi and Gerhard Hensler

Institute of Astronomy, Vienna University
Türkenschanzstrasse 17, A-1180 Vienna, Austria
recchi@astro.univie.ac.at,
hensler@astro.univie.ac.at

Abstract

Blue Compact Dwarf and Dwarf Irregular galaxies are generally believed to be unevolved objects, due to their blue colors, compact appearance and large gas fractions. Many of these objects show an ongoing intense burst of star formation or have experienced it in the recent past. By means of 2-D hydrodynamical simulations, coupled with detailed chemical yields originating from SNeII, SNeIa and intermediate-mass stars, we study the dynamical and chemical evolution of model galaxies with structural parameters similar to IZw18 and NGC1569. Bursts of star formation with short duration are not able to account for the chemical and morphological properties of these galaxies. The best way to reproduce the chemical composition of these objects is by assuming long-lasting episodes of star formation and a more recent burst, separated from the previous episodes by a short quiescent period. The last burst of star formation, in most of the explored cases, does not affect the chemical composition of the galaxy observable in H II *regions, since the enriched gas produced by young stars is in a too hot phase to be detectable with the optical spectroscopy.*

1 Introduction

Among dwarf galaxies, Blue Compact Dwarfs (BCDs) and Dwarf Irregulars (dIrrs) are characterized by large gas content and often an active star formation (SF). They also show very blue colors and low metallicities and are therefore commonly believed to be poorly evolved systems. They are consequently ideal targets to study the feedback between star formation and interstellar medium. They have also been suggested to be the local counterparts of faint blue objects detected in excess at $z \sim 1$ (Babul & Rees 1992; Lilly et al. 1995).

It has recently become clear that most of these objects show the presence of stars of intermediate-old age (Kunth & Östlin 2000), but their importance for the global metallicity and energy budget of the galaxy is still unknown. It is interesting to

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simulate galaxies whose light and colors are dominated by young stars (like IZw18 and NGC1569) and to see whether their chemical and morphological properties are dominated by a recent burst of star formation or whether older episodes of SF are required in order to explain some of their characteristics.

In general, the SF in BCDs is described as a *bursting* process (Searle et al. 1973), namely, short, intense episodes of SF are separated by long inactivity periods. A *gasping* mode of SF (long episodes of SF of moderate intensity separated by short quiescent periods) is instead often used to describe the star formation in dIrrs (Aparicio & Gallart 1995). Good galaxy candidates experiencing gasping star formation are for instance NGC6822 (Marconi et al. 1995), Sextans B (Tosi et al. 1991) and the LMC (Gallagher et al. 1996). These two different SF regimes have been tested in the framework of chemical evolution models (Bradamante et al. 1998; Chiappini et al. 2003a; Romano et al. 2004), producing similar results, therefore is it not easy to discriminate between these two different SF scenarios on the basis of chemical evolution models alone. Our aim is to simulate the dynamical and chemical evolution of model galaxies by means of a 2-D hydrodynamical code in cylindrical coordinates, coupled with detailed chemical yields. Since the largest set of parameters is derived from various observations for IZw18 and NGC1569, we intend to see whether is it possible to put constraints on their past SF history.

Despite the different classification (IZw18 is a BCD galaxy, whereas NGC1569 is often classified as dIrr), these two objects show similar properties: both of these objects are in the aftermath of an intense burst of SF, are very metal poor (0.02 $Z_\odot$ for IZw18, Izotov & Thuan 1999; 0.23 $Z_\odot$ for NGC1569, González Delgado et al. 1997) and have an extremely large gas content.

In spite of their simplicity, the chemical composition of gas-rich dwarf galaxies is often peculiar and hardly understandable in terms of closed-box models. In particular, the N/O ratios are puzzling. For metallicities larger than 12 + log (O/H) $\sim$ 7.8, the log (N/O) is linearly increasing with the metallicity, although with a large scatter. This is consistent with a secondary production of nitrogen (N synthesized from the original C and O present in the star at birth). At lower metallicities, all the galaxies seem to show a constant log (N/O) (of the order of -1.55/-1.6), with almost no scatter (Izotov & Thuan 1999; hereafter IT99). This is a typical behaviour of element produced in a primary way (starting from the C and O newly formed in the star). Although some specific metal-poor objects seem to contradict the existence of the plateau (see e.g. Skillman et al. 2003; Pustilnik et al. 2004), an explanation is needed in order to understand the behavior of most dwarf galaxies in this range of metallicities.

This problem has been investigated in several papers and various ideas have been proposed to solve this puzzle. Izotov & Thuan (1999) proposed a significant primary production of nitrogen in massive stars, whereas the models of Henry et al. (2000) were able to explain the low log (N/O) at low metallicities with a very weak and constant star formation rate. Recently, Köppen and Hensler (2004) proposed the infall of metal-poor gas as a mechanism able to reduce the oxygen abundance of the galaxy, keeping the N/O ratio constant. For none of these models, however, a complete investigation of the structural and energetic effects by means of hydrodynamical simulations have been performed.

Moreover, IZw18 and NGC1569 have been carefully studied in the past and now we know, with reasonable accuracy, the chemical abundances not only in the H II medium, but also in other gas phases. In particular, recent *FUSE* (Far Ultraviolet Spectroscopic Explorer) data allowed two groups of astronomers (Aloisi et al. 2003; Lecavelier des Etangs et al. 2004) to calculate the H I abundances in IZw18. There is also an attempt to evaluate the chemical composition of the hot medium in the galactic wind of NGC1569, (Martin, Kobulnicky & Heckman 2002). It is challenging to compare the results of our simulations with these observations, in order to see whether is possible to put additional constraints on the past SF activity of IZw18 and NGC1569.

2 Chemical and dynamical evolution of IZw18

We first describe the evolution of a model galaxy resembling IZw18. This object, the most metal-poor galaxy locally known, has been considered in the past as a truly "young" galaxy, experiencing star formation for the very first time, since old stars could not be observed. Moreover, the spectral energy distribution is well described assuming a single, recent burst of SF (Mas-Hesse & Kunth 1999; Takeuchi et al. 2003). An underlying old population of stars has been first observed by Aloisi et al. (1999) in the optical and Östlin (2000) in the infrared, the age of which being however still disputed. This age ranges from some hundred Myrs (Aloisi et al. 1999) to a few Gyrs (Östlin 2000).

In the attempt of reproducing the characteristics of IZw18, we consider both a bursting and a gasping SF scenario. We first assume a couple of instantaneous bursts, separated by a quiescent period of 300-500 Myr. In the second subsection, we will consider a gasping SF with an old episode of SF lasting 270 Myr at a SF rate of 6×10^{-3} $M_{\odot}$ yr^{-1}, a gap of 10 Myr and a recent burst lasting only 5 Myr and being 5 times more intense then the long-lasting episode. This SF history has been suggested by Aloisi et al. (1999) by fitting the observed Color-Magnitude diagram of IZw18 with synthetic ones. In this attempt at reproducing the main characteristics of IZw18, we also vary the slope of the IMF and the adopted nucleosynthetic yields, both for massive and for intermediate-mass stars (IMS). The model parameters are summarized in Table 1.

We use a 2-D hydrodynamical code with source terms. The input of energy and chemical elements into the systems is provided by SNeII (mainly responsible for the production of α-elements), SNeIa (source of most of the iron-peak elements) and winds from low- and intermediate-mass stars (responsible for the bulk of nitrogen production and for a significant fraction of carbon). In all the considered models we will assume that SNeIa are more effective than SNeII in thermalizing the interstellar medium. This is due to the fact that SNeIa explode in a warmer and more diluted medium, owing to the previous activity of SNeII. The details about the code can be found in Recchi et al. (2001; 2002).

2.1 Bursting mode of star formation

The first (instantaneous) episode of SF produces 10^5 $M_\odot$ of stars and is separated from the second one by a quiescent period of 300-500 Myr. We follow the evolution of the ISM after the first burst. After the assigned inactivity interval, we calculate how much cold gas is remained in the central part of the galaxy and we convert 10% of this gas into stars. The metallicity of this new stellar population is given by the metallicity of the gas which the starts are formed from. We obtain a second burst of SF with a mass of $\sim 5 \times 10^5$ $M_\odot$ and a metallicity of 1/50 $Z_\odot$.

The first burst is not able to account for the metallicity of the gas in IZw18. At the onset of the second burst, there is a sudden increase of the oxygen content (and, consequently, a sudden decrease of C/O and N/O abundance ratios). This mode of SF is therefore characterized by huge variations of the chemical composition of the galaxy on very short timescales. A few tens Myrs after the onset of the second burst, N/O and C/O abundance ratios begin to grow, due to the release of chemical elements from IMS. The results of our simulations match the abundance ratios found in the literature for two age intervals of the last burst: between 4 and 7 Myr and between $\sim$ 40 and $\sim$ 80 Myr. The second solution does not fit neither the morphology nor the spectral energy distribution of IZw18 and has to be rejected. The favoured age of the last burst is then, in the framework of a bursting scenario of SF, between 4 and 7 Myr. This solution has a very short duration, since the oxygen abundance is increasing very rapidly in this phase. Models with a SF gap of 300 or 500 Myr show approximately the same behaviour.

2.2 Gasping mode of star formation

As we have seen in the previous section, the bursting mode of SF can fit the observed abundances and abundance ratios found in literature for IZw18 only in tiny intervals of time. This can also be seen in Fig. 1, where we have plotted the evolution of a bursting model with 300 Myr of inactivity between two instantaneous bursts (model IZw – 1; long-dashed line). This model crosses the values of log (N/O) and log (O/H) inferred by IT99, but, as stated in the previous section, the N/O abundance ratio in particular shows large variations on short time-scales and remains within the allowed range of values only very briefly. In this section we therefore study what happens if we relax the hypothesis of instantaneous bursts of SF. The way in which continuous episodes of SF can be treated by our code is described in Recchi et al. (2004).

Models with Salpeter IMF, yields from massive stars coming from Woosley & Weaver (1995) and IMS yields coming from the most cited papers (van den Hoek & Groenewegen 1997; Renzini & Voli 1981) overestimate the nitrogen content of the galaxy by 0.4 – 0.6 dex and some of them underestimate O/H (see Recchi et al. 2004). The best fit between the observations and the results of the model is obtained when implementing the yields of both massive and IMS from Meynet & Maeder (2002). In their models, nitrogen is mainly produced in a primary way through rotational diffusion of carbon in the hydrogen-burning shell. This set of nucleosynthetic yields has given good results in chemical evolution models (Chiappini et al. 2003b) and are therefore worth testing in our simulations. Is it, however, necessary to point

Table 1: Parameters for the IZw18 models

Model	SF mode[a]	x (IMF slope)	IMS yields	Massive stars yields
IZw – 1	bursting	1.35	RV81[b]	WW95[c]
IZw – 2	gasping	1.10	VG97[d]	WW95
IZw – 3	gasping	1.35	MM02[e]	MM02
IZw – 4	gasping	1.35	VG97	WW95

[a] Bursting (2 instantaneous bursts of SF) or gasping (long episode of SF plus a recent burst), as described in Sect. 2.
[b] Renzini & Voli (1981)
[c] Woosley & Weaver (1995)
[d] van den Hoek & Groenewegen (1997)
[e] Meynet & Maeder (2002)

out that these models do not take into consideration the last phases of the stellar evolution (in particular the third dredge-up) and may therefore underestimate the total amount of nitrogen produced in IMS.

The results of this model are shown in Fig. 1 (model IZw – 2; dotted line). This model nicely reproduces the log (N/O) of IZw18 and slightly overestimates the observed oxygen content. Another possibility to get results closer to the observations is by using a flatter IMF (with a slope of $x = 1.1$) in order to produce more oxygen in massive stars. This model is also shown in Fig. 1 (model IZw – 3; short-dashed line). The log (N/O) is ~ 0.2 dex larger than the observations, therefore it better reproduces the observations compared with models adopting Salpeter IMF and van den Hoek & Groenewegen (1997) IMS yields.

It is also worth noticing in Fig. 1 that, after the onset of the second burst of SF (i.e. at 280 Myr), the metallicity of the galaxy for the gasping models (IZw – 2 and IZw – 3) does not show any sudden increase, at variance with what happens in the framework of a bursting scenario of SF (model IZw – 1; long-dashed line). This is due to the fact that the first SF episode is sufficiently energetic to create an outflow. The metals produced by the second generation of stars are released in a hot medium or directly channelled along the outflow. Consequently, they do not have the chance to cool down to temperatures detectable with the optical spectroscopy. This means that, if the SF in a galaxy has been active long enough and has been energetic enough, the last burst of SF does not affect at all the metallicity of the gas. The so-called *self-pollution* of galaxies by freshly produced metals (Kunth & Sargent 1986) can hold only under particular conditions, i.e. for the very first bursts of SF or if the gap between subsequent episodes is long enough.

Another way to see the different chemical evolution of bursting and gasping models is by plotting the log (N/O) vs. log (O/H) diagram (Fig. 2). The solid line is the evolution of the IZw – 3 model, whereas the behaviour of the IZw – 4 model is shown

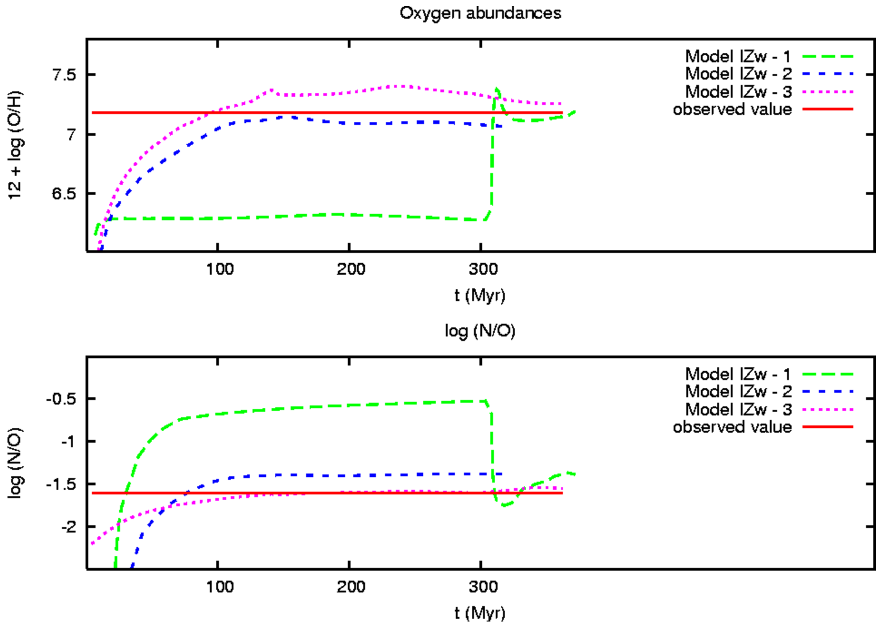

Figure 1: Evolution of 12 + log (O/H) (upper panel) and log (N/O) (lower panel) for IZw18 models. The solid line represents the observed values found for IZw18 (IT99). Model parameters are summarized in Table 1.

as dashed line. The bursting model IZw – 1 (dotted line) is plotted starting from the onset of the last burst. In Fig. 2 are also plotted the most recent data available in literature about O and N abundances in very metal-poor galaxies. As stated in the introduction, according to the results of IT99, these galaxies form a "plateau" in this diagram, the (N/O) ratios being very similar at different metallicities. Indeed, isolating the data of IT99 (filled squares and filled triangle), this plateau is pretty evident, whereas, when adding observations coming from other authors, the scatter seems to increase. We probably need more statistics and better measurements before drawing firm conclusions.

Model IZw – 4 exceeds the nitrogen of the most metal-poor galaxies (in particular the nitrogen of IZw18), whereas model IZw – 3 (solid line) matches the low log (N/O). It is also worth noticing that for this model it takes $\sim$ 100 Myr to reach the O abundance of the most metal-poor galaxies (see Fig. 1). After that, the chemical evolution tracks span a tiny region of the diagram for the remaining $\sim$ 200 Myr of the evolution of the galaxy. The bursting model IZw – 1 (dotted line) shows instead large abundance variations in very short time-scales. It takes only $\sim$ 80 Myr for this model to reach the final point. This kind of SF regime would produce a large scatter in the log (N/O) vs. log (O/H) diagram even at low metallicities. Under the hypothesis of a gasping SF regime the abundance ratios are stable for long time-scales, justifying the lack of scatter and the apparent plateau in the log (N/O) vs. log (O/H) diagram at low metallicities. Two recent papers (Aloisi et al. 2003; Lecavelier des

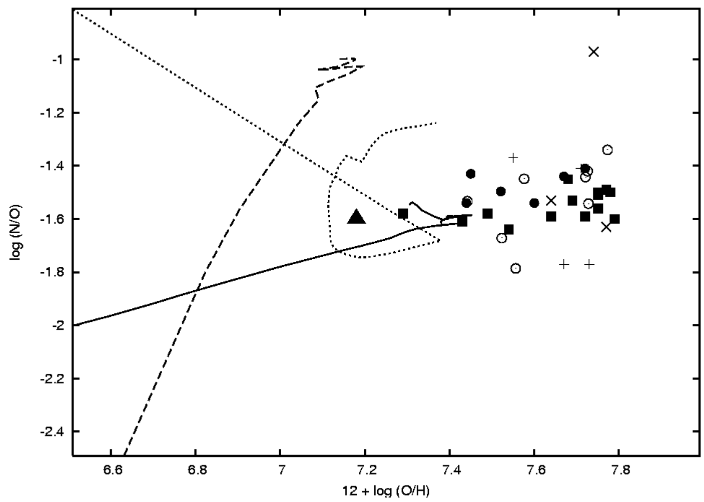

Figure 2: log (N/O) vs. 12 + log (O/H) in metal-poor BCD galaxies. The big filled triangle is the IZw18 value calculated by IT99. Filled squares are other galaxies measured by IT99. The collection of data by van Zee et al. (1997) is shown with pluses. The measurements by Kobulnicky & Skillman (1996) are indicated by suns. Crosses represent the values tabulated by Vílchez & Iglesias-Páramo (2003). The other data points (filled circles) are taken from different sources. Also shown is the evolution in the N/O vs. O/H plane of two gasping models: model IZw – 3 (solid line) and model IZw – 4 (dashed line). The dotted line represent the evolution of model IZw – 1 (bursting model), after the onset of the second burst of SF. Model parameters are summarized in Table 1

Etangs et al. 2004) tried to derive the chemical composition of the H I medium of IZw18. Even starting from the same *FUSE* data, the two papers differ significantly in the final abundance determinations. In particular, Lecavelier des Etangs et al. (2004) found an oxygen abundance in the neutral medium similar to the O/H derived in the H II regions, whereas Aloisi et al. (2003) obtained an O abundance a factor $\sim$ 3–4 lower than in the ionized gas. Due to the larger oxygen, the N/O ratio calculated by Lecavelier des Etangs et al. (2004) is much below the observations in the H II regions. The determination of Aloisi et al. (2003) is instead similar to the N/O found the in the ionized phase. In our models, we find a slight underabundance of O in the neutral medium, but not enough to justify the observations of Aloisi et al. (2003). The calculated log (N/O) is instead more consistent with the determinations of Lecavelier des Etangs et al. (2004) (see Recchi et al. 2004). Due to the differences in the results of these two groups, no robust constraints can be imposed by means of this comparison. A more careful parametrical study of gasping models for IZw18 will be presented in a forthcoming paper (Recchi et al. 2005, in prep.)

3 Chemical and dynamical evolution of NGC1569

We adopt the same hydrodynamical code described in the previous section to model a galaxy resembling NGC1569, a prototypical starburst galaxy. This galaxy is particularly valuable as a case study due to its proximity (2.2 Mpc according to Israel (1988); 1.95 or 2.8 Mpc according to Makarova & Karachentsev (2003)). It consists of two super star clusters (SSCs), with an absolute separation of 80–85 pc. The IMF slope of the SSCs is well constrained by the luminosity/mass ratio and is close to the Salpeter slope (Sternberg 1998). The stellar population in NGC1569 is dominated by stars younger than a few tens Myrs, the majority of which are found in two prominent super star clusters (Anders et al. 2004), although the presence of older stars have been inferred (Vallenari & Bomans 1996; Greggio et al. 1998).

We therefore adopted two possible SF histories for NGC1569. The first is a single burst of star formation, lasting for 25 Myr. The SF rate inferred by Greggio et al. (1998), assuming a Salpeter IMF, is 0.5 $M_\odot$ yr^{-1}. A weaker SF rate for the present burst (0.13 $M_\odot$ yr^{-1}) has been found in more recent studies of the CMD diagram of NGC1569 (Angeretti et al. 2005). Martin et al. (2002), by fitting the Hα luminosity, found a SF rate of 0.16 $M_\odot$ yr^{-1} for the last burst. Given the uncertainties of this value, we keep the SF rate as a free parameter.

A more complex episode of SF has been recently discovered by Angeretti et al. (2005) and is characterized by 3 episodes of SF. The first happened between 600 and 300 Myr ago at a rate of 0.05 $M_\odot$ yr^{-1}. This episode is followed by a period of inactivity of 150 Myr and then by a second episode lasting 110 Myr at a SF rate of 0.04 $M_\odot$ yr^{-1}. After a short quiescent period (3 Myr) the last episode of SF started. The onset of this episode is therefore 37 Myr ago, lasting until 13 Myr ago (24 Myr of duration in total, consistent with the estimates of Anders et al. 2004) at a rate of 0.13 $M_\odot$ yr^{-1}. It is worth pointing out that, in this work, the stars in a field of 200 $\times$ 200 pc have been analyzed and, therefore, the gaps in the SF process might be spurious. Table 2 summarizes the parameters adopted to model NGC1569.

Table 2: Parameters for the NGC1569 models

Model	SF episodes	SF rate ($M_\odot$ yr^{-1})	M_{gas} ($M_\odot$)
NGC – 1	1	0.1	10^8
NGC – 2	1	0.5	10^8
NGC – 3	3	0.05; 0.04; 0.13	10^8
NGC – 4	3	0.05; 0.04; 0.13	1.8×10^8

3.1 Single episode of star formation

In the models described in this section, the SF lasts for 25 Myr and the SF rate is a free parameter. We have simulated two model galaxies: one with a SF rate of 0.1 $M_\odot$ yr^{-1} (model NGC – 1) and one with a rate of 0.5 $M_\odot$ yr^{-1} (model NGC – 2; see Table 2). It is hard to fine-tune the SF rate: a large rate (model NGC – 1) injects a large amount of energy into the ISM. This energy drives a very powerful galactic wind, able to push away from the galaxy most of the pristine gas at variance with what is observed in NGC1569. On the other hand, in the model with a lower SF rate (model NGC – 2), the oxygen produced by massive stars does not reach the observed abundance of NGC1569 of 12 + log (O/H) = 8.19 (Kobulnicky & Skillman 1997). In Fig. 3 we plot the evolution of oxygen and N/O for the model NGC – 1. As we can see, this model is neither able to explain the amount of oxygen present in the galaxy nor the (N/O) abundance ratio.

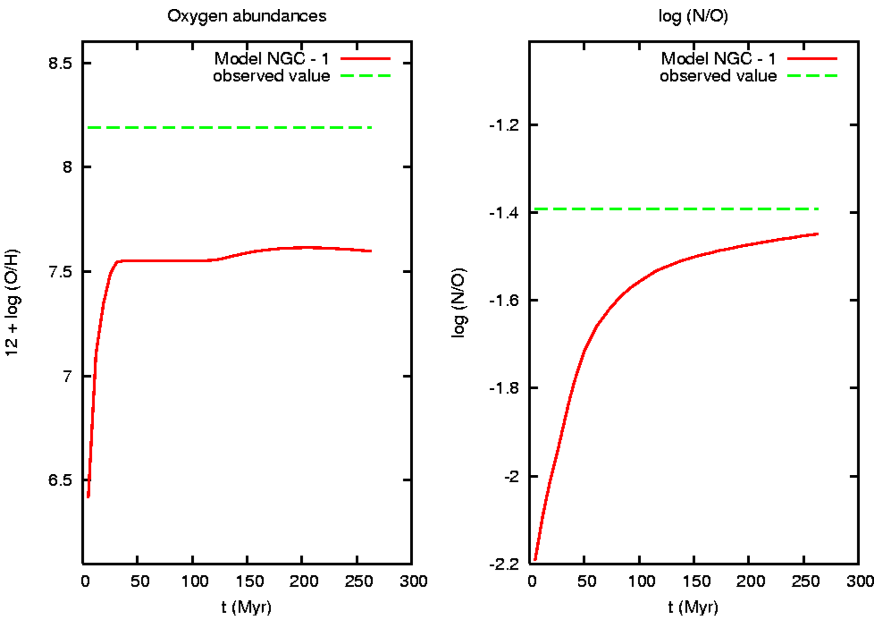

Figure 3: Evolution of 12 + log (O/H) (left panel) and log (N/O) (right panel) for a NGC1569 model with a single episode of SF at a rate of 0.1 $M_\odot$ yr^{-1} (model NGC – 1; solid lines). The dashed lines are the observed values found by Kobulnicky & Skillman (1997).

As anticipated in the introduction, Martin et al. (2002) were able to give an estimate of the metallicity of the hot X-ray emitting gas in the galactic wind. This information completes the puzzle of understanding the metal enrichment. Even if the single-burst models are not able to account for the chemical and morphological properties of NGC1569, it is none the less interesting to calculate the metallicity of the hot gas (i.e. of the gas with temperatures larger than 0.3 keV) and compare it with the estimates of Martin et al. (2002). This comparison is shown in Fig. 4 for the NGC – 2 model. At the moment of the onset of a galactic wind, the oxygen abundance of the hot phase is already 1/4 of solar. It increases up to 2 times solar after $\sim$ 50 Myr from the beginning of the burst. The arrows drawn in the plot represent the estimates of the oxygen content of the galactic wind of NGC1569 (best fit; upper and lower limits). The oxygen composition of the hot gas increases continuously in this phase since, after 50 Myr, massive stars are still exploding and releasing oxygen into the interstellar medium. At later times however, the oxygen composition begins to decrease due to the larger fraction of pristine gas ablated from the supershell and entrained in the galactic wind. The [O/Fe] ratio is initially larger than solar due to the fact that the break-out occurs when SNeIa are not yet releasing their energy and metals into the ISM. At later times, since the SNeIa eject their products from the galaxy very easily (Recchi et al. 2001), the [O/Fe] ratio decreases. The observations of Martin et al. (2002) point toward a galactic wind dominated by α-elements, therefore the outflow is probably still triggered by SNeII.

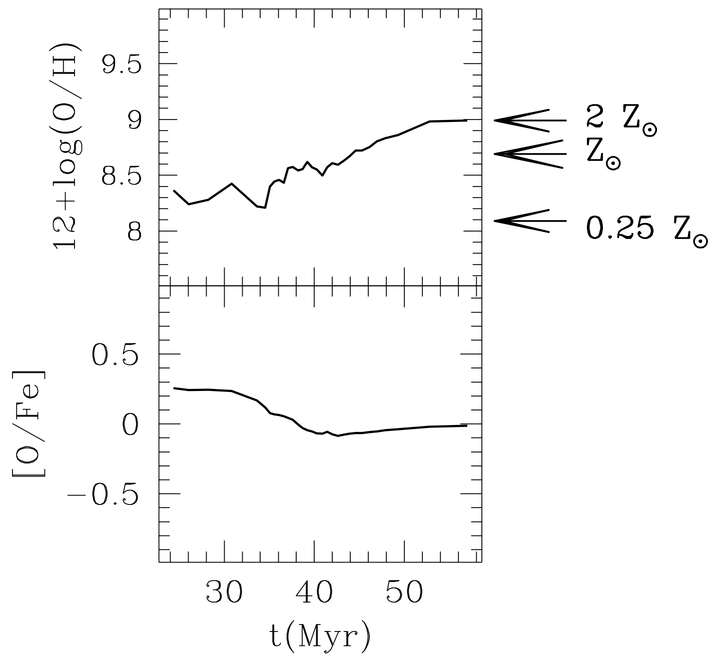

Figure 4: Evolution of 12 + log (O/H) (upper panel panel) and [O/Fe] abundance ratio (lower panel) for the hot gas entrained in the galactic wind for the model NGC – 2 (see Table 2). The arrows indicate the oxygen abundance of the galactic wind inferred by Martin et al. (2002).

3.2 Three episodes of star formation

As shown in the previous section, single SF bursts of short durations are not able to account for the global properties of NGC1569. We therefore describe in this section the evolution of models in which the SF is a gasping process, occurring in 3 different episodes as explained in Sect. 3. Since in this case the SF rate is no longer a free parameter, we decide to explore the effect of a different initial ISM distribution. In particular, we consider a "light" model (model NGC – 3), in which the total galactic H I mass at the beginning of the simulation is $\sim 10^8$ $M_{\odot}$ and a model with a factor of 2 more gas initially present inside the galaxy (model NGC – 4; see Table 2). Since there are still uncertainties about the total gas mass of NGC1569 (see e.g. Stil & Israel 2002; Mühle et al. 2003) one has the freedom to test different values of the initial mass and to see which one is more appropriate to reproduce the characteristics of NGC1569. We adopt hereafter the nucleosynthetic prescriptions of Meynet & Maeder (2002), since they seem to give the better description of the chemical properties of IZw18 (see Sect. 2), bearing in mind that the predicted nitrogen can be a lower limit.

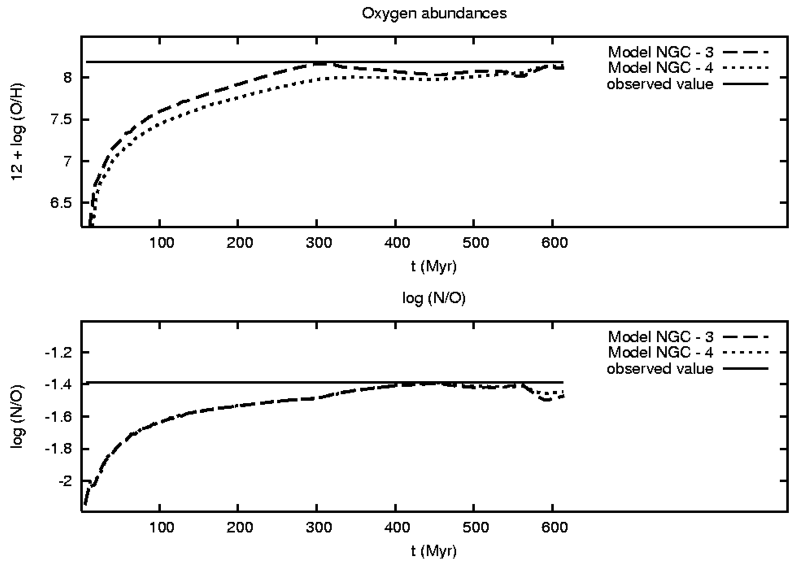

Figure 5: Evolution of 12 + log (O/H) (upper panel) and log (N/O) (lower panel) for two NGC1569 models in which the Angeretti et al. (2005) SF history is implemented. The solid line represents the observed values found for NGC1569 (Kobulnicky & Skillman 1997). The dashed line is the evolution of model NGC – 3, whereas the dotted line shows the evolution of model NGC – 4 (see Table 2). Note that the N/O evolution of the two models is almost identical until t $\sim$ 560 Myr, therefore it is diffucult, in the lower panel, to disentangle the two lines.

In Fig. 5 we show the evolution of oxygen (upper panel) and log (N/O) (lower panel) for the models NGC – 3 (dashed lines) and NGC – 4 (dotted lines) and we compare them with the abundances derived from Kobulnicky & Skillman (1997) (solid lines). At the end of the simulations (after $\sim$ 600 Myr), the oxygen is reproduced nicely by the model NGC – 4 and also model NGC – 3 is close to the observed value. It is worth noticing that the outflow created by the pressurized gas is very weak in the NGC – 4 model and of moderate intensity for the model NGC – 3. The fraction of oxygen lost through the galactic wind is larger in the light model. In the first hundreds of Myrs the oxygen abundance predicted by the model NGC – 3 is larger, since it is diluted by a smaller amount of hydrogen. At later times, however, the O abundance predicted by this model slightly decreases with time, since some oxygen is expelled from the galaxy.

The final log (N/O) predicted by these models are $-$ 1.47 (model NGC – 3) and $-$ 1.44 (model NGC – 4). These values slightly underestimate the observations of Kobulnicky & Skillman (1997), but are still reasonably close to it, considering the observational errors (0.05 dex).

3.3 Model with a big infalling cloud

Observations show the presence of extended H I clouds and complexes surrounding NGC1569 (Stil & Israel 1998). In particular, there is a series of gas clumps in the southern halo probably connected with a H I arm present in the western side of the galaxy. These H I features can be attributed to the debris of a tidally disrupted big cloud infalling towards NGC1569 (Mühle et al. 2005). The mass of this complex is difficult to asses. The lower limit given by Mühle et al. (2005) is 1.2×10^7 $M_\odot$ (the sum of the mass of all the detected groups of clouds), but some H I could have been already accreted. If this complex is similar to the high velocity clouds in the Local Group, one has to expect masses larger than a few 10^7 $M_\odot$ (Blitz et al. 1999). As a first attempt to study the effect of a big cloud infalling towards the galaxy, we assume a mass of 2×10^7 $M_\odot$. The initial position of the cloud is 2 kpc away from the center of the galaxy along the polar axis (due to the assumed symmetry of the system, this is the only reasonable initial configuration). The infalling velocity of this cloud is 10 km s^{-1}, similar to the local sound speed, and its radius is 1 kpc. The other structural parameters are as in model NGC – 3 (see Table 2).

The evolution of oxygen and log (N/O) for this model is shown in Fig. 6. The development of the galactic wind is hampered by the pressure of this big infalling cloud and, consequently, no major outflow is developed during the simulation. The oxygen abundance is therefore always increasing, since only a negligible fraction of it is lost from the galaxy. The final log (N/O) is consistent with the observations, whereas this model underestimates the final oxygen content of the galaxy (by $\sim$ 0.15 dex). This is due to the fact that the big cloud on its path towards the galaxy sweeps up and drags some gas initially present in the outer regions of the galaxy. The final gas mass inside the galaxy is therefore larger than the initial one. It is worth noticing that the prominent outflow visible in NGC1569 (Martin et al. 2002) deviates from the results of this simulation. Therefore, we either have to consider a larger input of energy into the system or have to consider a different infall direction of

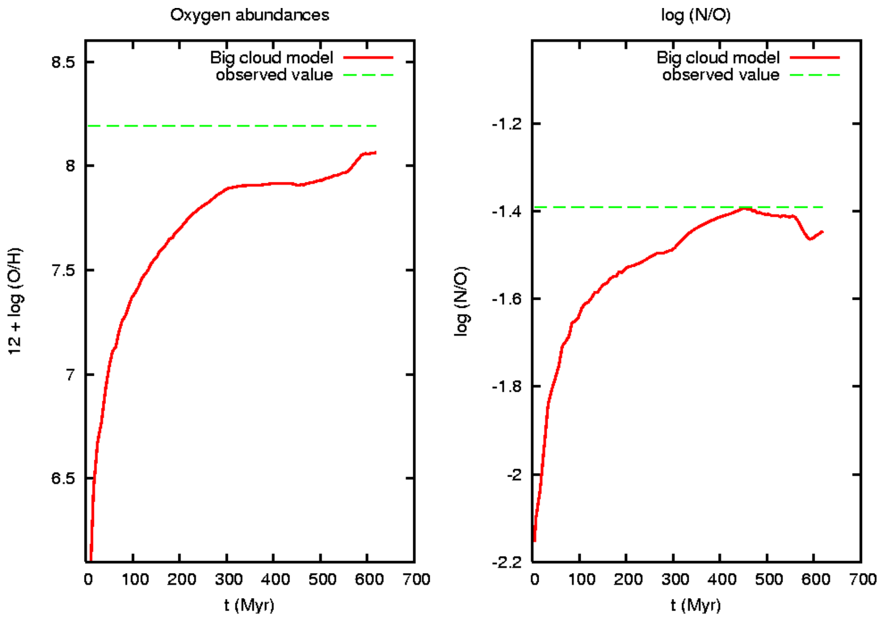

Figure 6: Evolution of 12 + log (O/H) (left panel) and log (N/O) (right panel) for a NGC1569 models in which the infall of a big cloud towards the center of the galaxy is taken into consideration.

the cloud. Indeed, observations show that this H I complex seems to wrap around the disk of NGC1569 and to approach the galaxy from the western side. A more careful parametrical study of model galaxies reproducing NGC1569 will be presented in a forthcoming paper (Recchi & Hensler 2005, in prep.)

4 Conclusions

By means of a 2-D hydrodynamical code, we have studied the chemical and dynamical evolution of model galaxies resembling IZw18 and NGC1569, two gas-rich dwarf galaxies in the aftermath of an intense burst of SF. We have considered in both cases either episodes of SF of short duration (bursting SF), or more complex SF behaviours, in which the galaxies have experienced in the past long-lasting episodes of SF, separated from the last more intense burst by short periods of inactivity (gasping star formation).

Models with a bursting star formation are generally unable to account for the chemical and morphological properties of these two objects. In the case of IZw18, they produce huge variations of the chemical composition of the galaxy in short time-scales. They are able to fit at the same time the C, N, O composition of IZw18, but only for very short time intervals. This pattern of the chemical tracks would presumably give rise to a large scatter in the abundance ratios. The observations available nowadays disagree with this scenario, since most metal-poor galaxies seem to share the same [N/O] abundance ratio (IT99). In the case of NGC1569, models with a single short episodes of SF either severely underproduce O or inject too much energy into the system, enough to unbind a too large fraction of the gas initially present in the galaxy.

The best way to reproduce the chemical composition of both, IZw18 and NGC1569, is therefore assuming long-lasting, continuous episodes of SF of some hundreds Myrs of age and a recent and more intense short burst. Adopting the star formation prescriptions derived from the comparison of the color-magnitude diagrams with synthetic ones (Aloisi et al. 1999 for IZw18; Angeretti et al. 2005 for NGC1569) we produce results in good agreement with the observations, if the yields of Meynet & Maeder (2002) are implemented.

For what concerns NGC1569, a model in which a big cloud is falling towards the center of the galaxy along the polar axis inhibits almost completely the formation of a galactic wind, at variance with what observed.

In most models with gasping star formation, the presently observed chemical composition of the galaxy reflects mostly the chemical enrichment from old stellar populations. In fact, if the first episodes of SF are powerful enough to create a galactic wind or to heat up a large fraction of the gas surrounding the star forming region, the metals produced by the last burst of star formation are released in a too hot medium or are directly expelled from the galaxy through the wind. They do not have the chance to pollute the surrounding medium and contribute to the chemical enrichment of the galaxy.

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