THE STAR FORMATION HISTORY OF I Zw 18
ALESSANDRA ALOISI, MONICA TOSI, AND LAURA GREGGIO
Received 1999 January 19; accepted 1999 April 1

ABSTRACT

The star formation history in I Zw 18 has been inferred from Hubble Space Telescope Wide Field Planetary Camera 2 archival data. This is done by comparing the derived $V$, $B-V$ and $V$, $V-I$ color-magnitude diagrams and luminosity functions with synthetic ones, based on various sets of stellar evolutionary tracks. At a distance of 10 Mpc, the stars resolved in the field of I Zw 18 allow for a look-back time up to 1 Gyr. We find that the main body is not experiencing its first episode of star formation. Instead, it has been forming stars over the last 0.5–1 Gyr, at a rate of $\sim$(1–2) $\times$ 10$^{-2}$ $M_\odot$ yr$^{-1}$ kpc$^{-2}$. A more intense activity of $(6–16) \times 10^{-2}$ $M_\odot$ yr$^{-1}$ kpc$^{-2}$ has taken place between 15 and 20 Myr ago. For the secondary body, the look-back time is 0.2 Gyr at most and the uncertainty is much higher because of the shallower diagrams and the small number of resolved stars. The derived range of star formation rate is $(3–10) \times 10^{-3}$ $M_\odot$ yr$^{-1}$ kpc$^{-2}$. The IMF providing the best fit to the observed stellar populations in the main body has a slope 1.5, much flatter than in any similar galaxy analyzed with the same method. In the secondary body, it is peaked at $x \approx 2.2$, closer to Salpeter’s slope ($x = 2.35$).

Key words: galaxies: evolution — galaxies: individual (I Zw 18) — galaxies: irregular — galaxies: photometry — galaxies: stellar content

1. INTRODUCTION

In the last 20 years, increasing attention has been paid to the study of dwarf galaxies in order to understand their crucial role in galaxy formation and evolution. In hierarchical clustering theories (White & Frenk 1991; Kauffmann, White, & Guiderdoni 1993) these systems can constitute the building blocks from which larger systems have been created by merging, while in monolithic collapse scenarios (Tinsley & Gunn 1976; Tinsley 1980a) they have been suggested to represent the debris of massive galaxies unable to form stars until $z \sim 1$. A population of newly star-forming dwarfs at $z < 1$ has been also invoked in some evolutionary models (Broadhurst, Ellis, & Shanks 1988; Babul & Ferguson 1996; see also Ellis 1997 for a review on the subject) to reproduce the excess of faint blue galaxies observed in deep photometric surveys, the most famous being the Hubble Deep Field (Williams et al. 1996).

Early-type dwarfs (dE’s and dSph’s) are gas-poor and are constituted by intermediate and old stellar populations, while late-type dwarfs (dIrr’s) are gas-rich, and their light is dominated predominantly by very young stars associated with bright H II regions, indicators of an ongoing star formation process. The former kind of dwarfs show a smooth luminosity distribution with a low surface brightness (like Sextants, NGC 147, Leo I, Fornax, Sculptor, among others), while the latter group appears with a patchy intensity distribution (NGC 6822, NGC 1569, IC 1613, among others) and an intermediate surface brightness, which can become very high in the bright blue knots of blue compact dwarf galaxies (BCDGs).

At present it is not well understood if there is an evolutionary interconnection between dIrr and dE galaxies (see, e.g., Gallagher 1998), as no consistent picture of dwarf galaxy evolution has emerged yet. It has been suggested (Davies & Phillips 1989 and references therein) that the natural evolution of dIrr’s could be the condition of dE’s through the phase of BCDG. In this hypothesis, a strong starburst (intense star formation episode concentrated in a very short time) can originate a galactic superwind (Heckman 1995) with the mechanical energy supplied by stellar winds and supernova explosions generated by newly formed massive stars. This wind can blow out all the gas from a dIrr, because of its shallow potential well, and transform the galaxy into a gas-poor dE. Indeed, narrowband Hα images and X-ray maps show evidence of the existence of these superwinds in some irregulars and BCDGs, as, for example, NGC 1569 (Heckman 1995), NGC 1705 (Meurer et al. 1992), and I Zw 18 (Martin 1996; Petrosian et al. 1997). On the other hand, taking into account observed chemical, photometric, and kinematic properties of both dwarf irregulars and ellipticals, it seems quite hard to find an efficient mechanism to transform a late-type dIrr into a dE (Jerjen & Binggeli 1997). The derivation of the star formation history of dwarf irregular galaxies and the corresponding identification of objects with a starbursting regime become thus of primary importance to gain an insight into the nature and evolution of dwarf galaxies in general.

I Zw 18 (also Mrk 116 or UGCA 166) is possibly the BCDG with the most striking properties. At a recession velocity of $745 \pm 3$ km s$^{-1}$ (Dufour, Esteban, & Castañeda 1996a), corresponding to a distance of 10 Mpc ($H_0 = 75$ km s$^{-1}$ Mpc$^{-1}$), this system shows very blue colors. The most recent estimates on emission-line corrected broadband images give $U - B = -0.88$ and $B - V = -0.03$ (van Zee et al. 1998). These colors are indicative of a very young population but do not exclude an underlying older one. The total mass of I Zw 18 from the rotation curve at a radius of $10''–12''$ is estimated to be $\sim 10^8$ $M_\odot$ (e.g., Davidson & Kinman 1985; Petrosian et al. 1997; van Zee et al. 1998). A large amount of neutral gas is detected all around the system, totaling $\sim 7 \times 10^7$ $M_\odot$. This corresponds to $\sim 70\%$ of the total mass, but only $10^7$ $M_\odot$ of H I are associated.
with the optical part of the galaxy (e.g., Lequeux & Vialle-
fond 1980; van Zee et al. 1998). When discovered by Zwicky
(1966), I Zw 18 was described as “two galaxies separated by
5′6 and interconnected by a narrow luminous bridge,” sur-
rounded by two “very faint flares” at 24° northwest. More
recent CCD ground-based images (Davidson, Kinman, &
Friedman 1989; Dufour & Hester 1990; hereafter DFK89
and DH90, respectively) have revealed a more complex
structure: the two galaxies are in fact two star-forming
regions of the same galaxy (usually indicated as northwest
and southeast components), while the two flares are just the
most prominent of a few nebulosities surrounding I Zw 18.
These minor systems are roughly aligned toward the north-
west and were initially believed at the same distance, but
now we know from spectroscopic studies that only one
component (referred to as component C in DFK89) is at the
same distance as I Zw 18 and is physically associated with
the main body (Dufour et al. 1996a; Petrosian et al. 1997;
vanzee et al. 1998). The other diffuse objects have been
recognized as background galaxies (see Fig. 1a of Dufour et
al. 1996b, hereafter D96, for an overview of the whole I Zw
18 system). In the following we will refer to I Zw 18 and to
component C as main body and secondary body (or
companion), respectively, of I Zw 18. Both systems have
been resolved into single stars for the first time only with the
Hubble Space Telescope (HST) Wide Field Planetary
Camera 2 (WFPC2) by Hunter & Thronson (1995, hereafter
HT95) and D96. Indeed, I Zw 18 and its companion irregu-
lar galaxy are currently one of the most distant systems ever
resolved into stars.

This apparently insignificant BCDG became famous
right after its discovery, when Searle & Sargent (1972) mea-
sured from its emission-line spectrum an oxygen abundance
[O/H] = −1.14, corresponding to only 7% of the solar
value and indicating a quite unprocessed gas content. Fur-
thermore, the first studies on its color and composition
(Sargent & Searle 1970; Searle & Sargent 1972; Searle,
Sargent, & Bagnuolo 1973) already emphasized a current
star formation rate (SFR) much higher than the mean value
in the past. All this observational evidence raises the basic
question on the nature of I Zw 18: is it a young galaxy that
is presently experiencing its first burst of star formation or is
it an old system that has already formed stars in the past in
at least another episode of star formation?

Subsequent spectroscopic studies in I Zw 18 (Lequeux et
al. 1979; French 1980; Kinman & Davidson 1981; David-
son & Kinman 1985; Dufour, Garnett, & Shields 1988;
Garnett 1989, 1990; Pagel et al. 1992; Skillman & Ken-
nicutt 1993; Kunth et al. 1994; Stasińska & Leitherer 1996;
Garnett et al. 1997; Izotov & Thuan 1998) have confirmed
its extreme metal deficiency, around 1/30–1/50 Z⊙. Despite
many efforts to detect other galaxies with very low metal-
licity (Terlevich, Skillman, & Terlevich 1995), I Zw 18 still
remains the galaxy with the lowest metal and helium
content known so far. This makes the system a fundamental
point in the derivation of the primordial helium abundance
(Izotov, Thuan, & Lipovetsky 1994, 1997; Olive, Steigman,
& Skillman 1997; Izotov & Thuan 1998) and in the study of
the properties of chemically unevolved galaxies. However,
there are several observational indications that I Zw 18 is
not a primordial galaxy, for instance the presence of rela-
tively high C/O and N/O abundance ratios justified only
with an earlier population of low- and intermediate-mass
stars (Dufour et al. 1988; Garnett et al. 1997) and the photo-
metric evidence of an underlying red stellar population,
both from surface photometry of the whole galaxy in the
NIR (Thuan 1983) and from photometry of single stars in
the optical bands (HT95; D96).

For nearby galaxies the safest determination of their SF
history is obtained resolving their stellar population into
single stars and inferring their SFR and initial mass func-
tion (IMF) with the synthetic color-magnitude diagram
(CMD) method. This method was first developed for dwarf
irregular galaxies in the Local Group observed with
ground-based telescopes (Ferraro et al. 1989; Tosi et al.
1991, hereafter TGGMF; Greggio et al. 1993, hereafter
GGMF; Marconi et al. 1995, hereafter MTGF) and has now
been updated (Greggio et al. 1998, hereafter G98) for
an optimized application to galaxies observed with HST.
A procedure for the comparison between observed and syn-
thetic CMDs has been developed also by Tolstoy & Saha
(1996), who have introduced the concept of Bayesian infer-
ence to give the relative likelihood of different models to
constitute a suitable representation of the data. Gallart et al.
(1996) also follow a similar approach and have introduced
in the method the concept of metallicity evolution following
a given law for the chemical enrichment of the interstellar
medium. Here we have applied the synthetic CMD method
to I Zw 18 using the HST archive data from HT95 and D96.

The data reduction is described in § 2, and the resulting
CMDs and luminosity functions (LFs) in § 3. The method
and a description of the comparison of these data with
theoretical synthetic CMDs and LFs are given in § 4, with
the resulting conclusions on the recent evolution of I Zw 18
and its companion. Last, an overall discussion of these con-
clusions in the framework of the current common know-
ledge on this galaxy is given in § 5.

2. OBSERVATIONS AND DATA REDUCTION

I Zw 18 has been observed with different instruments on
board of HST4 by different investigators. For our purposes
we have retrieved from the HST archive and rereduced all
the HST/WFPC2 images made available before 1998 January
1.

2.1. The Data

Two sets of deep exposures were taken in 1994 Novem-
ber, and a third set of shorter ones in 1995 March. In the
first set of data (PI: D. A. Hunter, GO-5309, 1994
November) I Zw 18 was centered on the PC CCD, with an
effective plate scale of 0′045 pixel−1 and a field of view
comprising 36′ × 36′. The target was observed in the three
broadband filters, F336W, F555W, and F814W
(similar to the standard ground-based broad bands U, V,
and I), and in the two narrowband filters F469N and
F656N (sampling the nebular lines He II λ4686 and Hα
λ6563), in order to map the ionized gas and WR stars.
Results from this set of data are presented in HT95.

The second set of exposures (PI: R. J. Dufour, GO-5434,
1994 November) consists of deep frames of I Zw 18 and its
companion system on the WF3 CCD, with a plate scale and
a field of view of 0′1 and 80′ × 80′, respectively. The frames

4 Observations with the NASA/ESA Hubble Space Telescope, obtained
at the Space Telescope Science Institute, which is operated by the Associa-
tion of Universities for Research in Astronomy (AURA), Inc., under
NASA contract NAS 5-26555
are available in the three broadband filters F450W, F555W, and F702W (corresponding indicatively to B, V, and R), and in the two narrowband filters F502N and F658N, mapping the two nebular lines [O III] λ5007 and [N II] λ6583. Photometric results from this set of data are presented by D96.

Finally, the third set of images (PI: R. J. Dufour, GO-5434, 1995 March), are in the three broadband filters F439W, F555W, and F675W (the F439W is a filter in the B-band region narrower than the F450W; the F675W is a filter in the R-band region narrower than the F702W).

A complete summary of all the data available for I Zw 18 as observed with the HST WFPC2 is presented in Table 1, where we have indicated the filter (col. [1]), the WFPC2 camera where the target was centered on (col. [2]), the principal investigator (col. [3]), the epoch of observation (col. [4]), the integration time in seconds for each single exposure (col. [5]), and the image root names (col. [6]).

We actually used only a subset of all the data available on I Zw 18, as indicated in Table 1 by an asterisk near the image name. In fact, we were interested in obtaining the principal investigator (col. [3]), the epoch of observation (col. [4]), the integration time in seconds for each single exposure (col. [5]), and the image root names (col. [6]).

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We reduced the data applying all the corrections required to minimize photometric uncertainties and to achieve the highest photometric accuracy. All the reductions were performed in the IRAF environment.

For each single exposure we corrected warm pixels and flagged hot pixels in the data quality files using the IRAF STSDAS task WARMPIX. To restore the correct relative count numbers between pixels at different positions on the CCD, we performed geometric distortion and CTE corrections on each single frame by applying the correcting image f1k1552bu.r9h available from the archive (see Leitherer 1995 for more details) and the linear-ramp image with the appropriate value depending on the background as indicated in Holtzman et al. (1995a, 1995b; hereafter H95a and H95b, respectively).

Multiple frames through each filter in each data set were simultaneously co-added and cosmic rays were removed. We also removed where possible the contribution of ionized gas from broadband images, proceeding as follows: after having adequately smoothed narrowband images to eliminate pointlike sources from gas maps, we calculated with SYNPHOT the percentage of flux detected in each narrowband filter and subtracted it from each broadband image.

The prereduction provided the following data useful for our purposes: for I Zw 18 and its companion on the WF3 camera, four deep frames in the F555W, F450W, F502N, and F658N filters (total integration time of 4600 s for each filter); for I Zw 18 on the PC camera we have two images in the F555W filter, the deepest one obtained from Hunter’s frames (for a total integration time of 6600 s) and the shorter one from Dufour’s data (1200 s in total). We preferred not to combine the two final PC F555W frames, because of a great rotational displacement of one frame with respect to the other, which would have implied a repixelization and data manipulation. Also available are one deep image in the F814W band (6600 s), a less deep frame in the F439W band (2000 s), and a quite deep frame in F656N filter (total integration time of 4200 s). In Figures 1 and 2 we show the deepest WFPC2 images in the F555W filter for I Zw 18 on the PC camera and for its companion galaxy on the WF3 detector, respectively: both systems are well resolved into single stars. It is also possible to distinguish H II regions in the southeast part of I Zw 18 as well as the northwest cluster, while two bright star clusters are evident in the center and in the northwest part of the companion system.

The photometric reduction of the frames was performed using the DAOPHOT package in IRAF for point-spread function (PSF) fitting photometry in crowded fields on both original and gas-subtracted broadband images. First we applied the automatic star detection routine DAOFIND to the deepest F555W frame (detection threshold at 4 σ above the local background level), and then we performed an accurate inspection by eye of each single detected object to reject any feature misinterpreted as star by the routine (namely, nuclei of faint galaxies, PSF tendrils, noise spikes, etc.). The identification of stars in the other filters was then forced assuming the final positions of the stars detected in the F555W deeper image as input coordinates for the start-

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5 IRAF is distributed by the National Optical Astronomy Observatories, which are operated by AURA, Inc., under cooperative agreement with the National Science Foundation.
ing centering and aperture photometry in the new frame. We also tried to force the photometry from the deepest F555W image to the rotated F439W image, taking into account the coordinate transformation, but we obtained systematically higher photometric errors, introduced by transformation uncertainties. We therefore decided to couple the F439W image with the shallower but unrotated F555W one.

In spite of the performed centering, forcing the photometry in the second band leads to some mismatches. These have been identified by plotting the distance between the centers in the two images as function of the F555W instrumental magnitude. To overcome this problem, we used the two routines DAOMATCH and DAOMASTER, kindly made available by P. B. Stetson, to finally match the coordinate lists in the two coupled filters.

In order to obtain the best PSF for our frames we experimented with three different methods: (1) we used some well-isolated stars (three or four) in each frame to build the observed PSF, (2) we ran the TINY TIM software (Krist & Hook 1996) to obtain a theoretical PSF, and (3) we made use of the new tool of the WFPC2 PSF library to get empirical PSFs. The different PSFs considered give quite similar results for the PC camera; eventually we preferred to adopt the observed PSF since it takes into account all technical conditions occurring at the epoch of data acquisition (real focus value, thermal breathing, etc.). For the WF3 camera theoretical PSFs seem instead to work better, since

Fig. 1.—Deep combined image of I Zw 18 on a logarithmic scale in the WFPC2 F555W filter. The target is centered on the PC camera, and the displayed field of view is 31′:5 × 31′:5. The pixel scale corresponds to 0′′045 pixel−1, and the total integration time is 6600 s.
in this case we have to deal with a more dramatic undersampling of the observed/empirical PSFs, which introduces a higher photometric uncertainty.

Once all the stars were measured with the PSF fitting, those with a disturbed image (as indicated by the two image-peculiarity indices $\chi^2$ and “sharpness”) were identified and rejected. The index $\chi^2$ gives essentially the ratio of the observed pixel-to-pixel scatter in the fitting residuals to the expected scatter based on the values of the detector characteristics (readout noise and gain). The sharpness is related to the intrinsic angular size of the astronomical object. We removed all the objects with $\chi^2 > 3$ and sharpness lower than $-1$ or larger than $+1$, that is, objects with size smaller than a star (like cosmic rays or image defects) or objects too extended (like blends or semiresolved star clusters, H II regions, and galaxies). We also checked individually all the stars in critical positions in our reference CMDs (i.e., the CMD of stars with photometric error smaller than 0.2 mag in both filters), like very bright blue and red stars (possible blends, unresolved stellar clusters, or unidentified cosmic rays), very faint objects (possible peaks of noise in the forced filters, or residuals of cosmic-ray detections). Finally, we checked accurately all the red stars, which are particularly important to discriminate among different SF histories.

2.3. Calibration

The instrumental magnitudes obtained with the PSF-fitting technique were then converted into calibrated magnitudes following the prescription of H95a and H95b. Since in H95a and H95b the standard calibration is given for an aperture of 0.5, we transformed the instrumental magnitudes on an aperture radius of 2 pixels into the corresponding ones on an aperture radius of 0.5 (11 pixels for PC and 5 pixels for WF3) by calculating the aperture correction.

This turned out to be a very delicate step as a result of the small number of isolated stars, suitable for aperture photometry, in the field of I Zw 18. The derived aperture corrections strongly depend on the choice of the adopted stars, and the small number of good templates leads to a large statistical uncertainty. Figure 3 illustrates this point for the deepest $V$ and $I$ frames. For all the isolated stars in each frame (5–15 objects) we measured the instrumental magnitudes based on aperture photometry with different radii. For each star, the aperture corrections (i.e., the difference between the magnitude at a certain aperture radius and the PSF-fitting magnitude) are shown as open circles for different values of the aperture radius. The filled dots represent the correction averaged over all the measured stars, with a 2 $\sigma$ rejection algorithm, and the vertical bars show the corresponding 2 $\sigma$ ranges. To these mean aperture corrections we added the encircled energy corrections as indicated by H95b; the obtained values corresponding to the conventional radius of 0.5 are indicated by crosses.

As is apparent from Figure 3, the uncertainty in the calibration increases with the aperture radius, with more points deviating from the mean value, as it becomes increasingly difficult to find no defects in the outer pixels that are pro-

Fig. 2.—I Zw 18 companion system displayed in logarithmic scale on the combined F555W image of the WF3 camera for a total integration time of 4600 s. The field of view considered is 28.6' x 20.1', and the resolution 0.1 pixel$^{-1}$. The two objects inside a black circle on the right are the two bright red stars survived in the final observed CMD: because of their brightness together with their distance from the central stellar condensation, it could be possible that they do not belong to the system.
The aperture correction values over the considered range of aperture radii is indicated in Figure 3 by the horizontal thick line, which corresponds to corrections of $-0.38$ mag and $-0.54$ mag in the $V$ and $I$ bands, respectively. These values are almost identical to those given by H95b, which is encouraging. We thus used directly the H95b corrections for our deepest F555W and F814W frames. For homogeneity, we extended the use of H95b aperture corrections to the other frames of I Zw 18 on the PC camera, as well as to the frames of the companion galaxy on WF3, where the aperture corrections are much more difficult to determine empirically.

We finally corrected our measures for the gain factor, the WF3 normalization, and the contamination effect, where necessary, and applied the zero points to scale the photometry into the WFPC2 synthetic system relative to Vega (Table 9 of H95a). When the value of one of these correcting parameters was not available (as for the F450W filter) we took it from public images of calibration programs (e.g., the aperture correction for F450W on WF3) or assumed it from the corresponding value of similar filters (F439W instead of F450W).

2.4. Completeness Analysis

One of the larger uncertainties affecting galaxy photometry is due to crowding. Thus we carried out an accurate completeness analysis using the DAOPHOT routine ADDSTAR. For each frame we performed a series of tests, by adding each time $\sim10\%$ of the stars detected in each half-magnitude bin on the original image. We then performed a new photometric reduction of the frame using the same procedure applied to the original frame and considering the same rejection criteria for spurious objects. We then checked how many added stars were lost either because they were not detected by the automatic routine or because they were recovered with a large magnitude difference $\Delta m$, which makes them migrate to another magnitude bin. We eventually estimated the completeness factors by averaging the results obtained repeating the test 10--20 times on each frame. Because of the uneven distribution of stars on the images, fainter objects are more easily recovered in the outer, less crowded regions. In order to derive the average completeness factors affecting our CMDs we constrained the ADDSTAR routine to put artificial stars in the frame regions where the galaxy is actually located.

For every pair of filters used to construct the CMD, we performed the completeness analysis independently on each frame. Since we forced the stellar detection in the shallower frame, the overall completeness factor is actually that corresponding to the shallower filter: in practice, either the $B$ or the $I$ frame. Table 2 shows the completeness factors (percentage of recovered artificial stars) and the corresponding uncertainties as a function of magnitude for all the frames considered in our photometric analysis. The listed values take also into account the star selection with photometric error smaller than 0.2 mag described in the next section. The completeness factors are averages over the whole galaxy. Clearly, incompleteness can be quite different from one region to the other, depending on crowding. For instance in the most crowded zone in the northwest cluster, incompleteness is so dramatic that we recover only $\sim20\%$ of the artificial stars already at the 23d magnitude. H II regions and the rich star clusters are unresolved in our images and are therefore to be considered fully incomplete. Although it could be more appropriate to apply different

| MAGNITUDE | Deep F555W | Deep F814W | Shallow F555W | Shallow F439W | Companion: WF3 IMAGES |
|-----------|------------|------------|---------------|---------------|----------------------|
| <21.0      | 100        | 100        | 100           | 100           | Deep F555W 100       |
| 21.0--22.0 | 100        | 100        | 90 $\pm$ 31   | 95 $\pm$ 22   | Deep F450W 84 $\pm$ 27 |
| 22.0--23.0 | 89 $\pm$ 16| 99 $\pm$ 4 | 83 $\pm$ 22   | 93 $\pm$ 16   | 83 $\pm$ 26         |
| 23.0--24.0 | 85 $\pm$ 12| 90 $\pm$ 10| 79 $\pm$ 18   | 83 $\pm$ 16   | 93 $\pm$ 18         |
| 24.0--25.0 | 73 $\pm$ 13| 74 $\pm$ 12| 65 $\pm$ 23   | 64 $\pm$ 23   | 80 $\pm$ 29         |
| 25.0--26.0 | 52 $\pm$ 13| 47 $\pm$ 12| 36 $\pm$ 20   | 20 $\pm$ 18   | 84 $\pm$ 27         |
| 26.0--27.0 | 20 $\pm$ 8 | 13 $\pm$ 9 | 5 $\pm$ 6     | 0             | 68 $\pm$ 29         |
| 27.0--28.0 | 5 $\pm$ 7  | 0          | 0             | ...           | 0                   |
| 28.0--29.0 | 0          | ...        | ...           | ...           | 4 $\pm$ 13          |
completeness factors in different regions, when computing our theoretical simulations we apply only the average completeness factors in Table 2. Indeed, the resolved objects are not numerous enough to allow us to simulate individual different regions.

The completeness tests allowed us also to evaluate the influence of blending in our photometry and the goodness of the applied rejection criteria ($\chi^2$, sharpness, error, etc.). In the deepest $V$ and $I$ images of I Zw 18 on the PC detector, the rejection criteria seem to affect more intermediate/faint magnitudes (24 $\leq V \leq 27$ and $23 \leq I \leq 25$), while in the shallower $B$ and $V$ frames they remove more objects at brighter magnitudes (22 $\leq V \leq 24.5$ and $22 \leq B \leq 24$). A large fraction of the artificial stars rejected for $\chi^2 > 3$ and sharpness outside the range from $-1$ to $1$ (actually a few objects, usually rejected for the $\chi^2$ parameter) were recognizable as blends: we have been able to actually see the companion star for $\sim 50\%$ of the objects rejected in the $B$ image, for $\sim 65\%$ in both the $V$ images, and $\sim 75\%$ in the $I$ image. For I Zw 18's secondary body on WF3 there were very few objects discarded, and they were all blends in both the $V$ and $B$ frames. This result confirms the need of applying these criteria in order to remove from the CMDs spurious objects due to blends.

We also looked at the effect of blending on the derived stellar magnitude by selecting the artificial stars that were recovered with a magnitude brighter than $\Delta m = 0.25$ mag with respect to the input value. This happened for 4.7% and 4.0% of the stars added in the deeper $V$ and $I$ frames of I Zw 18, respectively; for 2.9% and 5.2% in the shallower $V$ and $B$ images, respectively; and around 3.5% in both the $V$ and $B$ frames for the companion system on WF3. These values give an estimate of the frequency of cases in which blending affects the photometry more than our allowed photometric error in the CMDs ($\sigma_{DAO} < 0.2$ mag in both filters). We conclude that our data are affected by blending at an average level of $\sim 4\%$, which we consider negligible for the interpretation of the CMD with the simulation procedure.

2.5. Photometric Errors

Figures 4 and 5 show the behavior of the photometric error $\sigma_{DAO}$ (estimated by DAOPHOT) as a function of magnitude for I Zw 18 in each combined PC image and for the companion galaxy in each combined WF3 frame, respectively. In these plots we considered all the stars fitted in both coupled filters: 568 and 321 objects, respectively, for the $V$ versus $V-I$ and $V$ versus $B-V$ diagrams relative to I Zw 18, and 117 stars for the $V$ versus $B-V$ diagram of the companion.

When the rejection criteria of $\chi^2$ and sharpness are applied, most of the points with high $\sigma_{DAO}$ at bright magnitudes disappear, since they are most probably small unresolved stellar associations, H II regions, or blends.

For the theoretical interpretation we will restrict our CMD to objects with photometric error smaller than $\sim 0.2$ mag. We notice that $\sigma_{DAO}$ remains below 0.2 mag down to $m \sim 26$ in each deeper frame of both I Zw 18, and the companion and down to $m \sim 25$ in the less deep ones of I Zw 18. However, $\sigma_{DAO}$ may underestimate by $\sim 20\%$ the total photometric error (Stetson & Harris 1988), and we have therefore derived an independent estimate of the latter using the outcome of the completeness tests and looking at the amplitude of the difference $\Delta m$ between the assigned and recovered magnitudes of the artificial stars. It turned out
that for the companion of I Zw 18, the upper envelope of the distribution of the $\Delta m$ coincides with that of the observed $\sigma_{DAO}$, indicating that in this case the errors are well estimated. For the PC frames with I Zw 18, instead, $\sigma_{DAO}$ underestimates by more than 20% the actual error, especially at the brightest magnitudes. The larger error estimates $\Delta m$ have therefore been adopted in the CMD simulations described in § 4.

2.6. Comparison with Previous Photometric Analyses

We have compared the photometric results obtained for I Zw 18 in the deep F555W and F814W images on the PC camera with the results of HT95. The comparison of our CMD (see Fig. 7 below) with that published by HT95 (see their Fig. 5) shows that we reach a fainter limiting magnitude. Our diagram contains many more blue and red stars fainter than $V \sim 26$. We have carefully checked the faintest objects to reject any uncertain detection with ambiguous shape or profile, but most of them remain and are localized in the outer and less crowded part of the southeast star-forming region where the photometry of fainter objects is easier. A possible reason for our fainter limiting magnitude could be our forcing the photometry in the shallower filter.

We have also compared our CMD in the F439W and F555W filters for I Zw 18’s companion in the WF3 camera (see Fig. 11 below) with the corresponding diagram published by D96 in their Figure 3, accounting for the reddening correction. The general aspect of the two distributions is quite similar, despite some differences. In our CMD there are less faint objects with unphysical color $B-V \leq -1$, probably thanks to the task for masking hot and warm pixels (that could be mistaken as faint stars), which has become available after the photometric reduction by D96. There is also an offset in the zero points of both filters, with our distribution being $\sim 0.5$ mag brighter than D96 in $V$ and in $B$. D96 worked on gas-subtracted and rebinned images in order to construct an artificial PSF better sampled than the observed one, while we preferred to work on the original frames (but, again, we found no differences at all using the gas-subtracted images) and to use a PSF simulated with the TINY TIM software. As for the HT95 data, we attribute the photometric offsets to uncertainties in the estimate of the aperture corrections, enhanced in this case by the undersampling of the WF3 camera.

For what concerns the CMD in the F450W and F555W filters of I Zw 18 on the PC camera, the archival data have not been published yet. We can therefore compare only indirectly our resulting CMD (see Fig. 8 below) with that derived from the F450W and F555W filters on the WF3 detector and plotted in D96’s Figure 2. Both diagrams show a fairly large sequence and are very similar to each other. When accounting for the reddening, our edge of the blue plume (at $V \approx 22.5$), the faint limiting magnitude (at

![Fig. 6](image-url)
$V \approx 27$), and the average color of the star distribution around $B - V \approx 0$ seem consistent with those in D96.

3. OBSERVED COLOR-MAGNITUDE DIAGRAMS AND LUMINOSITY FUNCTIONS

3.1. I Zw 18 Main Body

Figures 7 and 8 show the CMDs derived from the PC images of I Zw 18 in the HST F555W, F814W, and F439W bands, which will be referred to below as the $V$ versus $I$ and the $V$ versus $B - V$ CMDs, respectively. In Figures 7a and 8a we plotted all the objects measured in both filters with a $\chi^2 < 3$ and $-1 < \text{sharpness} < 1$ (444 in the $V$ vs. $V-I$ and 267 in the $V$ vs. $B-V$, respectively), while in Figures 7b and 8b we show only the stars with a photometric error $\sigma_{\text{DAO}} < 0.2$ in both bands, after removing spurious detections (247 objects remain in the red CMD and 106 in the blue one). The main features of the complete diagram remain unaltered after the $\sigma_{\text{DAO}} < 0.2$ selection. Thus, we used the CMDs in Figures 7b and 8b as reference diagrams for the theoretical simulations, as they have a more reliable photometry.

Since this target is located at high galactic latitude ($b = +45^\circ$), its CMDs do not suffer from significant contamination from foreground stars belonging to our Galaxy, and it is not necessary to consider this factor of uncertainty in our simulations or to correct for it our observed CMDs.

A first analysis of the observed $V$ versus $V-I$ diagram of I Zw 18 (Fig. 7b) shows that we reached a limiting magnitude of $V \approx 26.5$, which goes down to $V \approx 27$ for objects with the reddest $V-I$ color. From a morphological viewpoint, in this CMD we can easily distinguish the typical blue plume observed in ground-based observations of Local Group irregulars: this plume is populated both by main-sequence (MS) stars and by stars at the hot edge of the post-MS evolutionary phases. For I Zw 18 the plume extends up to $V \approx 22$ and has a median color $V-I \approx 0$, indicative of a very low reddening. This is in agreement with the most recent values proposed for this parameter, for example, $E(B-V) = 0.04$ in HT95. We also note the presence in the CMD of several bright supergiants with a wide spread of colors from blue to red, and some faint red stars. As described in the previous sections, they all turned out to be real stars after a detailed analysis of their shape and profile. All the bright blue and red stars are concentrated in

![Figure 7](image.png)

**Fig. 7.** CMD in the F555W and F814W filters for I Zw 18 as observed in the PC field of view. (a) The 444 objects with $\chi^2 < 3$ and $-1 < \text{sharpness} < 1$. (b) Subsample after selecting the objects with photometric error $\sigma_{\text{DAO}} < 0.2$ in both filters and after having cleaned the CMD from uncertain detections (247 stars).

![Figure 8](image.png)

**Fig. 8.** Same as Fig. 7, but for the F555W and F439W bands of the PC camera (267 and 106 objects, respectively).
the innermost and more crowded regions, particularly in the northwest component of I Zw 18.

All the H II regions recognized by HT95 (as well as many stars in the badly resolved northwest cluster), were automatically removed from our $V$, $V-I$ diagram because they turned out to have $\chi^2 > 3$ and/or sharpness outside the range $[-1, 1]$. Also, the bright star clusters and associations are rejected for the same reason. This implies that our CMD is not sampling extremely young stars. The percentage of flux discarded with this procedure corresponds roughly to 3.5% (2%) of the total flux of the whole galaxy in the $V$ ($I$) filter, while it is $\sim$40% of the total flux sampled by the resolved stars in both bands.

An inspection of the $V$ versus $B-V$ diagram shows that also in this case we reached the limiting magnitude $V \approx 26$. We have, however, a shallower cutoff as the $B-V$ color becomes redder: this is due to the shorter integration time and to the lower sensitivity of the F439W filter with respect to the F814W. Again in this CMD we can recognize the typical blue plume of the MS and post-MS stars, with a median color of $B-V \approx 0$, and an upper brightness limit of $V \approx 22.5$. Also in this case, we are not retaining the H II regions of HT95 and the star clusters, the total flux of the galaxy lost with the rejection criteria being 1% (0.5%) in the $V$ ($B$) band, again $\sim$40% of the light in the resolved stars.

To estimate the masses of the stars visible in the CMDs and the corresponding look-back times, we have converted stellar evolutionary tracks into the observational plane and superposed them on the observed CMDs. In Figure 9 we show the Padua tracks with $Z = 0.0004$ (Fagotto et al. 1994) converted to the $V$ versus $V-I$ (Fig. 9a) and $V$ versus $B-V$ (Fig. 9b) plane, having adopted a distance modulus $(m-M)_0 = 30$ and a reddening value $E(B-V) = 0.04$. The $V$ versus $V-I$ diagram shows that in I Zw 18 we have detected MS stars with masses higher than $12 M_{\odot}$ (corresponding to lifetimes younger than $\sim 20$ Myr) and blue-loop stars with masses down to $\sim 3-4 M_{\odot}$ (thus with ages up to $\sim 0.2$ Gyr). The faintest clump of red objects in Figure 9 can be populated by (red) core helium burning, asymptotic giant branch (AGB) stars and bright red giant branch (RGB) stars, whose masses can be in principle as low as $\sim 1 M_{\odot}$, extending the look-back time up to several Gyr. However, given the large photometric error, it is not possible to estimate precisely the mass, and therefore the age, of these faint stars. In the following we will conservatively assume a look-back time of 1 Gyr. In the $V$ versus $B-V$ diagram we see objects with mass larger than $12 M_{\odot}$ in the MS stage ($t \approx 20$ Myr) and larger than $7 M_{\odot}$ in the post-MS phase, thus with ages less than $\sim 50$ Myr. We will use the $V$ versus $V-I$ diagram to infer the SF history of I Zw 18 over the last 1 Gyr, while the $V$ versus $B-V$ diagram will be used as a further check over the last $\sim 50$ Myr.

In Figure 10 we plot the differential luminosity functions (LFs) of all the stars with $\sigma_{DAO} < 0.2$ in both filters present in the $V$ versus $V-I$ and the $V$ versus $B-V$ diagrams (Figs. 10a and 10b, respectively). We can see in both cases a rather smooth trend. The LFs will be used in the simulations to check the consistency between models and observations.

It is clear from Figure 9 that the blue plume of I Zw 18 is populated by stars both on the MS and at the hot edge of the blue loop evolutionary phase and that no safe criterion can be found to separate the two different populations. For this reason we do not even attempt to derive a MS LF, which would be inevitably affected by too large uncertainties to be of any use.

Also, the derivation of the slope of the LF may turn out too uncertain, once we consider that, as listed in Table 2, the data start to be incomplete already at the brightest magnitudes and significantly incomplete at $V = 24$. For the mere sake of comparison with other galaxies and warning that these values should only be taken as indicative, we have nonetheless computed the slope by means of a maximum likelihood fitting on the deeper $V$ data. Down to $V = 23$, where the data are almost complete but where only very few stars are present, $\Delta \log N/\Delta V = 1.28 \pm 0.04$; at $V = 24$, where completeness is 85%, the slope is $0.68 \pm 0.02$, and at $V = 25$ (75% of completeness) it is $0.45 \pm 0.04$. The latter value is consistent with those derived by HT95 from the same data for stars in three different locations (slopes between 0.58 and 0.65), once we consider that they have corrected them for incompleteness.

HT95 pointed out that these slopes are steeper than those derived for other star-forming systems like R136 and NGC 604. They also appear steeper than the average

![Fig. 9.—CMDs of I Zw 18 compared with the Padua tracks with $Z = 0.0004$. (a) $V$ vs. $V-I$; (b) $V$ vs. $B-V$. The stellar mass of each track is given in $M_{\odot}$. The right vertical axis is the absolute magnitude in the F555W filter.](image-url)
Fig. 10.—Luminosity function of stars in I Zw 18 present in the CMD. (a) This refers to the $V$ vs. $V-I$ diagram and thus to the deeper F555W image; (b) refers to the F555W shallower frame of the $V$ vs. $B-V$. Error bars correspond to the rms.

$0.70 \pm 0.03$ derived by Freedman (1985) and Hoessel (1986) from a large sample of irregulars and than those derived by us in Local Group irregulars (TGMF; GMTF; MTGF) and in NGC 1569 (G98), since those were derived in the complete portion of the stellar sample distribution. The difference is more striking if one considers that the literature values are supposed to refer to MS stars, whereas here we have all kinds of objects, and in general, MS LFs are steeper than global ones, which can include bright supergiants.

As discussed by HT95, it seems unlikely that such a steep LF is due to a steep IMF, and we certainly endorse their opinion, since we will show below that the data of I Zw 18 are actually best reproduced by assuming a flat and not a steep IMF. We are rather inclined to attribute this unusual steepness to the particular star formation history of the galaxy, which can have superposed around $V \sim 24-25$ two distinct stellar populations, making that magnitude bin much more populated that the brighter ones.

3.2. I Zw 18 Companion System

Figure 11 shows the $V$ versus $B-V$ diagram for I Zw 18’s companion, resolved into individual stars in the field of view of the WF3 camera. In Figure 11a, we plotted the 109 stars measured in both the F555W and F450W filters with $\chi^2 < 3$ and $-1 < \text{sharpness} < 1$, while in Figure 11b we considered only the subsample of stars (58 objects) with $\sigma_{DAO} < 0.2$, after an accurate check for spurious detections. It is worthwhile to point out that the rejection criteria eliminates $\sim 1\%$ of the total flux of the secondary body in both $B$ and $V$ filters, and contrary to I Zw 18, this corresponds only to $\sim 15\%$ of all the light in the measured stars. Furthermore, the error constraint implies the loss of a lot of faint stars and saves only the brightest part of the blue plume and a few red supergiants and giants. The blue plume has a median color $B-V \approx 0$ and reaches the bright limit of $V \approx 24$ (the brightest point at $V \approx 22$ in Fig. 11a) corresponds to the star cluster in the center of the system). Given the high galactic latitude of the system, again we expect no contamination problems. The foreground reddening is assumed to be $E(B-V) = 0.04$ as for the main body.

In Figure 12 we report the differential LF in the $V$ band, which refers to the CMD of the secondary body. The derivation of the slope of the LF is even more uncertain than for the main body; we have nonetheless computed it by means of a maximum likelihood fitting. Down to $V = 25$, incompleteness is low, but only 10 stars are present, and the slope is $\Delta \log N/\Delta V = 0.60 \pm 0.16$; down to $V = 26$, where completeness is 80%, the slope is $0.50 \pm 0.08$. These values are totally consistent with those derived for other irregulars (see § 3.1).

As already done for the main body, in Figure 13 we show the comparison between the Padua tracks with $Z = 0.0004$ and the $V$ versus $B-V$ diagram of the companion galaxy. Taking into account the photometric error, the resolved stars could all be MS objects, yielding a look-back time of
only a few tens of Myr at most. The two brightest red stars, which appear as evolved objects of \( \sim 7 \, M_\odot \), are in fact the two objects circled in Figure 2, located rather far from the bulk of the system, and might therefore be foreground objects. As an alternative interpretation, the observed CMD can be populated by only a few MS stars, with most of the detected objects in the blue loop phase. In this case most of the MS would be fainter than our limiting magnitude, and the CMD would be sampling the evolved progeny of 4–9 \( M_\odot \) objects, yielding a look-back time of \( \sim 0.2 \) Gyr.

From a comparison between the CMDs of I Zw 18 and its companion it is evident that the blue plume of the main system is \( \sim 2 \) mag brighter in \( V \) than that of the secondary body: at first glance this may be interpreted as an indication of a considerably younger population in the bigger system. However, the interpretation can be quite different, once we take into proper account the different contributions to the blue plume of MS and post-MS stars.

4. COMPARISON WITH SYNTHETIC DIAGRAMS

In order to derive the SF history and IMF of I Zw 18 and its companion, we have compared the observed CMDs and LFs with theoretical simulations based on homogeneous sets of stellar evolutionary tracks. The procedure applied here for the creation of synthetic CMDs is the same described in detail in TGMF for ground-based observations of Local Group irregulars and in G98 for \( HST \) optical data of the nearest starburst dwarf NGC 1569. In the latter paper a detailed description of the whole procedure and of the conversion of synthetic CMDs to the \( HST/\text{WFPC2} \) Vega-mag system is also given.

Literature values for the distance to I Zw 18 range from 9.8 to 11.2 Mpc, corresponding to true distance moduli between 30 and 30.3 mag. For our simulations we adopted \( (m - M)_0 = 30 \), and for the reddening \( E(B - V) = 0.04 \) (HT95), which turned out to provide synthetic MSs with average color in agreement with the observed one.

For an adopted IMF, SFR, and set of stellar evolutionary tracks of a given metallicity, the final product of the simulation is a synthetic diagram containing the same number of objects (247 for \( V \), \( V - I \) and 106 for \( V \), \( B - V \) in the main body, and 58 in the companion) above the same limiting magnitude as the observed CMD and with the same properties of photometric uncertainties and incompleteness (Figs. 4 and 5, and Table 2). The free parameters for the CMD simulations are the following: IMF slope; starting epoch, duration, and ending epoch of the star formation activity; mode of the SF (continuous or episodic, constant or exponentially decreasing with time). For any adopted set of stellar evolution models, we have first generated synthetic CMDs assuming constant SF throughout all the observable epoch, duration, and ending epoch of the star formation activity; mode of the SF (continuous or episodic, constant or exponentially decreasing with time). For any adopted set of stellar evolution models, we have first generated synthetic CMDs assuming constant SF throughout all the observable look-back time and Salpeter's (1955) IMF (\( \alpha = 2.35 \)) and then modified the assumptions on each parameter to see the resulting effect on the comparison between the predicted CMD and LF and the empirical data. Here we show only a few illustrative cases; for a larger compilation of model samples see Aloisi (1998, hereafter A98).

The comparison between the simulated CMDs and the observed one is carried out in terms of the major features of the stellar distribution in the color-magnitude plane, as for example the relative number of stars in different evolutionary phases, the color and magnitude of the brightest stars or of the blue plume, etc. A more quantitative comparison is performed on the LFs. We do not perform quantitative tests on the color distribution because of the large intrinsic uncertainties in the effective temperatures of models of massive stars in their post-MS stage, which are reflected in the color determination.

To constrain the model selection as much as possible, we have simulated independently the \( V \), \( V - I \) and the \( V \), \( B - V \) diagrams and compared the corresponding results only a posteriori. This approach may appear to waste time since the two diagrams correspond to the same galactic area and therefore represent the same stellar population, but it adds independent and useful constraints because stars of different temperature have quite different weight on the distribution of \( B - V \) and \( V - I \) CMDs and because the photometric errors and incompleteness factors are different in different frames. Besides, these independent simulations provide a useful test on the self-consistency of the method. The \( B - V \) CMD is in general too shallow to provide by itself reliable information on the SF history of I Zw 18; nonetheless, it is
very useful for a further selection of the models providing the better agreement with the $V - I$ data, thanks to its higher sensitivity to the younger (i.e., bluer) population. We have found that only a few of the models selected in $V - I$ turn out to reproduce also the $B - V$ observed features. This has significantly constrained the overall scenario able to fit both the $B - V$ and the $V - I$ distributions.

To evaluate the theoretical uncertainties due to different stellar codes, input physics, and metallicity effects, it is always important to generate synthetic CMDs with more than one set of homogeneous tracks, when available. Since the overall metallicity of I Zw 18 and its companion is estimated to be between $Z \sim 0.0006$ and 0.0004, we have performed our simulations for both systems using the Padua tracks with $Z = 0.0004$ (Fagotto et al. 1994) and the Geneva tracks with $Z = 0.001$ (Schaller et al. 1992) and $Z = 0.0004$ (kindly made available by D. Schaerer).

These sets of stellar models differ from each other in several aspects, some of which have significant effects on the synthetic CMDs:

At the same nominal metallicity ($Z = 0.0004$) the Padua tracks have the same temperatures as the Geneva ones for MS stars (core H-burning phases) and for stars at the hot edges of the blue loops (core He-burning phases), but lower temperatures for red giants and supergiants, thus spanning a larger color range.

The Geneva tracks with $Z = 0.001$ assign lower temperatures to the red stars (due to the higher metallicity) and cover the maximum color interval, in spite of their slightly cooler hot edges of the blue loops.

The lifetimes of massive stars at the blue loop edge are systematically longer in the Geneva tracks than in the Padua ones. This implies that the Geneva models tend to predict post-MS massive stars mostly at the blue edge of the loops, whereas the Padua models populate more homogeneously all the colors from the red to the blue edges. The opposite occurs for intermediate-mass stars, for which the Padua models predict longer lifetimes at the blue edge than the Geneva ones.

4.1. Main Body: Simulations with Padua Tracks.

We have performed about 300 simulations with the set of Padua models with metallicity $Z = 0.0004$, testing various values for the slope of the IMF, the starting epoch, the mode and the duration of the SF activity, under the hypotheses of one or two SF episodes occurred during the last 1 Gyr. All the synthetic CMDs based on these tracks show a short color extension: the bluest stars are properly reproduced, but the coolest objects predicted by these models have systematically $V - I \leq 1.7$, whereas the empirical ones are as red as $V - I \sim 2$. The cause of this inconsistency could be an excessively low metallicity parameter in the tracks or an inadequacy of stellar models to reproduce the effective temperatures in the coolest phases. Besides, the color conversions are more uncertain in these phases, as a result of the much more difficult treatment of molecules in model atmospheres. On the other hand, the calibration of HST data may still be slightly uncertain and the data may present color equations not properly taken into account.

Independently of the IMF and SFR, the most evident result that clearly emerges from the comparison of synthetic and observed CMDs is that we can safely exclude that only one single recent burst has occurred, started later than a few $10^7$ yr ago. This scenario definitely does not allow us to reproduce the observed red and blue stars fainter than $V \sim 26$ populating the $V$ versus $V - I$ diagram and leads in general to an overabundance of bright blue stars compared with those observed both in the $V - I$ and in the $B - V$ CMDs. As an example, in Figure 14 (left) we have plotted the $V - I$ and $B - V$ CMDs and corresponding LFs of an SF episode started 10 Myr ago and still ongoing at a constant rate. In this case the IMF is steep ($\alpha = 3.0$, much steeper than Salpeter’s value of 2.35). With such a late start, all the objects with masses lower than $\sim 20 M_\odot$ are still on the MS, and there is no chance to populate the blue loops at intermediate and faint magnitudes. As a result, the synthetic stars are all bluer than $V - I \approx 0$, at variance with the observational distribution. In addition, the synthetic LF turns out underpopulated in the $V \gtrsim 25.5$ portion and overpopulated in the range $V \lesssim 23$. Flattening the IMF clearly worsens the result. Also, the $V, B - V$ synthetic diagram is inconsistent with the data, being populated only with stars bluer than $B - V \approx 0.2$. To fit the data we need an earlier start of the SF activity: from many tests, we have found that to obtain acceptable results, the SF in I Zw 18 must have started at least 200 Myr ago (see A98).

A continuous SF provides results consistent with the data either with a currently ongoing SF or with one stopped not earlier than 5 Myr ago. In Figure 14 (middle), we present the $V$ versus $V - I$, $V$ versus $B - V$ and relative LFs for the case of one episode started 1 Gyr ago with an exponentially decreasing SF activity (e-folding time $\tau = 500$ Myr) and still ongoing. The adopted IMF is $\alpha = 1.5$. Note that in the LF the maximum deviation of the model from the observational points is around 3 $\sigma$. Similar results are obtained with a later onset of the SF. With this type of models we reproduce fairly well the CMDs and LFs, provided that the adopted IMF is flat ($1.5 \leq \alpha \leq 1.8$). Steeper slopes (even when coupled with a constant SFR) lead to worse results, since they don’t provide enough bright stars when the faint end of the LF is matched. For instance the best model obtained with a Salpeter’s slope ($\alpha = 2.35$) leads to a LF that deviates in several magnitude bins by more than 4 $\sigma$ from the observational points (A98).

Trying to better reproduce the observed color distribution of the stars, we have considered a two-episode scenario. Models in which the old episode occurs from $\sim 1$--0.2 Gyr to 100--50 Myr ago, and the young one from $\sim 100$--30 Myr ago on, provide acceptable results (similar to those shown in Fig. 14 [center] for a single episode) when the IMF is flat ($1.5 \leq \alpha \leq 1.8$). In these cases the predicted LF is always within 1--2 $\sigma$ from the empirical one. From these simulations we find that the SFR in the two episodes is quite similar and that a significant quiescent intermediate phase is not necessary (see A98). At the end of the two-episode simulations, we can thus assert that I Zw 18 has experienced a rather continuous star-formation activity over a large fraction of the whole look-back time sampled by our CMDs.

The distribution of the yellow and red supergiants in the observed CMD is quite peculiar: there is a clump of faint red stars (at $V \sim 26$--27), and a continuous distribution of objects at brighter magnitudes ($V \sim 23$), with a gap in between. These features are not reproduced by the simulations, unless a very specific SF history (hereafter, the burst scenario) is adopted, as we discuss below. As already men-
tioned, these stars have been carefully checked and confirmed to be most likely actual single objects (not extended ones or spurious detections), members of I Zw 18. We have thus considered two different episodes, one of which could efficiently populate the evolved portions of the tracks with masses between 12 and 15 \( M_\odot \) (see Fig. 9). This corresponds to forcing most of the stars in this mass range to be in a post-MS phase and is equivalent to considering a burst that occurred between 20 and 15 Myr ago. An older longer episode of SF populates the fainter red giant region. As an example, in Figure 14 (right) we show the CMDs and LFs obtained assuming a first episode of SF from 1 Gyr to 30 Myr ago and a second one, 10 times stronger, from 20 to 15 Myr ago, both with \( \alpha = 1.5 \). It can be noted that in this case all the observational features are reproduced pretty well, with deviations of models from the data always less than 1 \( \sigma \). All the models in better agreement with the data assume quite flat IMFs. However, while the second burst can reproduce the observed features only if \( \alpha \approx 1.5 \), acceptable distributions are also obtained when a Salpeter IMF is adopted for the first episode (\( \alpha \approx 2.35 \)), with a proper tuning of the SF parameters.

4.2. Main Body: Simulations with Geneva Tracks

The set of Geneva tracks with \( Z = 0.0004 \) (kindly provided by D. Schaerer) only has models for stars with masses \( M \gtrsim 3 \ M_\odot \). Consequently, our simulations cover only the last 0.3 Gyr. The synthetic CMDs based on this set are all
characterized by a color extension even smaller than that of the Padua models with the same nominal metallicity. As a general result, these simulations tend to overpredict the number of bright blue supergiants, while underpopulating the magnitude range around $V \sim 23.5$. Varying the IMF and SFR parameters the agreement can be improved, but we did not find a satisfactory representation of the data (see A98). An illustrative case is shown in Figure 15, which assumes two episodes of SF: the first from 300 to 100 Myr ago, and a second one started 90 Myr ago and still ongoing. The IMF slope is $z = 2$, and the SF rates in the two episodes are similar to each other. In spite of being one of our best simulations with this set of tracks, the deficiency of stars with $V \approx 23.5$ can still be noted in the LF, where the maximum deviation is almost 4 $\sigma$.

Different from the others, the Geneva set with $Z = 0.001$ does span a color range as large as the one observed in the main body of I Zw 18. In spite of the relatively large value of the $Z$ parameter, the synthetic blue plume overlaps the observed one when the canonical $E(B-V) = 0.04$ is adopted.

As already found with the other sets of stellar tracks, models with only one and recent episode of SF activity are definitely inconsistent with the observed CMD and LF. This can be easily understood from Figure 16 where we show the superposition of the observed $V-I$ CMD with the Geneva $Z = 0.001$ tracks. In order to populate the region at $V-I \gtrsim 1$, and fainter than $V \approx 25.5$, stars of 3–5 $M_\odot$ must have had the time to evolve off the MS, indicating SF activity earlier than $\sim 100$ Myr ago. Moreover, in the faintest portion of the blue plume we find objects of $\approx 5–7$ $M_\odot$, with ages up to 100 Myr. For these reasons, simulations with SF starting later than $\sim 0.1$ Gyr are inconsistent with the observations, as already shown in the previous subsection for the Padua set.

Figure 17 shows three of the best cases obtained with this set of tracks under different assumptions for the SF history. In all the cases the IMF slope is 1.5. In the left-hand panels, we plot the result of assuming a constant SF over the last 1 Gyr, but stopped 5 Myr ago. Despite the flat IMF, the synthetic LF is underpopulated around $V \approx 24$, with deviations at a 2 $\sigma$ level, an inconsistency that worsens with steeper IMFs. Had the SF continued in more recent epochs, too many bright blue stars would have appeared. The middle panels show a simulation with two SF episodes; the oldest one started 500 Myr ago and stopped 100 Myr ago, while the recent one started 100 Myr ago and is still active. The rate of SF in the first episode is slightly higher than in the second one. In the $V$ versus $B-V$ diagram we can see only the stars born during the most recent activity. Both the $B-V$ and the $V-I$ LFs deviate from the empirical one by at most $\sim 3$ $\sigma$, but the color distribution, especially for the brightest stars, is not satisfactorily reproduced.
As already discussed, this particular feature is difficult to reproduce because of the short lifetimes of massive stars in the post-MS phases. The only way to overcome this problem is to force the models to populate the bright part of the diagram only with evolved stars (i.e., with no contribution from the upper MS). This can be achieved assuming that the more recent SF episode stopped fairly long ago (15 Myr ago) so that no stars brighter than $V \approx 25$ can be on the MS. The right-hand panels of Figure 17 show one of the best cases of this type, with the first SF episode from 200 to 30 Myr ago and the second one from 20 to 15 Myr ago. To obtain enough stars in the brighter portion of the CMD, we find that the SF rate in the second burst has been almost 7 times higher than in the old one. These models reproduce fairly well both the observed distribution of cool and warm supergiants and the curvature of the upper blue plume in the $V-I$ CMD. They also reproduce quite well the observational $B-V$ CMD.

4.3. Summary of the Results for the Main Body

The results obtained with the three sets of stellar models are consistent with each other in suggesting the overall scenario for the recent evolution in I Zw 18. The different values obtained for the various parameters depending on the adopted tracks give an estimate of the theoretical uncertainty still associated with stellar evolution models. Their relatively small differences support the reliability of our conclusions. Some of the results are completely independent of the adopted stellar models, like the flatness of the IMF and the presence of stars with intermediate ages.

In all the simulations we have found indications of an IMF significantly flatter than Salpeter's ($\alpha = 2.35$). The
exponents that have turned out to be mostly consistent with the observations are in the range $\alpha = 1.5$–2.0, with some preference for the flatter extreme of this range. Steeper IMFs look inappropriate also in the case of currently ongoing SF, because they imply too few massive MS stars and too many intermediate-mass stars, with a consequent overpopulation of the faint blue plume. Note, however, that the derived slope obviously refers to the visible range of masses. At the distance of I Zw 18, nothing can be inferred with our method on the IMF of stars less massive than $\sim 2 M_\odot$.

Given the relatively short look-back time of the empirical CMDs of I Zw 18, we have considered a star formation activity distributed over one or at most two episodes with a regime constant or exponentially decreasing with time. We should recall that two is possibly the maximum number of SF bursts allowed by the extremely low metallicity of this galaxy (e.g., Kunth, Matteucci, & Marconi 1995). In no case have we been able to reproduce the observed CMDs and LFs with one single episode of SF started more recently than 0.1 Gyr ago. This rules out, beyond any reasonable doubt, that I Zw 18 has started very recently to form its first stars.

A single SF episode can reproduce rather well the data if extending over a sufficiently long period of time ($\gtrsim 0.2$ Gyr). With an IMF slope of 1.5 we derive typical SF rates of $\sim 6 \times 10^{-3} M_\odot$ yr$^{-1}$ for stars more massive than 1.8 $M_\odot$. If the SF episodes sampled by the resolved stars in I Zw 18 are two, we find a better agreement between synthetic predictions and empirical data especially when the younger episode is relatively old and 7–10 times stronger than the previous one. To reproduce the observed features, the younger episode must have occurred between $\sim 20$ and 15 Myr ago, with an SFR of $\sim 3 \times 10^{-2} M_\odot$ yr$^{-1}$ for the Geneva (Padua) tracks. The older episode can have started any time between 1 and 0.2 Gyr ago and continued until approximately 30 Myr ago. An earlier stop of the latter SF activity would lead to an underpopulated blue plume at the faint magnitudes. If we want instead the SF in I Zw 18 to have taken place until recently, not only in the densest unresolved regions (Kunth et al. 1995; de Mello et al. 1998; Izotov & Thuan 1998; van Zee et al. 1998), but also in the resolved field, the best agreement is attained if the most recent of these two episodes has occurred from 0.1 Gyr ago at a rate of $(2-5) \times 10^{-3} M_\odot$ yr$^{-1}$. In this case, however, as well as in the single-episode case, the yellow/red supergiants observed in I Zw 18 are not reproduced by the models. For this reason we definitely prefer the burst scenario with the intense SF episode between 20 and 15 Myr ago.

To evaluate the actual SFR in I Zw 18, the value obtained from the synthetic CMDs must be extrapolated from the lower mass limit adopted in the simulation ($m_{\text{low}} = 1.8$ and 2 $M_\odot$ for the Padua and Geneva sets, respectively) to the physical lower mass cutoff. Since the IMF at the low-mass end is still highly uncertain (Larson 1998; Leitherer 1999) both in the slope and in the lower mass cutoff, the extrapolations have been performed exploring a few simple cases. For the lower mass cutoff, we have adopted the value of 0.1 $M_\odot$. If $\alpha = 1.5$ over the whole mass range, the extrapolation leaves basically unaltered the SFRs quoted above. Alternatively, if a Salpeter slope is adopted below $m_{\text{low}}$, the corrected SFR amounts to 1.4 times the values quoted above.

Since the size of I Zw 18 is estimated to be $840 \times 610$ pc$^2$ (DH90), the rates presented above and corrected for the IMF extrapolation become on average $(1-2) \times 10^{-2} M_\odot$ yr$^{-1}$ kpc$^{-2}$ in the cases of one or two SF episodes. Only when the second episode stops as early as 15 Myr ago, its SFR can be as high as $(6-16) \times 10^{-2} M_\odot$ yr$^{-1}$ kpc$^{-2}$, depending on the adopted IMF and evolutionary tracks.

### 4.4. Simulations for the Secondary Body

The fiducial stars populating the CMD of I Zw 18 companion are so few (58), that the comparison with the corresponding synthetic diagrams is inevitably affected by small number statistics. Besides, only the $V, B-V$ CMD is available for this object, thus sensibly reducing the look-back time, and in general the available constraints to discriminate between different evolutionary scenarios. Nevertheless some interesting conclusions can still be drawn, thanks to the circumstance that all the sets of stellar tracks favor the same overall scenarios for its star formation history. For this reason, in the following we show only the results for the Padua set of tracks.

As illustrated in § 3.2, the blue plume of the secondary body is 1.5–2 mag fainter than that of the main body. This is not necessarily a signature of an older stellar population, since we have seen in the previous sections that the brightest blue stars in the main body are mostly post-MS objects, much brighter than their MS progenitors. As visible in Figure 13, the red portion of the blue plume fainter than $V = 25.5$ can be populated either by stars of approximately 4–6 $M_\odot$ in the blue loop or by more massive stars still on the MS. As a consequence, the observed magnitude distribution of the stars in the companion can be reproduced either with a quite young SF episode (started around 50 or less Myr ago) or with a rather old one (started around 200 Myr ago). Nonetheless, the color of the blue plume is (slightly) better reproduced by the older scenario.

Figure 18 shows the synthetic diagrams obtained for an SF started 10 Myr ago (top, third from top) and an SF started 150 Myr ago (second from top). Their luminosity functions are shown in the bottom panel (solid lines, dotted lines, and dashed lines, corresponding to the top, second, and third CMD, respectively). In order to compensate for the higher number of massive young stars in the top case, its IMF slope is steeper than in the second case, 2.6 and 1.5, respectively. It can be seen that both models give a fair representation of the data. The panel third from the top (and dashed LF) shows what happens to the top panel model if one only changes the adopted IMF slope from 2.6 to 1.8. Too many massive blue supergiants populate the top of the blue plume, making it far too bright, and correspondingly, too few MS stars populate its faint end. Similar results are obtained with the other sets of tracks, though with somewhat different values for the parameters, reflecting the different lifetimes in the various evolutionary stages. For example, slightly earlier starts for the SF activity and steeper IMF slopes are derived with the $Z = 0.001$ Geneva sequences.

In the case of the secondary body where the observational constraints are modest, the range of acceptable values for the parameters is larger than for the main body. In addition, as shown in Figure 18, it is difficult to disentangle the contribution of the IMF and of the SFR to the observed stellar distribution. From the hundreds simulations performed on the secondary body, we believe that no quantitative information can be derived on its IMF slope. The range of acceptable slopes for the IMF is large (1.5–3.0),...
Fig. 18.—Synthetic CMDs and LFs for the secondary body of I Zw 18 based on the Padua tracks with $Z = 0.0004$. The CMD in the top panel corresponds to a constant SF episode started 10 Myr ago; the CMD in the second to top panel, to a relatively old exponentially decreasing SF, started 150 Myr ago, and the CMD in the third from top panel to the same model as in the top panel, but with flatter IMF. The adopted IMF slope is indicated. In the bottom panel are shown the LFs corresponding to the CMD from the top panel (solid line), the CMD from the second to top panel (dotted line), and the CMD from the third from top panel (dashed line). These LFs are compared with the empirical one (dots) in the bottom panel.

but the slopes leading to diagrams in better agreement with the data are peaked at $\alpha = 2.2$, somewhat flatter than that of Salpeter ($\alpha = 2.35$), and definitely steeper than the slopes required for the main body. Besides, the trend of a steeper IMF with more recent star formation is confirmed by all models. With $\alpha$ flatter than 2, an SF started more recently than ~30 Myr ago and still active has to be excluded, and one started as early as 0.15–0.20 Gyr is preferable. For steeper IMFs, SF activities started as late as 10 Myr ago and still ongoing can be appropriate to interpret the observed features.

The rate of SF is obviously inversely proportional to the duration of the activity (since the number of generated stars still visible is given by the data). Considering the extrapolation from $m_{\text{low}}$ to the lower physical mass cutoff 0.1 $M_\odot$, either with a single-slope IMF with $\alpha = 2.2$ or with Salpeter's slope, the derived SFRs must be corrected by a factor of 2.5 or 2.9, respectively. Thus for young SF episodes, occurring in the last 10–50 Myr, the average rate is $(2–5) \times 10^{-3} M_\odot$ yr$^{-1}$, depending on the adopted stellar tracks. For SF activity started as early as 0.2 Gyr ago, the average rate is lower, $(1–2) \times 10^{-3} M_\odot$ yr$^{-1}$. In terms of rate per unit area, these values translate into $(0.7–1.7) \times 10^{-2}$ and $(3.4–6.7) \times 10^{-3} M_\odot$ yr$^{-1}$ kpc$^{-2}$, respectively, once a size of $850 \times 350$ pc$^2$ is assumed for the secondary body (DH90). Therefore, the average SF rate in the secondary body has been similar or ~3 times lower than in the main body, depending on the preferred scenario.

5. DISCUSSION AND CONCLUSIONS

We have studied the SF history in I Zw 18, with the main goal of trying to disentangle the long-standing question of whether this system is experiencing now its first burst of star formation. Other investigators have already examined this question and provided contradictory answers. To mention just one recent example: Kunth et al. (1995) inferred from a series of chemical evolution models that I Zw 18 can have experienced at most two SF bursts, each of which with duration no longer than 10–20 Myr, whereas Legrand & Kunth (1999, hereafter LK) argue from a spectro-photometric-chemical model that the observed metal abundances and colors can be better explained in terms of a very low SFR $(10^{-4} M_\odot$ yr$^{-1}$), continuous during 16 Gyr, with burst occurrence (and SFR 100 times stronger) only in the last 50 Myr.

Other authors have argued in favor of a relatively recent onset of the SF activity in I Zw 18. Both HT95 and D96 suggest a continuous and still ongoing SF over the last 30–50 Myr, as deduced comparing the CMDs of the resolved stellar population on WFPC2 images with isochrones. From the kinematic analysis of ionized gas, Martin (1996) found a bipolar bubble with a lobe more evident in the southeast than in the northwest part of the galaxy. Its dynamical evolution and photometric properties are well described by a continuous SF episode started 15–30 Myr ago at a rate of ~0.02 $M_\odot$ yr$^{-1}$. On the other hand, in the literature there are some clues of an older SF activity in I Zw 18; for instance, from the comparison of the C/O ratio with predictions of chemical evolution models, Garnett et al. (1997) suggest an SF episode as long as a few hundred million years.

Our approach is to infer the SF history of the galaxy from the CMDs and LFs of its stars resolved by HST photometry. As already mentioned in the above sections, this method does not examine the denser, unresolved regions where some SF has certainly occurred at very recent epochs as demonstrated by the presence of several H II regions. The derived $V$, $V - I$ and $V, B - V$ diagrams have been interpreted in terms of SF and IMF by means of theoretical simulations. In comparison with other galaxies examined with the same method, it is more difficult to derive strict
constraints on the SF history of the I Zw 18 system, because its larger distance makes much smaller the number of resolved stars and consequently poorer the statistical significance of the results, especially for the secondary body. Nonetheless, in spite of this problem and the difficulties described above to fully reproduce all the observed features of the galaxy, the comparison of all the synthetic CMDs and LFs with the corresponding data has led to quite firm indications on the overall properties of the evolution of I Zw 18.

It is clear from the results presented above that in no way can a single SF episode started only a few tens of Myr ago reproduce the observed features of the faint blue plume of the main body. The SF in I Zw 18 must have been already active at least 100 Myr (but more likely 500 Myr) ago to provide all the observed faint stars, both blue and red. This same conclusion is reached with all the available sets of stellar evolution tracks and is therefore independent of the adopted models; it can then be considered quite firm. The overall scenario for the SF history of I Zw 18 is thus an almost constant SF activity from 1 Gyr up to ~30 Myr ago coupled with a burst almost 10 times stronger around 15~20 Myr ago: the oldest stellar population is practically concentrated in the southeast part of the galaxy, while the other stars are both in the northwest and southeast inner dense regions (see A98).

The presence of relatively old stars excludes one of the two alternative scenarios proposed by Kunth et al. (1995), which allows for only one ongoing episode started a few million years ago. The alternative case of two separate episodes is instead compatible with our results. At first glance, our results seem also in agreement with LK’s scenario of an almost continuous star formation activity. However, the average SF during the epochs covered by our analysis has turned out to be ~10^{-2} M_{\odot} yr^{-1}, 2 orders of magnitude higher than the low level predicted by LK’s model. Our rate is instead close to what LK attribute to the current burst. On the other hand, the duration of the SF activity is much longer in our scenario than in LK’s burst. We do find that a burst is likely to have occurred at roughly LK’s burst rate, but in a shorter time interval (from 20 to 15 Myr ago in our scenario, from 50 Myr ago until now in LK’s). Thus, our quantitative conclusions do not necessarily agree with LK’s values. This of course does not exclude that a continuous SF activity has taken place throughout the galaxy lifetime, but it should have had an intensity quite lower than in their model to compensate the longer duration of the recent interval at high rate. Our derived SF history is instead in agreement with Martin (1996) and Garnett et al. (1997) results. In particular, both the epoch and the level of the SFR in the most recent episode of our burst scenario agree with Martin’s (1996) finding. Thus, from the study of the resolved stars in I Zw 18 we find support to the idea that this episode of SF powered the bipolar bubble and possibly a galactic outflow.

For a direct comparison of the derived SFRs in I Zw 18 with those of other dwarfs, it is more physically meaningful to consider the rate per unit area. In these units the main body of I Zw 18 has an SFR 10^{-2}~10^{-1} M_{\odot} yr^{-1} kpc^{-2}, and the secondary body an SFR (3~10) \times 10^{-2} M_{\odot} yr^{-1} kpc^{-2}. The SFRs derived with the same method for irregular galaxies of the Local Group (e.g., Tosi 1999) are in the range 10^{-4}~10^{-2} M_{\odot} yr^{-1} kpc^{-2}, while for the extremely active dIrr NGC 1569 (G98) the estimated recent SFR is between 4 and 20 M_{\odot} yr^{-1} kpc^{-2} depending on the adopted IMF (2.35 \leq \alpha \leq 3.0). In the solar neighborhood the present SFR is in the range (0.2~1) \times 10^{-2} M_{\odot} yr^{-1} kpc^{-2} (Tinsley 1980b; Timmes, Woosley, & Weaver 1995). We can thus conclude that I Zw 18 shows a mean SF activity comparable to that of the region around the sun and that of the most active Local Group irregulars. As a consequence, its SFR falls short of ~2 orders of magnitude to make I Zw 18 a local counterpart of the faint blue galaxies, according to Babul & Ferguson (1996) model.

In all the approximately 500 simulations performed for the CMDs of I Zw 18 we have found indications of an IMF significantly flatter than Salpeter’s (\alpha = 2.35). The exponents that have turned out to be mostly consistent with the observations are in the range \alpha = 1.5~2.0, with some preference for the flatter extreme of this range. This is the first galaxy in our sample showing such a significant evidence in favor of a flat IMF. All the others analyzed by us with the same approach (DDO 210, NGC 1569, NGC 3109, NGC 6822, Sex B, WLM) turned out to have IMF slopes close to Salpeter’s or slightly steeper, in agreement with the current general belief (e.g., Leitherer 1999) of a roughly universal IMF in irregular galaxies. Besides, the global LF of I Zw 18 seems steeper and not flatter than those of other irregulars (see § 3.1). For this reason we have examined with particular attention all the alternatives to evaluate the possibility that a more standard IMF could be acceptable with other parameter combinations. However, in no case have we been able to reproduce the observed CMDs and LFs if all the stars were born following Salpeter’s IMF. As mentioned in § 4.1, we obtained acceptable results adopting a Salpeter slope in the older SF episode, but a flat IMF in the most recent generation seems required by the data. Could this peculiarity be due to the extremely low metallicity of I Zw 18, following the old suggestion (e.g., Terlevich 1985; Melnick & Terlevich 1987) that the lower the metallicity, the flatter the IMF of massive stars? This interesting possibility is, however, contradicted by the possible trend of the older metal-poorer episode more consistent with a steeper IMF than the younger metal-richer one and by the circumstance that the secondary body seems to have a more standard IMF (with \alpha \sim 2.2), despite the same low metallicity of I Zw 18.

It is worthwhile to stress here also the possible correlation existing between the SF activity in I Zw 18 and the stellar production in its companion system. Many papers in the literature consider the stellar population in component C older than that in the main body. Different studies on its resolved stellar population (D96), ionized gas (Izotov & Thuan 1998), and integrated colors and nebular spectrum (van Zee et al. 1998) indicate ages spanning from 100 to 300 Myr, all consistent with our older scenario for this minor system. The interpretation of the empirical CMD and LF in the secondary body is, however, much less constrained than for the main body because of the small number of observed stars. Indeed, we find consistency with the data also adopting a recent and still ongoing SF activity, provided that the IMF exponent is steep enough. Deeper and more accurate data would be necessary to derive tighter conclusions.

On somewhat speculative grounds, the general trend may be that of an SF propagating from the secondary body through the northwest part of I Zw 18 to its southeast component, where some H II regions and the brightest young clusters are concentrated and still visible (HT95;
D96; Izotov & Thuan 1998). Admittedly, the spatial correlation between stellar production in different regions of I Zw 18 and in its companion system is not strong. However, in the case of recent onset of the SF activity in the minor system (50–10 Myr ago), its starting epoch is similar to that (20–15 Myr ago) of the stronger burst in the main body. Also, the SFRs are roughly comparable: \( \approx 0.1 M_\odot \text{yr}^{-1} \text{kpc}^{-2} \) for the intense burst in I Zw 18 and \( \approx 0.02 M_\odot \text{yr}^{-1} \text{kpc}^{-2} \) for the companion system. Besides, the stars in the main body generated during the strong burst (red and yellow supergiants) are possibly located preferentially in the northwest part, near the companion: this burst in I Zw 18 might thus have been triggered by gravitational interactions.

To conclude, from the analysis of the resolved stellar population in I Zw 18 our major results are the following: The age of the older stars seen in the main body reaches from a few hundred million years up to \( \approx 1 \text{ Gyr} \); therefore, a single recent episode of SF is ruled out. Our preferred scenario for the SF history is the burst scenario, consisting of two episodes, the younger one having occurred between 15 and 20 Myr ago at a rate 7–10 times higher than in the previous activity. This refers to our analyzed field and not to the denser regions where an ongoing SF activity shows up through the H\alpha regions and unresolved star clusters. The SFRs that we derive for the main body of I Zw 18 are similar to those of nearby irregulars and the solar neighborhood. The IMF, instead, appears to be significantly flatter than in any of these normal galaxies. This is especially true for the second of the two episodes, the real burst. The IMF in the secondary body appears instead to be less extreme, with a likely slope of \( \alpha \approx 2.2 \).

We warmly thank Mark Clampin, Antonella Nota, and Marco Sirianni, who have been of invaluable help. We are deeply indebted with Daniel Schaerer for having computed for us the stellar models with \( Z = 0.0004 \), to Peter Stetson for providing some of his software, and to Manuela Zoccali for help in using it. Paolo Montegriffo has also helped a lot with his unusual skill for photometric reduction in very crowded fields. Useful conversations with Claus Leitherer, Daniel Schaerer, and Michele Bellazzini are also acknowledged. We are grateful to the anonymous referee for his/her useful comments and suggestions, which contributed to improve the paper. Part of this work has been funded by the Italian Space Agency ASI.

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