Astronomical and Astrophysical Transactions (*AApTr*), 2018, Vol. 30, Issue 4, pp. 379–386,
ISSN 1055-6796, Photocopying permitted by license only,

Optical observations of NGC 1156 galaxy in narrowband [SII] and Hα filters

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Received 21 September, 2016

We present observations of a Magellanic-type dwarf irregular galaxy NGC 1156 in narrow band [SII] and Hα filters, carried out in November 2015, with the 2 m RCC telescope at Rozhen National Astronomical Observatory in Bulgaria. Although our observations were with the intention to find new extragalactic supernova remnant candidates, we were successful in the detection of 59 HII regions. We give luminosity function and size distribution for the detected HII regions. Also, we found that relation between Hα luminosity and radius of HII regions in NGC 1156 has the slope of 2.7 ± 0.2 in logarithmic presentation, which is in good agreement with theoretical prediction for ionization-bounded HII regions.

Keywords: Galaxies: individual: NGC1156–HII regions

1 Introduction

NGC 1156 is a Magellanic-type dwarf irregular galaxy i.e. type IB(s)m, with apparent dimensions $3.3' \times 2.5'$ in V band* at approximate distance of 7.6 Mpc (Kim et al. 2012). The galaxy has a larger than average core and shows some signs of tidal interactions, unusual for an isolated galaxy. The Arecibo Galaxy Environment Survey (AGES) finds a small dwarf galaxy AGES J030039+254656 about 35 arcmin north-east of NGC 1156. Although it seems unlikely that this dwarf galaxy, in its current position, could be exerting any significant tidal force on NGC 1156, the possibility of an interaction in the past cannot be ruled out (Minchin et al. 2010). We have carried out new optical observations of NGC 1156 in narrow band filters at National Astronomical Observatory (NAO) Rozhen in Bulgaria, with the intention of finding

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new supernova remnant candidates and HII regions in this galaxy. For supernova remnants we expect [SII]/Hα emission line ratio higher than 0.4, while for HII regions [SII]/Hα ratio should be lower than 0.2 (e.g. Blair & Long 1997).

2 Observations and data reduction

Observations were carried out during two nights, November 3/4 - 4/5, 2015, with the 2 m RCC telescope at NAO Rozhen. The telescope was equipped with VersArray: 1300B CCD camera with 1340 × 1300 px array, plate scale of 0.25″/px, giving the field of view 5′45″ × 5′35″. We took images through Hα, [SII] and red continuum filters, with total exposure time of 9600 s for each filter. Typical seeing was 1.5″. Data reduction was done using standard procedures in IRIS[†]. For details see Arbutina et al. (2009), Andjelić et al. (2011), Vučetić et al. (2013, 2015).

3 Results

In this paper we present the first optical survey of NGC 1156 galaxy for emission nebulae. Although our observations were unsuccessful in detecting new extragalactic supernova remnant candidates, we detected 59 HII regions. In order to classify detected objects, we made [SII]-0.4Hα image. Since all emission nebulae were dark in this image, we concluded that there are no SNRs. Also, all sources were dark in [SII]-0.2Hα image, meaning that all HII regions have [SII]/Hα ratio less than 0.2. For that reason we did not measure [SII] fluxes and in this paper omit continuum-subtracted [SII] image. Figure 1 represents observed region in Hα emission, with marked HII regions. The properties of the detected objects are listed in Table 1. We have measured objects' Hα fluxes by subtracting sky from continuum-subtracted image, then setting image median to zero and drawing 2σ contours around sources. To check Hα fluxes, we measured both contour and aperture fluxes – F_c, F_a, for several isolated objects. Although F_a are systematically larger then F_c, the difference is not very large and is probably of the order of other uncertainties. If we define the flux quality measure as $\delta = 2|F_c - F_a|/(F_c + F_a)$, then $\delta_{\max} = 54\%$, while $\langle\delta\rangle = 27\%$.

In Fig. 2a we show the Hα luminosity function (LF) for detected HII regions in NGC 1156. HII regions LF is usually represented by a power law of the following form: $N(L)\mathrm{d}L = AL^a\mathrm{d}L$. Kennicutt et al. (1989) found that the Hα LFs of bright HII regions in 30 nearby spiral and irregular galaxies are represented approximately by a power law with $a = -2.0 \pm 0.5$, with Magellanic type galaxies having shallowest LF. Our obtained LF for NGC 1156 HII has the slope of $a = -1.0 \pm 0.1$ for luminosities larger than $\log L$ [erg s^{-1}] ≈ 38, where distribution's maximum occurs. Maximum of the diameter distribution is around 100 pc (Fig. 2b). The angular resolution for our sample is ∼1.5″ (seeing value), which corresponds to 60 pc.

We examined the correlation between Hα luminosities and diameters of the detected objects. The slope of this correlation is an important diagnostic parameter of conditions inside the HII region. According to the classical theory for the simple case

[†]Available at *http://www.astrosurf.com/buil/*

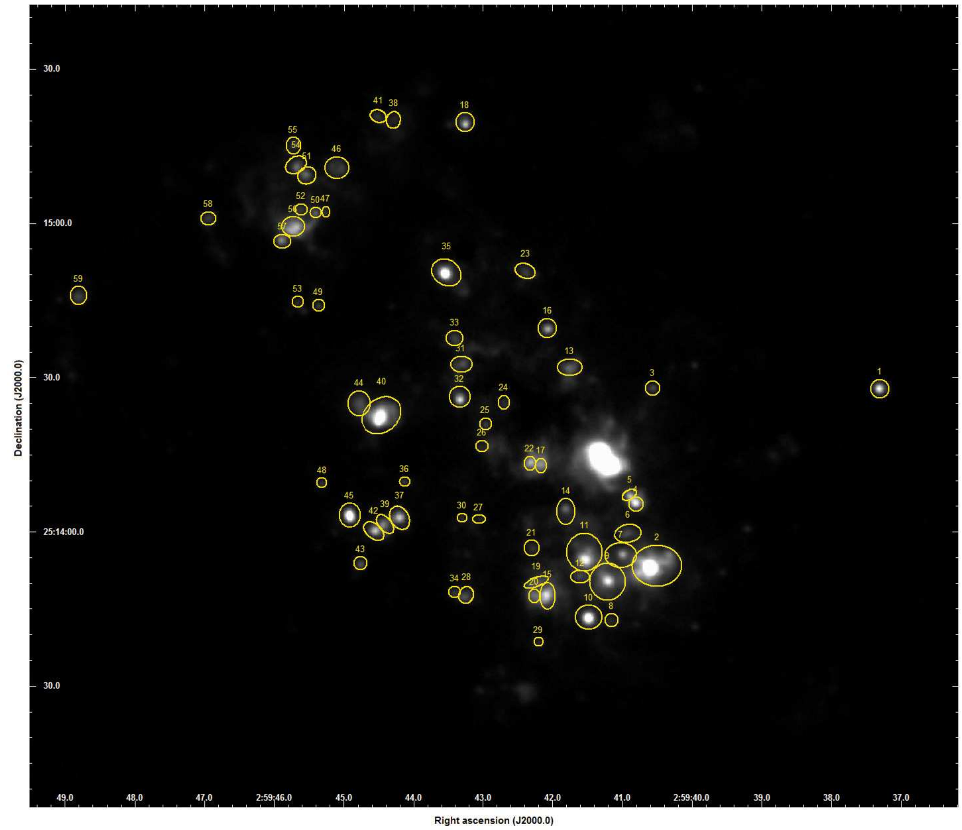

Figure 1 The continuum-subtracted Hα image of NGC 1156 galaxy. Numbers correspond to the entries in Table 1.

of ionization-bounded HII region in constant density, Hα luminosity should scale the cube of the HII region diameter (Strömgren 1939, Osterbrock 1989). We found that the log–log plot of Hα luminosity versus R has the slope of $b = 2.7 \pm 0.2$ (Fig. 2c), which is in good agreement with theory for ionization-bounded HII regions. Slope coefficients found in the literature for different galaxies are in the range of 1.5–3, depending on the galaxy type and procedure used to derive the size of the HII region (e.g. Lee et al. 2011, Gutiérrez et al. 2011).

4 Summary

In this paper we presented the first optical survey of NGC 1156 galaxy for emission nebulae, conducted from NAO Rozhen. We detected 59 HII regions, and no supernova remnants. The relation between Hα luminosities and radii of detected HII regions in log-log scale has the slope of 2.7, which is close to the theoretical prediction for ionization-bounded HII regions.

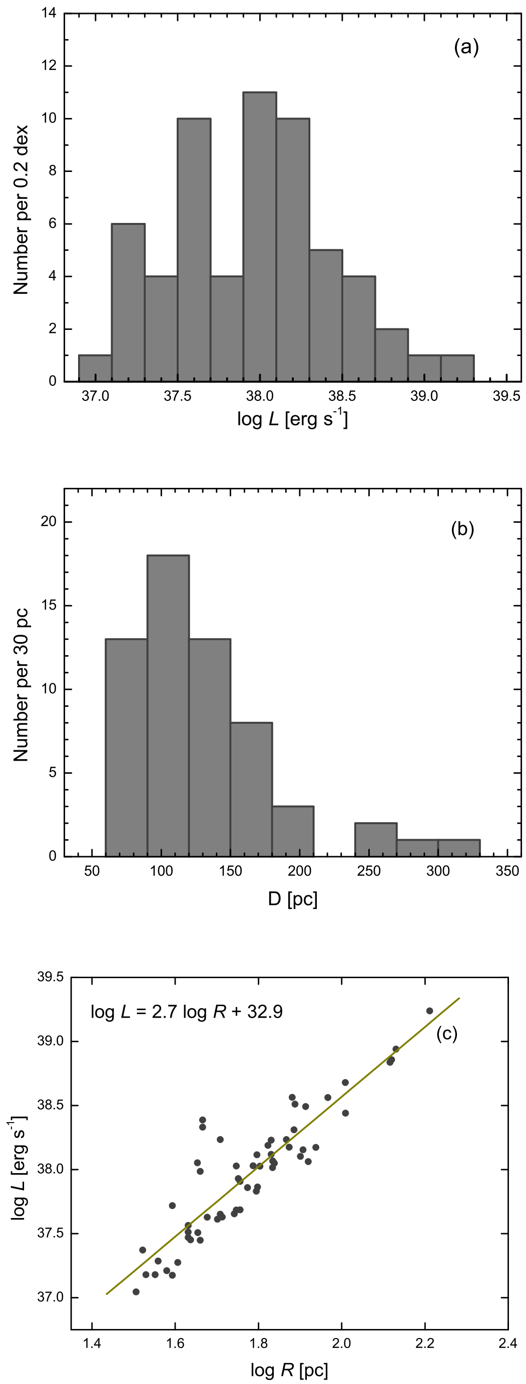

Figure 2 (a) Hα luminosity function of HII regions in NGC 1156. Luminosities have been corrected for reddening (Schlafly & Finkbeiner 2011). (b) Diameter distribution. (c) Relation between the Hα luminosities and R in log-log scale.

Table 1 Coordinates, angular diameters, mean radii and Hα fluxes for 59 detected objects. Adopted distance to the galaxy is 7.6 Mpc (Kim et al. 2012). Hα flux has not been corrected for reddening.

Source No.	R.A.	Dec.	Angular diameter θ [arcsec]	Radius $\langle R \rangle$ [pc]	Hα flux F [10^{-15} erg s^{-1} cm^{-2}]
1	02:59:37.3	+25:14:28	3.6 × 3.6	70	14.3
2	02:59:40.5	+25:13:54	9.7 × 8.0	160	160.5
3	02:59:40.6	+25:14:28	2.7 × 2.7	50	3.8
4	02:59:40.8	+25:14:05	2.8 × 2.8	50	15.9
5	02:59:40.9	+25:14:07	3.1 × 1.8	40	10.4
6	02:59:40.9	+25:14:00	5.2 × 3.5	80	11.7
7	02:59:41.0	+25:13:56	6.2 × 4.9	100	25.5
8	02:59:41.2	+25:13:43	2.4 × 2.4	40	3.0
9	02:59:41.2	+25:13:50	7.0 × 7.2	130	63.5
10	02:59:41.5	+25:13:43	5.3 × 4.8	90	33.7
11	02:59:41.5	+25:13:56	7.0 × 7.3	130	66.6
12	02:59:41.6	+25:13:51	3.7 × 2.4	60	7.5
13	02:59:41.8	+25:14:32	4.9 × 3.2	80	13.8
14	02:59:41.8	+25:14:04	3.6 × 5.2	80	13.2
15	02:59:42.1	+25:13:48	3.0 × 5.3	80	33.8
16	02:59:42.1	+25:14:40	3.7 × 3.7	70	10.8
17	02:59:42.2	+25:14:13	2.2 × 2.8	50	22.6
18	02:59:42.2	+25:13:39	1.8 × 1.7	30	1.0
19	02:59:42.2	+25:13:50	4.9 × 1.7	60	9.9
20	02:59:42.3	+25:13:48	2.3 × 2.7	50	8.9
21	02:59:42.3	+25:13:57	3.0 × 3.1	60	4.5
22	02:59:42.3	+25:14:13	2.3 × 2.7	50	19.8
23	02:59:42.4	+25:14:51	4.0 × 2.8	60	6.8
24	02:59:42.7	+25:14:25	2.2 × 2.8	50	2.6
25	02:59:43.0	+25:14:21	2.3 × 2.4	40	2.7
26	02:59:43.0	+25:14:17	2.4 × 2.2	40	3.0
27	02:59:43.1	+25:14:03	2.6 × 1.7	40	1.4
28	02:59:43.2	+25:13:48	2.8 × 3.3	60	7.9
29	02:59:43.3	+25:15:20	3.6 × 3.7	70	2.1
30	02:59:43.3	+25:14:01	1.9 × 1.7	40	1.4
31	02:59:43.3	+25:14:33	4.4 × 3.1	70	10.4
32	02:59:43.3	+25:14:26	4.0 × 4.0	70	15.8
33	02:59:43.4	+25:14:38	3.5 × 3.0	60	6.7
34	02:59:43.4	+25:13:48	2.4 × 2.3	40	2.6
35	02:59:43.5	+25:14:50	6.1 × 4.9	100	44.3
36	02:59:44.1	+25:14:10	2.1 × 1.9	40	1.8
37	02:59:44.2	+25:14:03	3.5 × 4.8	80	18.9
38	02:59:44.3	+25:15:20	2.7 × 3.3	60	4.2
39	02:59:44.4	+25:14:02	4.3 × 2.5	60	12.1
40	02:59:44.5	+25:14:23	8.2 × 6.4	140	80.5

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Table 1 (continued)

Source No.	R.A.	Dec.	Angular diameter θ [arcsec]	Radius R [pc]	Hα flux F [10^{-15} erg s^{-1} cm^{-2}]
41	02:59:44.5	+25:15:21	3.2 × 2.4	50	3.9
42	02:59:44.6	+25:14:00	2.8 × 4.5	70	15.7
43	02:59:44.8	+25:13:54	2.6 × 2.6	50	3.9
44	02:59:44.8	+25:14:25	4.4 × 5.0	90	13.8
45	02:59:44.9	+25:14:03	4.1 × 4.8	80	28.7
46	02:59:45.1	+25:15:11	4.8 × 4.3	80	10.7
47	02:59:45.3	+25:15:02	1.5 × 2.1	30	2.2
48	02:59:45.3	+25:14:10	1.9 × 1.9	40	1.4
49	02:59:45.4	+25:14:44	2.2 × 2.2	40	1.7
50	02:59:45.4	+25:15:02	2.2 × 2.1	40	4.8
51	02:59:45.5	+25:15:09	3.7 × 3.2	60	9.8
52	02:59:45.6	+25:15:03	2.4 × 2.2	40	3.4
53	02:59:45.7	+25:14:45	2.1 × 2.1	40	1.5
54	02:59:45.7	+25:15:11	4.3 × 3.1	70	9.6
55	02:59:45.7	+25:15:15	2.8 × 3.4	60	4.5
56	02:59:45.7	+25:14:59	4.5 × 3.9	80	30.0
57	02:59:45.9	+25:14:57	3.4 × 2.7	60	9.8
58	02:59:46.9	+25:15:01	3.0 × 2.6	50	4.1
59	02:59:48.8	+25:14:46	3.2 × 3.6	60	6.3

Acknowledgements During the work on this paper the authors were financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia through the projects No. 176004 and No. 176005. This work is a part of the joint project of Serbian Academy of Sciences and Arts and Bulgarian Academy of Sciences "Optical search for supernova remnants and HII regions in nearby galaxies (M81 group and IC342)". The authors gratefully acknowledge observing grant support from the Institute of Astronomy and Rozhen National Astronomical Observatory, Bulgarian Academy of Sciences.

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