

Two compact H II regions at the remote outskirts of the Magellanic Clouds^{*}

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ABSTRACT

Aims. The H II regions LMC N191 and SMC N77 are among the outermost massive star-forming regions in the Magellanic Clouds. So far, few works have dealt with these objects despite their interesting characteristics. We aim at studying various physical properties of these objects regarding their morphology (in the optical and *Spitzer* IRAC wavelengths), ionized gas emission, nebular chemical abundances, exciting sources, stellar content, age, presence or absence of young stellar objects, etc.

Methods. This study is based mainly on optical ESO NTT observations, both imaging and spectroscopy, coupled with other archive data, notably *Spitzer* images (IRAC 3.6, 4.5, 5.8, and 8.0 μm) and 2MASS observations.

Results. We show the presence of two compact H II regions, a low-excitation blob (LEB) named LMC N191A and a high-excitation blob (HEB) named SMC N77A, and study their properties and those of their exciting massive stars as far as spectral type and mass are concerned. We also analyze the environmental stellar populations and determine their evolutionary stages. Based on *Spitzer* IRAC data, we characterize the YSO candidates detected in the direction of these regions. Massive star formation is going on in these young regions with protostars of mass ~ 10 and $20 M_{\odot}$ in the process of formation.

Key words. H II regions – stars: early-type – stars: formation – stars: fundamental parameters – Magellanic Clouds

1. Introduction

The compact H II regions residing in the Magellanic Clouds are interesting in the context of massive star formation in these neighboring galaxies. Typical Magellanic Cloud H II regions are giant complexes of ionized gas with sizes of several arc minutes, corresponding to physical scales of more than 50 pc and are powered by a large number of exciting stars. In contrast, Magellanic Cloud compact H II regions are small regions mostly $\sim 5''$ to $10''$ in diameter, corresponding to ~ 1.5 to 3.0 pc and excited by a much smaller number of massive stars. There are two types of compact H II regions, high-excitation blobs (HEBs, for a review see Heydari-Malayeri et al. 2010) and low-excitation blobs (LEBs, Meynadier & Heydari-Malayeri 2007). The members of the first group are often observed lying adjacent or projected onto giant H II regions and are younger than the associated giant H II regions. Do HEBs indeed belong to the same region of the Magellanic Clouds at which the giant H II regions have formed or is the association between these two types of H II regions a line-of-sight effect? If they are associated, are HEBs powered by triggered, second-generation massive stars? Why has star formation not proceeded in a single burst although massive stars are believed to form in the dense core of giant molecular clouds? These are some interesting questions, the answers to which will be helpful for better understanding massive star formation in the Magellanic Clouds. A problem is that HEBs are not numerous, and moreover, few of them have been studied individually in detail.

This paper is devoted to a first detailed study of two compact H II regions, one in the Large Magellanic Cloud (LMC)

H II region N191 and the other in the Small Magellanic Cloud (SMC) N77 (Henize 1956). Among the LMC H II regions listed by Henize (1956), N191 is one of the outermost, lying below the bar, at a distance of $\sim 200'$ (~ 3 kpc in projection) from the famous 30 Doradus. N191 appears as an elongated structure, with two components N191A and N191B in the Henize catalog. Here we essentially study the brightest component N191A, also known as DEM L 64b (Davies et al. 1976). N77 is one of the most northern H II regions of the SMC; it is situated at a distance of $\sim 25'$ (~ 440 pc in projection) from the pre-eminent SMC H II region N66 (Heydari-Malayeri & Selier 2010, and references therein). SMC N77 is identified in the optical survey of Davies et al. (1976) as DEM S 117.

Few works have been devoted to these two H II regions despite their interesting characteristics. LMC N191 belongs to the OB association LH 23 (Lucke & Hodge 1970). It was also detected as IRAS source 05051-7058 (Helou & Walker 1988). The compact H II region SMC N77 seems to coincide with the stellar association B-OB 24 (Battinelli 1991). It was identified in the infrared as IRAS source 01011-7209 (Helou & Walker 1988) and as source #48 in the ISO $12 \mu\text{m}$ catalog (Wilke et al. 2003). Furthermore, LMC N191 and SMC N77 were part of a *Spitzer* study of compact H II regions by Charmandaris et al. (2008) and have been included in several radio continuum surveys of the Magellanic Clouds (Filipović et al. 1995, 2002). Both compact H II regions are associated with molecular clouds. The giant molecular cloud LMC N J0504-7056 is centered at $130''$ south of N191 (Fukui et al. 2008). Moreover, the OB association LH 23 and the H II region are related to this molecular cloud (Fukui et al. 2008; Kawamura et al. 2009). A small molecular cloud has been detected near the position of SMC N77 (Mizuno et al. 2001).

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This paper is arranged as follows. Section 2 presents the observations, data reduction, and the archive data (*Spitzer* data, 2MASS data). Section 3 describes our results (overall view, extinction, nebular emission, stellar content and chemical abundances). Section 4 presents our discussion, and finally our conclusions are summarized in Sect. 5.

2. Observations and data reduction

2.1. NTT imaging

LMC N191 and SMC N77 were observed on 28 September 2002 using the ESO New Technology Telescope (NTT) equipped with the active optics and the Superb Seeing Imager (SuSI2; D’Odorico et al. 1998). The detector consisted of two CCD chips, identified as ESO #45 and #46. The two resulting frames were automatically combined to produce a single FITS file, while the space between the two chips was “filled” with some overscan columns so that the respective geometry of the two chips was approximately preserved. The gap between the chips corresponds to ~ 100 true CCD pixels, or $\sim 8''$. The file format was 4288×4096 pixels, and the measured pixel size $0''.0805$ on the sky. Each chip of the mosaic covered a field of $5'.5 \times 2'.7$. We refer to the ESO manual SuSI2 for more technical information.

Nebular imaging was carried out using the narrow-band filters centered on the emission lines $H\alpha$ (ESO #884), $H\beta$ (#881), and $[O\text{ III}]$ (#882). N191 was observed with three exposures of 180 s for each filter. N77 was also observed with exposures of 180 s: five exposures in $H\alpha$ and three $H\beta$ and $[O\text{ III}]$ exposures. The image quality was quite good during the night, the seeing was $0''.8$. We constructed the line-ratio maps $H\alpha/H\beta$ and $[O\text{ III}]/H\beta$ from nebular imaging. We also took exposures using filters ESO #811 (*B*), #812 (*V*), and #813 (*R*) with unit exposure times of 15 s for *B* and *V* and 10 s for *R*, respectively. The exposures for each filter were repeated twice using ditherings of $5''$ – $10''$ for bad pixel rejection.

PSF-fitting photometry was obtained for all filters using the DAOPHOT package under IRAF¹. The magnitudes were then calibrated using the photometric calibration package photcal. To perform this calibration, seven standard stars, belonging to two Landolt photometric groups SA 92 and TPhe (Landolt 1992) were observed at four different airmasses. This led to the determination of the photometry coefficients and zero-points. Those coefficients agree well with the indicative values displayed on the SuSI2 web page.

The aperture corrections were calculated as follows. Starting from one of the frames, we subtracted all stars except those used for determining the PSF with the daophot. substar procedure, using our preliminary DAOPHOT photometry and the corresponding PSF. This led to a frame with only a few bright, isolated stars plus residues from the subtraction. We then performed both aperture and PSF-fitting photometry on those stars, using the same aperture as for standard stars. The comparison led to aperture corrections of 0.02, 0.04, and 0.03 mag in *B*, *V*, and *R*, respectively.

During the photometry process, some slight discrepancies between the intensity of the frames were found: this effect was considered to be the consequence of episodic variations in the sky transparency by 7% at most. To avoid introducing a systematic underestimation of star magnitudes when averaging the frames, we decided to perform photometry on each individual frame.

¹ <http://iraf.noao.fr>

By cross-correlating the positions of the sources in the various photometry files, we obtained the mean magnitude (average of the 2 mag of each filter) and a decent estimator of the uncertainty in this magnitude (difference between maximum and minimum magnitudes). Finally, the process yielded the photometry of 644 stars for the LMC N191 field and 236 stars for that of SMC N77 in all three filters. This difference of the number of sources is partly due to the limit magnitude of the photometry (~ 21 mag for LMC N191, ~ 20 mag for SMC N77). It is better for LMC N191 than for SMC N77 because of the better sky conditions. The results for the brightest stars toward LMC N191 and SMC N77 are presented in Table 2. The whole photometry is available in electronic form.

2.2. NTT spectroscopy

The EMMI spectrograph (Dekker et al. 1986) attached to the ESO NTT telescope was used on 29 September 2002 to obtain several long-slit stellar spectra. The grating was # 12 centered on 4350 \AA (BLMRD mode) and the detector was a Tektronix CCD TK1034 with 1024^2 pixels of size $24 \mu\text{m}$. The covered wavelength range was 3810 – 4740 \AA and the dispersion 38 \AA mm^{-1} , giving FWHM resolutions of 2.70 ± 0.10 pixels or $2.48 \pm 0.13 \text{ \AA}$ for a $1''.0$ slit. At each position, we took three 10-min exposures. The instrument response was derived from observations of the calibration stars LTT 7379, LTT 6248, and LTT 7987. The seeing condition was $0''.8$ (FWHM). The identifications of the stars along the slits were based on monitor sketches drawn during the observations.

Furthermore, EMMI was used on 28 September 2002 to obtain nebular spectra with gratings # 8 (4550 – 6650 \AA) and # 13 (4200 – 8000) in the REMD mode and with grating # 4 (3650 – 5350 \AA) in the BLMD mode. In the REMD mode, the detector was CCD # 63, MIT/LL, 2048×4096 pixels of $15^2 \mu\text{m}^2$ each. Spectra were obtained with the slit set in east-west and north-south orientations using a basic exposure time of 300 s repeated several times. The seeing conditions varied around $0''.7$. Reduction and extraction of spectra were performed using the IRAF software package. Fluxes were derived from the extracted spectra with the IRAF task SPLOT. The line fluxes were measured by fitting Gaussian profiles to the lines as well as by simple pixel integration in some cases. The nebular line intensities were corrected for interstellar reddening using the formulae given by Howarth (1983) for the LMC extinction, which is very similar to that of the SMC in the visible. The intensities of the main nebular lines are presented in Table 4 where $F(\lambda)$ and $I(\lambda)$ represent observed and de-reddened line intensities. The uncertainties are indicated by capital letters: *A* < 10%, *B* = 10–20%, *C* = 20–30%, and *D* > 30%.

2.3. Archive Spitzer and 2MASS data

We used data obtained with the Infrared Array Camera (IRAC) on board the *Spitzer* Space Telescope to build composite images of LMC N191 and SMC N77 and also to carry out their photometry. The observations of the LMC were part of the SAGE-LMC survey (PI M. Meixner, PID = 20 203, see Meixner et al. 2006), while the SMC data belong to the S³MC project (PI A. Bolatto PID = 3316, see Bolatto et al. 2007).

The typical PSF of the IRAC images in the 3.6, 4.5, 5.8, and $8.0 \mu\text{m}$ bands is $1''.66$ to $1''.98$. The derived photometry for LMC N191 in the 3.6, 4.5, 5.8, and $8.0 \mu\text{m}$ bands are 10.50, 9.48, 8.03, and 6.47 mag (Charmandaris et al. 2008), respectively, using an

integration aperture of 3 pixels, or $3.6''$ in radius (Charmandaris et al. 2008). Using the same aperture the IRAC photometry for SMC N77 in the 3.6, 4.5, 5.8, and $8.0 \mu\text{m}$ bands are 13.86, 13.87, 12.65, and 10.64 mag (Charmandaris et al. 2008). Measurements with either slightly larger or smaller apertures do not affect the color results.

We also used the *JHK* photometry provided by the 2MASS point source catalog², as presented in Table 2. Note that the embedded stars in the H II region LMC N191A (i.e. #1, #2, #3, #4 and #5) are not resolved in 2MASS data, so the *JHK* photometry of the star N191-1 corresponds to the whole N191A compact H II region. The same is true for the *JHK* photometry of SMC N77-1, which corresponds to the whole N77A H II region.

3. Results

3.1. Overall view

The images taken with the NTT telescope (Sect. 2.1) have a whole area of $\sim 5' \times 5'$ corresponding to $\sim 73 \text{ pc} \times 73 \text{ pc}$ for a distance of $\sim 50 \text{ kpc}$ (LMC) or $\sim 90 \text{ pc} \times 90 \text{ pc}$ for a distance of $\sim 60 \text{ kpc}$ (SMC) (Laney & Stobie 1994).

The LMC N191 H II region (Henize 1956) consists of two components A and B in the optical, as displayed in Fig. 1. The brighter component A contains a compact H II region on which we focus here. Component B is comparatively very diffuse. The *Spitzer* observations show a richer nebulous region (Fig. 2) compared to the optical, the brightest object of which is the compact H II region N191A. The *Spitzer* observations also uncover two relatively bright, compact nebulae situated north of component A. These two objects correspond to star #13 (Table 2) and a young stellar object (YSO) candidate (Sect. 4). The component N191B is very weak or almost nonexistent in the *Spitzer* bands. It is crossed by a curl of gas emanating from the N191A region. The bright source, seen in the middle of the curl and called #14, has no noticeable optical counterpart. It is in fact an ‘‘extreme AGB star’’, as detected in the SAGE Survey and is cataloged as SSTISAGE1C J050426.95-705351.6 (Vijh et al. 2009).

The compact H II region N191A has a mean angular radius, $(\theta_\alpha, \theta_\delta)^{1/2}$, of $5''.2$ corresponding to a radius of 1.2 pc. Broad-band images in *B*, *V*, and *R* (Fig. 1, lower panel) reveal seven stars (#1 to #7) within less than $6''$ of the compact H II region, whose positions and photometry are listed in Table 2. We will show that the central star #1 is the exciting source of the H II region (see Sect. 2.4).

The SMC N77 field presents a different situation in the optical for the diffuse nebula. N77 is composed of two components A and B (Fig. 3). N77A contains two stars (#1 and #2) separated by only $1''.3$. This compact region of ionized gas appears as a sphere of radius $\sim 10''$ ($\sim 2.9 \text{ pc}$) split into two lobes by a dust lane that runs along an almost east-west direction. The two lobes intersect about $1''$ south of star #2. Stars #1 and #2 are situated in the northern lobe, which is brighter in the Balmer lines $H\alpha$ and $H\beta$ and also in the [O III] line. The $H\alpha$ image shows faint emission around star #4 (Fig. 3) situated $\sim 26''$ southwest of N77A. This nebula is known as N77B in the Henize catalog. The positions and photometry of stars #1 and #2 are listed in Table 2. The *Spitzer* observations (Fig. 4) display a curved structure focused on N77 in which the two lobes merge, but this is probably only because of low resolution. N77B is very dim in the *Spitzer* image. Figure 4 also indicates three YSO candidates that will be discussed in Sect. 4.

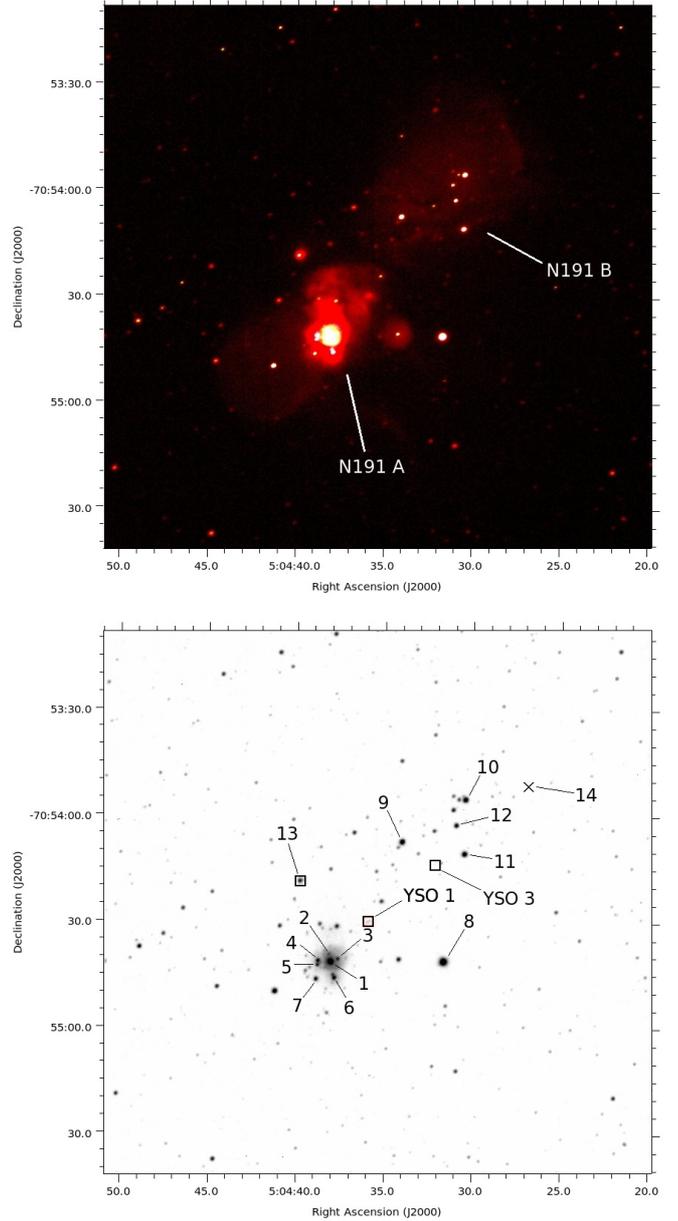


Fig. 1. Large Magellanic Cloud H II region N191. *Upper panel:* composite three-color image showing the two components A and B. The main component, N191A, is situated at $\alpha = 05^{\text{h}}04^{\text{m}}38^{\text{s}}$ and $\delta = -70^{\circ}54'41''$. This image, taken with the ESO NTT/SuSI2, is a coaddition of narrow-band filters $H\alpha$ (red), [O III] (green), and $H\beta$ (blue). The field size, $153'' \times 153''$ ($\sim 37 \times 37 \text{ pc}$), is a close up of an original image covering a field of $319'' \times 327''$ ($78 \times 79 \text{ pc}$). North is up and east to the left. *Lower panel:* the same field through the broad-band filter *V*. The brightest stars of the field and the young stellar object candidates are labeled (Tables 2 and 3).

3.2. Extinction

The map of the $H\alpha/H\beta$ Balmer decrement confirms that the H II region LMC N191 is heavily affected by interstellar dust. The $H\alpha/H\beta$ ratio is on average 7.0 ($A_V = 2.7 \text{ mag}$) and up to 10.0 ($A_V = 3.8 \text{ mag}$) in the most extinguished area. The extinction toward star #1 can be derived from a second method. O-type stars have an intrinsic color of $B - V = -0.28 \text{ mag}$ (Martins & Plez 2006). This yields a color excess of $E(B - V) = 0.39 \text{ mag}$ or a visual extinction of $A_V = 1.2 \text{ mag}$. This value is lower

² <http://tdc-www.harvard.edu/catalogs/tmpsc.html>

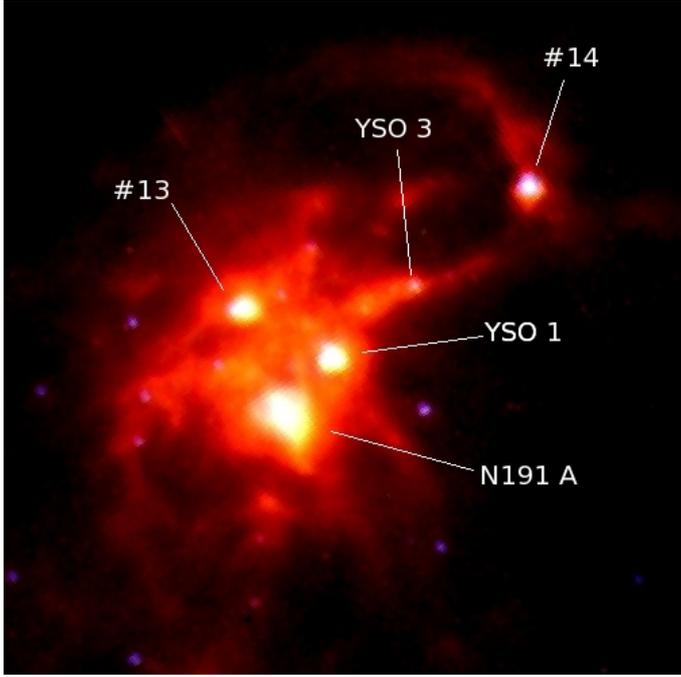


Fig. 2. Composite image of the LMC N191 region obtained with *Spitzer* IRAC. The $4.5\ \mu\text{m}$ band is represented in blue, the $5.8\ \mu\text{m}$ band in yellow, and the $8.0\ \mu\text{m}$ band in red. The field size and orientation are the same as for Fig. 1.

than the result from the Balmer decrement because the central regions of the H II region are less affected by extinction. The dust has been more dispersed along the line of sight of star #1. Moreover, the extinction toward LMC N191 was estimated by a third method using radio continuum observations. N191 appears as the source B0505-7058 in the Parkes radio continuum survey at 2.45, 4.75 and 8.55 GHz, which had beam-sizes of $8''.85$, $4''.8$ and $2''.7$, respectively (Filipović et al. 1995). The resulting extinction, $A_V = 2.4$ mag, is comparable with that obtained using the previously mentioned methods in the optical range.

The average value of the Balmer decrement toward the H II region SMC N77 is about 3.1, corresponding to $A_V = 0.25$ mag. The most extinguished part of the H II region is its western border, along the dust lane (see Sect. 3.1), where the $H\alpha/H\beta$ ratio reaches a value of 4.5 ($A_V = 1.4$ mag). We also derived the extinction from the radio observations of SMC N77. High-resolution observations of this object were obtained by Filipović et al. (2002), who used the Australia Telescope Compact Array (ATCA) in radio continuum emission at 1.42, 2.37, 4.80 and 8.64 GHz with synthesized beams of $98''$, $40''$, $30''$ and $15''$, respectively. The resulting extinction, $A_V = 0.56$ mag, is comparable with that inferred using the Balmer decrement.

3.3. Nebular emission

The total $H\beta$ fluxes of the compact H II regions LMC N191 and SMC N77 were derived using the following method. First we calculated the relative $H\beta$ flux in an imaginary $1''$ slit passing through the $H\beta$ image with respect to the total flux emitted by the whole H II region. This value was then compared with the absolute flux obtained from the spectra. The total $H\beta$ flux thus obtained for N191 was $F(H\beta) = 1.52 \times 10^{-12}$ erg cm $^{-2}$ s $^{-1}$. Studies of the extinction in the LMC and the SMC reveal reddening laws that are similar to the average Galactic law for the optical and

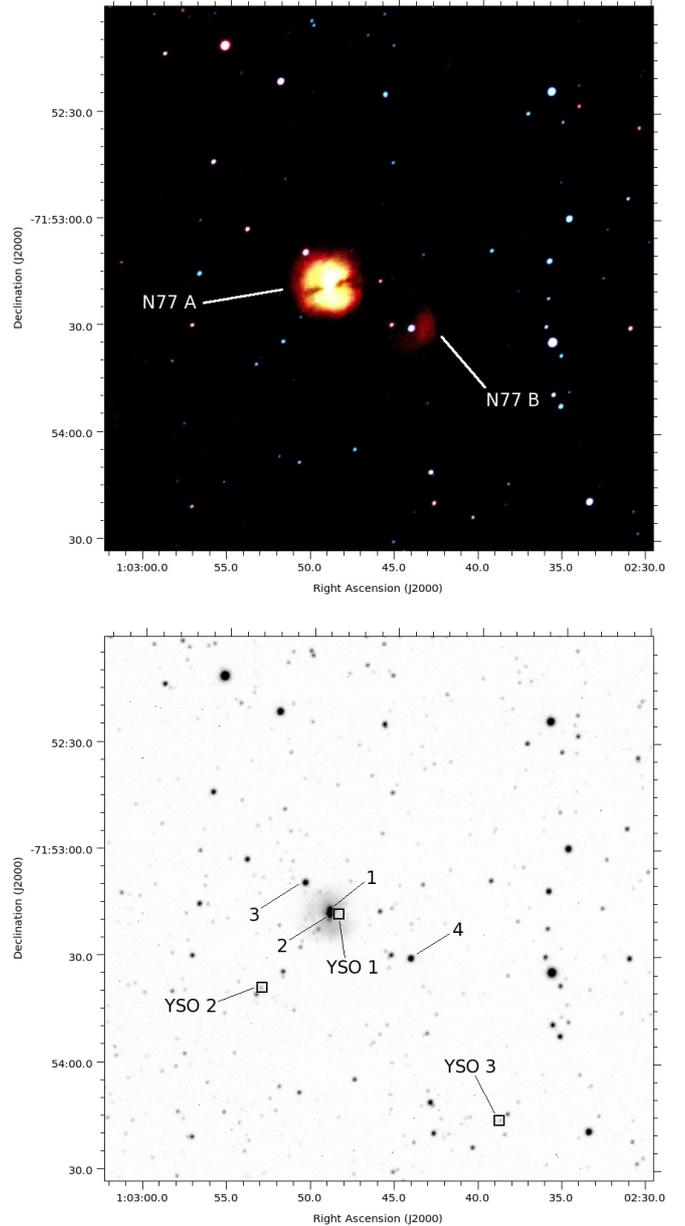


Fig. 3. Small Magellanic Cloud H II region N77. *Upper panel:* a composite three-color image showing the two components A and B. The main component, N77A, is situated at $\alpha = 01^{\text{h}}02^{\text{m}}49^{\text{s}}$ and $\delta = -71^{\circ}53'18''$. This image, taken with the ESO NTT/SuSI2, is the coaddition of narrow-band filters $H\alpha$ (red), $[O\text{III}]$ (green), and $H\beta$ (blue). The field size $153'' \times 153''$ ($\sim 45 \times 45$ pc), is a close up of an original image covering a field of $319'' \times 327''$ (93×95 pc). North is up and east to the left. *Lower panel:* the same field through the broadband filter V. The brightest stars of the field and the young stellar object candidates are labeled (Tables 2 and 3).

near-IR wavelengths (Howarth 1983; Prévot et al. 1984; Bouchet et al. 1985). The reddening coefficient, derived from the mean $H\alpha/H\beta$ ratio of 7, was $c(H\beta) = 1.26$. Considering the extinction law for the LMC (Howarth 1983), we computed the reddening corrected intensity $I(H\beta) = 2.77 \times 10^{-11}$ erg cm $^{-2}$ s $^{-1}$.

This flux corresponds to a Lyman continuum flux of 1.78×10^{49} photons s $^{-1}$ for the star, assuming that the H II region is ionization-bounded. The exciting star needed to provide this flux should have an effective temperature of $\sim 41\,000$ K,

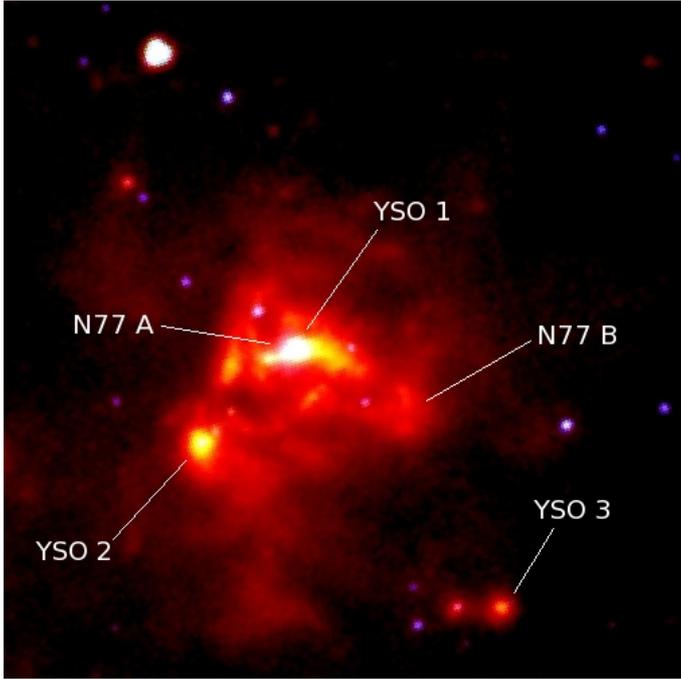


Fig. 4. Composite image of the SMC N77 region obtained with *Spitzer* IRAC. The $4.5 \mu\text{m}$ band is represented in blue, the $5.8 \mu\text{m}$ band in yellow, and the $8.0 \mu\text{m}$ band in red. The field size is the same as for Fig. 3. North is up and east to the left.

corresponding to a spectral type about O5 V, for Galactic metallicity (Martins et al. 2005). However, this flux is probably underestimated since the H II region is likely not completely ionization-bounded.

Similarly, the total H β flux obtained for N77 was $F(\text{H}\beta) = 2.03 \times 10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$. Considering the extinction law for the LMC (Howarth 1983), the corrected flux was $I(\text{H}\beta) = 2.61 \times 10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$ with the reddening coefficient $c(\text{H}\beta) = 0.11$. This flux value corresponds to a Lyman continuum flux of $2.4 \times 10^{48} \text{ photons s}^{-1}$ for the star. The exciting star needed is of spectral type about O8 V, for Galactic metallicity (Martins et al. 2005). This may be a lower limit, however, because of photon loss in a density-bounded H II region.

Several of the derived physical parameters of the compact H II regions are summarized in Table 1. The mean angular radius of the H II region, corresponding to the FWHM of cross-cuts through the H α image, is given in Col. 2. The corresponding physical radius, obtained using distance moduli of $m - M = 18.53 \text{ mag}$ for LMC N191 and $m - M = 18.94 \text{ mag}$ for SMC N77 (Laney & Stobie 1994) is presented in Col. 3. The reddening coefficient, derived from the mean H α /H β ratio, is listed in Col. 4. It corresponds to the whole H II region. It is different from the value found from the nebular spectrum (Table 4) because, in contrast, the spectrum belongs to a particular position and therefore does not cover the whole region. The de-reddened H β flux obtained from the reddening coefficient is given in Col. 5 and the corresponding H β luminosity in Col. 6. The electron temperature is given in Col. 7. For N77A the electron temperature is calculated from the forbidden-line ratio [O III] $\lambda\lambda 4363/(4959 + 5007)$, with an uncertainty of 4%. For N191A, the [O III] $\lambda 4363$ is not observed in our spectra so we used the electron temperature calculated from the forbidden-line ratio [O II] $\lambda\lambda (3726 + 3729)/(7323 + 7330)$, with an uncertainty of 10%, higher than the estimate from the [O III] ratio. The

electron density, estimated from the ratio of the [S II] doublet $\lambda\lambda 6717/6731$, is presented in Col. 8. It is accurate to $\sim 80\%$. It is well-known that the [S II] lines characterize the low-density peripheral zones of H II regions. Column 7 gives the rms electron density, $\langle n_e \rangle$, calculated from the H β flux, the radius, and the electron temperature, T_e , assuming that the H II region is an ionization-bounded Strömngren sphere. Furthermore, the total mass of the ionized gas, calculated from the $\langle n_e \rangle$ with the previously noted Strömngren sphere assumption is presented in Col. 9. The ionization is produced by Lyman continuum photon flux given in Col. 10.

3.4. Stellar content

3.4.1. LMC N191

The images show some 15 relatively bright stars lying within $10''$ of N191A. The brightest component of this group, star #1, has $V = 14.46 \text{ mag}$ and it is followed by stars #6 and #4 with $V = 16.28$ and 16.60 mag , respectively. Assuming an intrinsic color of $B - V = -0.28 \text{ mag}$ for O-type stars (Martins & Plez 2006) and a distance modulus of 18.53 mag , the absolute magnitude of star #1 is $M_V = -5.27 \text{ mag}$. Following the calibration of Martins et al. (2005) for Galactic stars, if the star is on the main sequence, it would be of a spectral type O5 V with a mass of $40 M_\odot$. This agrees well with what was found based on the stellar Lyman continuum derived from the H β emission of the H II region (see Sect. 3.3).

We obtained spectra of two stars of the N191 region in our program of stellar spectroscopy (Sect. 2.2), in particular star #1, for the first time. However, in spite of the relatively good seeing conditions, extracting uncontaminated spectra is not straightforward. The compact H II region has strong emission lines, in particular those of He I, that fill in the absorption lines of the embedded stars. Nevertheless, we classified #N191-1 as O8.5 V with a good accuracy (Fig. 6). The spectral classification was performed using the criteria stated by Walborn & Fitzpatrick (1990). This is colder than indirect estimates and more uncertain (absolute magnitude and stellar Lyman continuum). However, we cannot exclude that the spectrum of N191A-1 is not contaminated by unresolved close companions of later type than star #1. See Sect. 4 for discussion.

The spectrum of star #N191-8, the brightest object of the field, with $V = 13.79 \text{ mag}$, lying $\sim 30''$ west of star #1, outside N191A, is also presented in Fig. 6. Using the same classification criteria (Walborn & Fitzpatrick 1990), we can assign spectral type B0 to this star. The spectrum does not allow one to conclude firmly on the luminosity class because the B-type luminosity criteria are not sufficiently apparent here. Taking into account an extinction of $A_V = 1.2 \text{ mag}$, the absolute magnitude of this star is $M_V = -5.98 \text{ mag}$. This determination points to a supergiant Ib (Fitzpatrick & Garmany 1990). Therefore star #N191-8 likely provides a part of the ionizing photons that power the compact H II region. See below for more details about the evolutionary stage of this star.

The color–magnitude diagram of the star population in the entire NTT field of $319'' \times 327''$ ($\sim 78 \times 79 \text{ pc}$) for a cut-off magnitude of $V = 21$ is presented in Fig. 5. Three isochrones with ages 3 Myr, 8 Myr, and 1 Gyr, for a metallicity of $Z = 0.008$ (Lejeune & Schaerer 2001), are also overplotted. The diagram displays two principal groups: an apparent main sequence centered on $B - V \sim 0.1 \text{ mag}$ and an evolved population centered on $B - V \sim 1 \text{ mag}$.

Table 1. Some physical parameters of the compact H II regions SMC N77 and LMC N191.

Object	θ (")	r (pc)	$c(\text{H}\beta)$	$I(\text{H}\beta)$ $\text{erg s}^{-1} \text{cm}^{-2}$ $\times 10^{-12}$	$L(\text{H}\beta)$ erg s^{-1} $\times 10^{36}$	T_e (K)	Ne^{\dagger} cm^{-3}	$\langle n_e \rangle$ cm^{-3}	M_{gas} (M_{\odot})	N_L ph s^{-1} $\times 10^{48}$
LMC N191A	5.2	1.2	1.26	27.7	8.3	10 800	440	600	140	17.8
SMC N77A	10	2.9	0.11	2.6	1.1	14 240	40	60	200	2.4

Notes. ^(†) Estimated from the [S II] ratio.

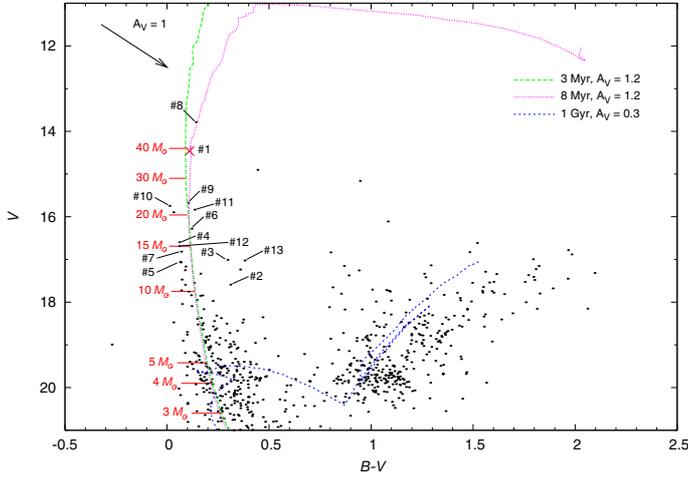


Fig. 5. Color–magnitude V versus $B - V$ diagram for stars observed toward LMC N191. Three isochrones are shown, 3 Myr ($A_V = 0.9$ mag, green dashed curve), 8 Myr ($A_V = 1.2$ mag, violet dotted curve) and 1 Gyr ($A_V = 0.3$ mag, blue thick dashed curve), computed for a metallicity of $Z = 0.008$ (Lejeune & Schaerer 2001) and a distance modulus of 18.53 mag. The red cross indicates the location of the main exciting star of N191A. The numbers refer to the stars listed in Table 2.

Star #1, indicated by a cross, is affected by an extinction of $A_V = 1.2$ mag therefore it seems reddened compared to the 3 Myr isochrone. Accordingly, star #1 appears to be the most massive young star of the field. The stars lying across the H II region N191 are concentrated along the main sequence. They are intermediate-mass stars of $\sim 10\text{--}15 M_{\odot}$ assuming that they are on the 3 Myr isochrone.

Star #8, which we described above, is apparently related to the 8 Myr isochrone. This means that star #8 is probably older than the exciting star of the compact H II region. The fact that no noticeable surrounding ionized region is associated with star #8 is compatible with this deduction. An initial mass of $22 M_{\odot}$ can be derived for this evolved B-type star.

The second group of stars on the diagram are evolved stars between $B - V = 0.8$ and 1.6 mag. They have a possible age ranging from 1 Gyr to 10 Gyr. It is very likely that this latter population is not physically associated with N191.

3.4.2. SMC N77A

The stellar environment of N77 is totally different from that of N191. The images reveal only two stars embedded in the blob. These two stars have similar visual magnitudes ($V = 17.35$ and 17.57 mag), and are fainter than the main N191 stars. Assuming that O-type stars have an intrinsic color of $B - V = -0.28$ mag (Martins & Plez 2006) ($A_V = 2.1$ mag) and a distance modulus of 18.94 mag, the absolute magnitude of star #1

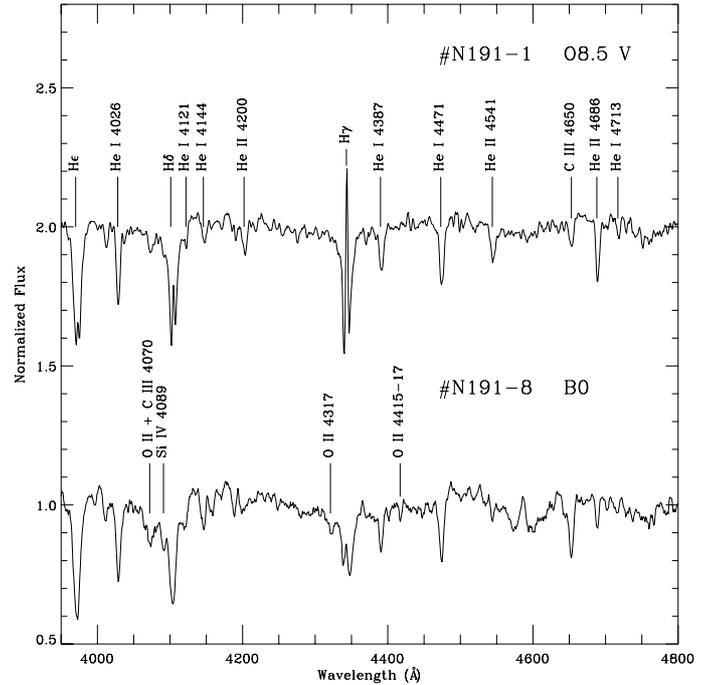


Fig. 6. Spectra of two stars observed toward LMC N191. Star #1 is the exciting source of the compact H II region N191A. Note the He II absorption lines indicating a hot massive star O8.5 V. Star #N191-8, lying in the field of N191, is classified as B0.

is $M_V = -3.69$ mag. It is too faint to be an O star (Martins et al. 2005) unless the extinction is underestimated.

Figure 7 displays the spectrum of star #1, or more precisely the spectrum of stars #1 and #2. Indeed, the two stars are too close to obtain separate spectra. Nevertheless, the He II absorption line at $\lambda 4686$ is certainly present, while in contrast He II $\lambda 4541$ is not observed. These features indicate that N77-1 is an early-type B star. This agrees with the estimate of the absolute magnitude. However, it is significantly colder than the spectral type inferred from the $H\beta$ flux measurement (see Sects. 3.3 and 4).

3.5. Chemical abundances

Table 4 lists the main lines of the nebular spectra of N191 and N77. The ionic abundances with respect to H^+ were calculated from nebular lines using the IRAF task ionic of the package NEBULAR (Shaw & Dufour 1995). The abundance values are listed in Table 5.

To derive the total abundances of a given element, it is necessary to estimate the amount of the element in ionization states not observed in our spectra. We therefore used a set of ionization-correction factors (ICFs) to convert into elemental abundances. The absence of the nebular He II line indicates that

Table 2. Positions and photometry of the main stars in the fields of LMC N191 and SMC N77.

Galaxy	Star ID	α (J2000)	δ (J2000)	V	$B - V$	$V - R$	J	H	K	Spectral type	H II region component	
LMC	N191-1	05:04:38.12	-70:54:41.28	14.46	0.11	-0.01	13.29	13.33	12.05	O8.5 V	A	
	N191-2	05:04:38.23	-70:54:39.05	17.59	0.31	0.43					A	
	N191-3	05:04:37.72	-70:54:40.50	17.01	0.30	0.19					A	
	N191-4	05:04:38.84	-70:54:40.95	16.60	0.06	0.14					A	
	N191-5	05:04:38.86	-70:54:42.11	17.06	0.06	0.17					A	
	N191-6	05:04:37.92	-70:54:45.78	16.28	0.12	0.16	14.37	14.11	12.36		A	
	N191-7	05:04:38.96	-70:54:46.16	16.82	0.07	-0.08					A	
	N191-8	05:04:31.71	-70:54:41.06	13.79	0.14	0.04	13.16	13.06	12.91		B0	A
	N191-9	05:04:34.08	-70:54:07.21	15.67	0.10	-0.04	15.35	15.15	15.02			B
	N191-10	05:04:30.49	-70:53:55.11	15.74	0.01	-0.11	15.53	15.78	15.28			B
	N191-11	05:04:30.53	-70:54:10.51	15.83	0.13	0.03	15.32	15.18	14.88		B	
	N191-12	05:04:31.00	-70:54:02.42	16.69	0.06	-0.11					B	
	N191-13	05:04:39.85	-70:54:19.00	17.02	0.38	0.38	15.00	14.45	13.71			
	N191-14	05:04:26.97	-70:53:51.71				16.34	14.01	12.44	AGB star		
SMC	N77-1	01:02:48.98	-71:53:16.58	17.35	0.40	-0.23	14.75	14.51	14.03	early B	A	
	N77-2	01:02:49.04	-71:53:17.69	17.57	0.30	0.23					A	
	N77-3	01:02:50.46	-71:53:09.10	17.01	1.53	0.23	14.13	13.51	13.45	G0 V (Galactic)		
	N77-4	01:02:44.12	-71:53:30.30	17.06	0.29	-0.38	16.38	16.02	14.98		B	

Notes. The BVR photometry results from the NTT observations while the JHK measures are taken from the 2MASS catalog.

Table 3. Positions and photometry of the YSO candidates in the fields of LMC N191 and SMC N77.

Field	YSO ID	Star ID	α (J2000)	δ (J2000)	J	H	K	[3.6]	[4.5]	[5.8]	[8.0]	[24.0]
LMC N191	YSO 1		05:04:35.85	-70:54:30.1	15.75	14.73	13.33	10.48	9.54	8.09	6.56	1.83
	YSO 2	N191-13	05:04:39.85	-70:54:19.0	15.00	14.45	13.71	11.28	10.57	8.68	6.95	0.85
	YSO 3		05:04:32.19	-70:54:14.0				13.32	12.73	10.95	9.34	4.84
SMC N77	YSO 1		01:02:48.54	-71:53:18.0				13.04	12.09	10.42	8.93	3.55
	YSO 2		01:02:53.13	-71:53:39.2	16.42	16.02	15.51	13.80	13.89	10.87	9.19	4.59
	YSO 3		01:02:38.81	-71:54:15.9				14.89		12.83	11.17	8.46

Notes. The JHK measures are taken from the 2MASS catalog. IRAC and MIPS photometry come from Bolatto et al. (2007) for the SMC field and from Gruendl & Chu (2009) for the LMC field.

$\text{He}^{2+}/\text{H}^+$ is negligible. Moreover, we assume that neutral helium is not important. Thus we assumed that the total He/H ratio is just equal to He^+/H^+ . The total abundance of oxygen was adopted to be the sum of the O^+ and O^{2+} abundances. The absence of He II recombination lines in our spectra and the similarity between the ionization potentials of He^+ and O^{++} implies that the contribution of O^{3+} is not significant. To obtain the total abundance of nitrogen, we used the usual ICF based on the similarity between the ionization potential of N^+ and O^+ (Peimbert & Costero 1969). The N^+ abundance does not depend strongly on the electron temperature. The largest errors come from the uncertainty in the $\lambda\lambda 6548$ and 6584 line intensities. Our N result is accurate to within about 30%. The only measurable lines in the optical range for Ne are those of Ne^{2+} but the amount of Ne^+ may be significant in the region. We adopted the usual expression of the ionization correction factor of Ne that assumes that the ionization structure of Ne is similar to that of O (Peimbert & Costero 1969).

The total chemical abundances for N191 and N77 are presented in Table 6. The most accurately estimated abundances belong to He and O, which are accurate to within 15% and 20%, respectively. Table 6 also presents the mean abundance values derived for the SMC and the LMC (Russell & Dopita 1992). The N77 abundances agree well with the SMC mean values. For N191, the He abundance is quite low compared with the LMC mean value. The strong stellar He I absorption lines could have contaminated the nebular spectra of the H II region. The

abundance of O, N and Ne are lower than the LMC mean value but this can be explained by uncertainties and also by the fact that N191 is more metal-poor than the LMC because of its external position.

4. Discussion

The two H II regions studied in this paper, LMC N191A and SMC N77A, belong to the class of compact H II regions, which are regions of newly formed massive stars in the Magellanic Clouds. Their sizes (~ 5 to $10''$) are much smaller than those of typical H II regions in the Magellanic Clouds (several arc minutes). They are also associated with a much smaller number of exciting stars. With an $[\text{O III}](\lambda\lambda 4959 + 5007)/\text{H}\beta$ ratio of ~ 2 and an $\text{H}\beta$ luminosity of $8.3 \times 10^{36} \text{ erg s}^{-1}$, LMC N191A is a low-excitation blobs (LEBs), as defined by Meynadier & Heydari-Malayeri (2007). At the same $\text{H}\beta$ luminosity, LEBs have lower excitation than HEBs and are powered by less massive exciting stars. In contrast, SMC N77A conforms more to the defining criteria of high-excitation blobs (HEBs), because it has an $[\text{O III}]/\text{H}\beta$ ratio of ~ 4 and an $\text{H}\beta$ luminosity of $1.1 \times 10^{36} \text{ erg s}^{-1}$. Nevertheless, with a diameter of $\sim 20''$, N77A is more extended than a typical HEB. Compared with N191A, N77A is more than a factor of two larger, about 40% more massive, but less dense and less extincted (Table 1).

N191 is situated outside of the main body of the LMC, at a large distance (3 kpc) from the major star-forming region

Table 4. Nebular line intensities of the compact H II region LMC N191A and SMC N77A.

λ (Å)	Iden.	LMC N191A			SMC N77A		
		$F(\lambda)^\dagger$	$I(\lambda)^\dagger$	Accuracy [‡]	$F(\lambda)^\dagger$	$I(\lambda)^\dagger$	Accuracy [‡]
3727, 29	[O II]	279.8	344.0	A	189.8	229.4	A
3797	H10	2.7	3.3	B	3.9	4.6	B
3835	H9	3.6	4.3	B	5.6	6.6	B
3869	[Ne III]	2.1	2.5	C	12.7	14.9	A
3889, 90	He I + H8	9.9	11.7	A	13.6	15.9	A
3968, 70	[Ne III] + H ϵ	9.7	11.3	A	14.5	16.7	A
4071	[S II]	1.2	1.4	D			
4101	H δ	39.1	44.3	A	19.0	21.3	A
4144	He I	1.3	1.5	D			
4340	H γ	34.6	37.5	A	40.3	43.4	A
4363	[O III]				4.8	5.1	B
4471	He I				4.3	4.5	C
4861	H β	100.0	100.0	A	100	100	A
4959	[O III]	49.7	49.1	A	104.6	103.4	A
5007	[O III]	147.4	144.6	A	300.2	295.0	A
5577	[O I]	20.2	18.6	A	45.2	41.9	A
5876	He I	10.5	9.4	B	11.1	10.0	B
6300	[O I]	9.8	8.5	C	73.8	64.5	A
6312	[S III]	1.2	1.0	C	2.0	1.7	C
6363	[O I]	3.1	2.7	D	23.4	20.4	A
6548	[N II]	13.2	11.2	C	10.1	8.7	C
6563	H α	340.0	286.0	A	335.7	286	A
6584	[N II]	37.9	32.0	B	11.6	9.9	B
6678	He I	2.7	2.3	B	3.2	2.7	B
6716	[S II]	17.2	14.4	B	15.8	13.4	B
6731	[S II]	15.9	13.3	B	11.6	9.9	B
7065	He I	2.4	2.0	C	2.8	2.3	C
7135	[Ar III]	8.7	7.1	B	9.2	7.6	B
7236	[Ar IV]	1.9	1.5	D	14.2	11.7	B
7323	[O II]	12.9	10.3	C	22.0	18.0	C
7751	[Ar III]	3.9	3.0	C	16.2	12.9	B
c(H β) =		0.24			0.22		

Notes. ^(†) $F(\lambda)$ and $I(\lambda)$ represent observed and de-reddened line intensities relative to H β . ^(‡) The capital letters represent the following uncertainties: A < 10%, B = 10–20%, C = 20–30%, and D > 30%.

Table 5. Nebular ionic abundances.

Ion	LMC N191	SMC N77
He ⁺ /H ⁺	0.070	0.079
O ⁺ /H ⁺ ($\times 10^5$)	14.9	6.76
O ⁺⁺ /H ⁺ ($\times 10^5$)	5.10	3.63
N ⁺ /H ⁺ ($\times 10^6$)	6.4	2.5
Ne ⁺⁺ /H ⁺ ($\times 10^6$)	2.77	4.75
S ⁺ /H ⁺ ($\times 10^7$)	6.86	5.33
Ar ⁺⁺ /H ⁺ ($\times 10^7$)	6.54	3.36

30 Dor. Among the southernmost H II region of LMC only N214 (Meynadier et al. 2005, and references therein) and N206 (Romita et al. 2010, and references therein) have been investigated in detail. In comparison with these two complexes, N191 is a smaller region with a fainter emission nebula. It is also linked to an OB association, LH 23 (Lucke & Hodge 1970), and a giant molecular cloud, 54×14 pc in size with a CO mass of $2 \times 10^5 M_\odot$ (Fukui et al. 2008). N77 is the northernmost H II region of the SMC so far studied in detail. It lies some 440 pc north of N66, the main star-forming region in the

SMC (Heydari-Malayeri & Selier 2010, and references therein). N77 is associated with a small molecular cloud (Mizuno et al. 2001) and a small OB association, B-OB 24 (Battinelli 1991).

An accurate characterization of the exciting source of each of these two compact H II regions requires a more detailed investigation. There is indeed a discrepancy between the spectral type indicated by the spectra and that derived from H β flux estimates. The spectrum obtained toward star #1 in LMC N191A belongs to an O8.5 V type (Sect. 3.4). In contrast, the H β flux indicates an earlier O5 V type (Sect. 3.3). The same is true for SMC N77A. The spectral classification indicates an early B type star (Sect. 3.4), whereas the H β luminosity suggests an O8 V type at least (Sect. 3.3). This discrepancy can be accounted for by the presence of hotter stars embedded in the H II regions. This assumption is in line with the indication of the $(V, B - V)$ color–magnitude diagram (Fig. 5) that is a $40 M_\odot$ star of 3 Myr old for the main exciting source of N191A. For N77A, we detected the nebular [O III] line $\lambda 4363$, which needs a much earlier exciting star than a B type. We note, however, that this line is not reported in the paper by Russell & Dopita (1990). Still, high-resolution observations in near-IR are necessary to check the possibility of embedded sources. Another explanation is that the spectral type is underestimated because of contamination from

Table 6. Elemental abundances.

Element	SMC N77	Mean SMC [‡]	LMC N191	Mean LMC [‡]
He/H	0.079	0.081	0.070	0.089
O/H ($\times 10^4$)	1.04	1.07	2.0	2.24
N/H ($\times 10^6$)	3.85	4.27	8.58	13.8
Ne/H ($\times 10^5$)	1.34	1.86	1.09	4.07

Notes. See Sect. 3.5 for uncertainties. ^(‡) Russell & Dopita (1992).

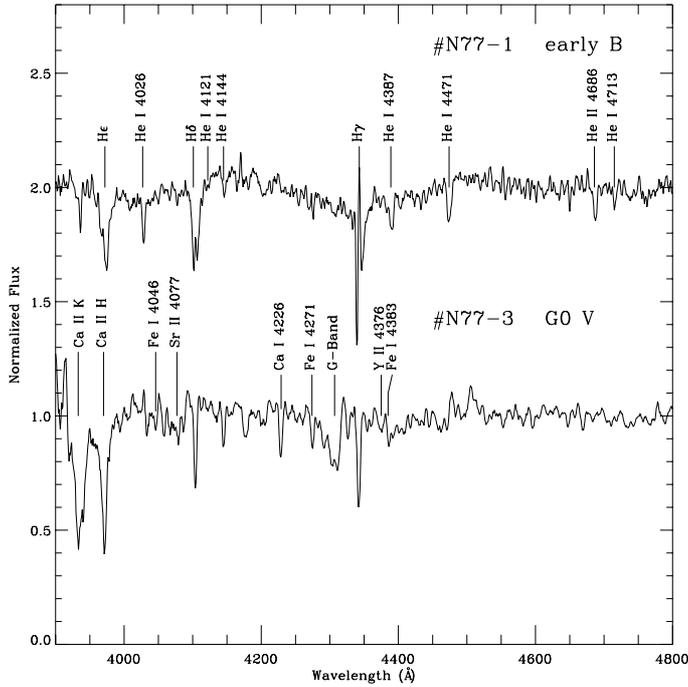


Fig. 7. Spectrograms of two stars observed toward SMC N77A. Star #1, an early B-type star, is the exciting source of the compact H II region N77A. Star #3 is classified as a Galactic star G0 V.

nebular emission lines. However, justifying a three-subtype uncertainty seems difficult.

The difference between the excitation degrees of LMC N191A and SMC N77A, as mentioned above, can be commented upon from another viewpoint: the $[O III]/H\beta$ ratio is higher in N77A (~ 4) compared to that in N191 (~ 2), even if the latter is denser. According to models for homogeneous H II regions (e.g., Stasińska 1990) the $[O III]/H\beta$ ratio is proportional to the electron density for a given exciting source. This means that we expect a lower ratio for N77A if the exciting sources have comparable effective temperatures. The higher $[O III]/H\beta$ ratio in N77A would suggest a hotter star than in N191A. Alternatively, the weak ratio of N191A may be due to the density structure of N191A. The aforementioned models predict that a density rise in the outer zones of an H II region results in a decrease of the global $[O III]/H\beta$ ratio. Otherwise the higher $[O III]/H\beta$ ratio of N77A may reflect the difference of metallicity between the LMC and SMC. In low-metallicity environments, the inefficiency of cooling raises the electron temperature so that forbidden oxygen lines become stronger despite the lower abundance. These assumptions may explain the apparent discrepancy between the higher $[O III]/H\beta$ ratio of N77A and the cooler ionizing star inferred from our study.

Three young stellar object (YSO) candidates detected by Gruendl & Chu (2009) lie toward N191A. Similarly, there are

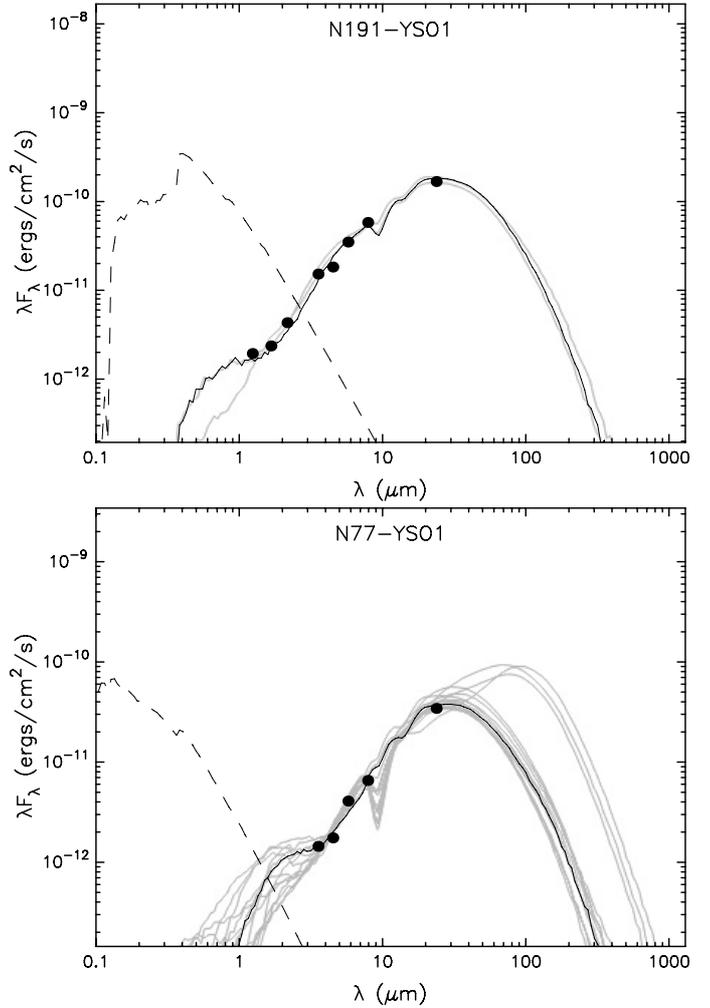


Fig. 8. Mid-IR *Spitzer* photometry of two YSOs fitted using YSO models (Robitaille et al. 2007). The filled circles represent the input fluxes. The black curve shows the best fit, while the gray curves display subsequent good fits. The dashed curve shows the stellar photosphere corresponding to the central source of the best-fitting model, as it would look in the absence of circumstellar dust (but including interstellar extinction). *Upper panel:* SED fit of N191-YSO1. The stellar mass according to these models varies between 16 and 21 M_{\odot} . The best fit is for a 20 M_{\odot} protostar with a derived total luminosity of $2.9 \times 10^4 L_{\odot}$. *Lower panel:* SED fit of N77-YSO1. The stellar mass according to these models varies between 10 and 17 M_{\odot} . Note that the lack of *JHK* photometry leads to a wider range of selected models. The best fit is for a 10 M_{\odot} protostar with a derived total luminosity of $1.0 \times 10^4 L_{\odot}$.

three such candidates detected in the N77 field (Bolatto et al. 2007). They are indicated in Figs. 1 and 3 (lower panels) and Figs. 2 and 4, respectively. Their coordinates are listed in Table 3. The N191 candidates lack an optical counterpart except for

object #13. The closest candidate to N191A, named 050435.85-705430.1 (or N191-YSO1 in the present paper), lies about $15''$ (3.6 pc) northwest of the exciting star #1. The *JHK* and *Spitzer* IRAC and MIPS colors of these objects are listed in Table 3. Two of the N77 candidates (YSO2 and YSO3) seem very close to two relatively bright field stars, which raises the question of their association. However, astrometrically speaking, these stars and the YSO candidates are not associated. It seems that these YSO candidates have very faint optical counterparts below our detection limits.

A comprehensive search for YSOs in the LMC has also been carried out by the SAGE team and was reported by Whitney et al. (2008). They have found only one YSO in the vicinity of N191A that corresponds to the closest candidate of Gruendl & Chu (2009). This difference is due to the different selection criteria, based on IRAC colors, used in different works. Gruendl & Chu (2009) argue that there are no simple criteria in color-magnitude space that can unambiguously separate the YSOs from AGB/post-AGB stars, planetary nebulae, and background galaxies. Moreover, the point source definition differs in the two approaches. Gruendl & Chu (2009) include slightly extended sources that are likely YSOs superimposed on a bright background. In contrast, because the SAGE definition is more constraining, it excludes such cases.

To be more specific, here we applied the selection diagrams used by Simon et al. (2007) to look into the nature of the YSO candidates. These authors used color-color diagrams $[3.6]-[4.5]$ versus $[5.8]-[8.0]$ and $[3.6]-[4.5]$ versus $[4.5]-[8.0]$ to characterize the candidate YSOs they have detected toward the SMC H II region NGC 346 (N66). We note that on the $[3.6]-[4.5]$ versus $[5.8]-[8.0]$ plot two of the YSO candidates have colors near to those of YSOs. These are N191-YSO3 and N77-YSO1. The other candidates show colors of “probable YSOs” or “poor fits/PAHs”. Note that the $[3.6]-[4.5]$ versus $[5.8]-[8.0]$ plot does not clearly separate YSOs from other types of sources, particularly stars with modest IR excesses and sources with PAH contamination (Simon et al. 2007). We also used the $[3.6]-[4.5]$ versus $[4.5]-[8.0]$ plot, which takes advantage of longer color baselines and the abrupt change in YSO spectra between the 4.5 and $5.8 \mu\text{m}$ bands, to distinguish YSOs from stars, galaxies, and PAH. However, on this plot all YSO candidates are offset with respect to the expected YSO positions, since they are redder, i.e. with higher $[4.5]-[8.0]$ color values, compared to YSOs.

A spectral energy distribution (SED) analysis provides a more efficient method for investigating the nature of YSOs. We used the *Spitzer* photometry to construct the mid-IR SEDs of our YSO candidates. We fitted these SEDs with the library of YSO models by Robitaille et al. (2006) using the online SED fitting tool provided by these authors (Robitaille et al. 2007)³. The SED plots of the brightest YSO candidates toward N191 and N77 are displayed in Fig. 8, N191-YSO1 is best fitted by models of 16 to $21 M_{\odot}$. The best fit suggests a $20 M_{\odot}$ protostar with a total luminosity of $2.9 \times 10^4 L_{\odot}$. With regard to N77-YSO1, the best models belong to masses ranging from 10 to $17 M_{\odot}$. The best fit is for a $10 M_{\odot}$ protostar with a total luminosity of $1.0 \times 10^4 L_{\odot}$. The majority of the best-fit YSO models include both circumstellar envelopes and disks. Moreover, in these models the accretion rate from the envelope onto the YSO indicates the evolutionary stage of the protostar (Robitaille et al. 2006). Based on the high accretion rates, 1×10^{-4} and $5 \times 10^{-5} M_{\odot} \text{ yr}^{-1}$ for N191-YSO1 and N77-YSO1, respectively, both objects can

be classified as Stage I sources (Robitaille et al. 2006). This classification is equivalent to the traditional Class I source. It should, however, be cautioned that these models are based on low-mass star formation scenarios, whereas we do not know how massive stars actually form. Therefore, massive YSOs may contrast in their properties with commonly studied low-mass YSOs, in particular in low-metallicity environments such as the Magellanic Clouds. However, the use of these models must be considered as a first approach and preliminary screening of the problem.

The two brightest YSO candidates are also the most closely adjacent objects to their respective H II regions. More specifically, N191 YSO1 lies $15''$ northwest of star #1, while N77 YSO1 is seen toward the central dust lane of the compact H II region, very close to the exciting star. Since N191 and N77 are young active H II regions, these two YSO candidates may effectively be associated with them. The presence of these YSO candidates confirms that star formation activity is still ongoing in N191A and N77A. More specifically, massive protostars of ~ 10 and $20 M_{\odot}$ are in the process of formation. The YSOs may have been triggered by the ionization front progression in the associated molecular clouds. However, high-resolution submillimeter observations, such as those of ALMA, are required to check these first results.

5. Concluding remarks

This paper presented the first detailed study of LMC N191A and SMC N77A using imaging and spectroscopy in the optical obtained at the ESO NTT as well as *Spitzer* and 2MASS data archives. The two objects are among the outermost star-forming regions of the Magellanic Clouds. We derived several physical characteristics of these regions and their powering sources. The compact H II region N191A, $\sim 10''$ (2.4 pc) in diameter, belongs to a small class of “low-excitation blobs” in the Magellanic Clouds. In contrast, SMC N77A, $\sim 20''$ (5.8 pc) in size, belongs to the “high-excitation blob” family. The class of compact H II regions in the Magellanic Clouds is not very populated. Therefore new members provide additional data for improving our knowledge of their characteristics and their formation processes. Higher resolution observations are necessary to deepen the study of these objects.

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