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An Optical Search For Supernova Remnants In The Nearby Spiral Galaxy NGC 3344

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1 ABSTRACT

An optical search was carried out for supernova remnants (SNRs) in the nearby spiral galaxy NGC 3344, using groundbased observations at the TUBITAK National Observatory (TUG, Antalya/Turkey). The SNR identification technique consisted of constructing continuum subtracted Hα and SII$\lambda\lambda$ 6716, 6731 images and then using [SII]/Hα ratios obtained from the image. We have identified 10 new SNR candidates in NGC 3344 with [S II]/Hα $\geqq$ 0.4 as the basic criterion. The [S II]/Hα ratio ranges from 0.44 to 0.92 and Hα intensities from $1.0x\ 10^{-17}$erg cm^{2} s^{-1} to $3.6x\ 10^{-17}$erg cm^{2} s^{-1}.

2 INTRODUCTION

SNR studies are important for theories of interstellar medium (ISM) and star formation, since supernova inject large amounts of matter and energy into the ISM. However, in spite of all the Galactic SNRs, their observations are impeded by several limitations such as the uncertainty on distances to individual objects and high extinctions along the line of sight in several regions of the Galactic plane. There are inherently fewer limitations and uncertainties in extragalactic samples. Assuming that all SNRs are the same distance from us for a given galaxy, we can easily compare their observed properties. The relative positions of such SNRs are determined with more precision. SNRs have been identified in a number of nearby spiral galaxies using optical observations (e.g. DOdorico et al.(1980) ; Braun and Walterbos (1993) ; Magnier et al.(1995); Matonick and Fesen (1997); Matonick (1997); Gordon et al.(1998,1999); Blair and Long (1997,2004) ; Sonbas et al.(2009) , Xray observations (Pence et al. (2001) ; Ghavamian et al.(2005), and radio observations (Lacey et al. (1997) ; Lacey and Duric (2001); Hyman et al. (2001). Multiwavelength surveys of SNRs have also been carried out by Pannuti et al. (2000, 2002, 2007). In our work, we use the well known and accepted criterion (S II/Hα $\geqq$ 0.4) proposed by Mathewson and Clarke (1973) to differentiate SNRs from typical H II regions. The rationale for this lies in the fact that, in a typical H II region, sulfur is usually expected to take the form of S++ owing to strong photoionizing fluxes from central hot stars, making the ratio [S

II]/Hα, typically, in the range $\sim$ 0.1 - 0.3. Shock waves produced by SN explosion propagate through the surrounding medium. The matter cools sufficiently behind these waves, and a variety of ionization states occur that include S+. This might be the reason for the increased $[SII]$/Hα ratio observed in SNRs. It follows that almost all discrete emission nebulae satisfying the above criterion are expected to be shockheated.

3 OBSERVATION AND DATA REDUCTION

NGC 3344 was observed in 2007 November with the 1.5 m Russian Turkish Telescope (RTT150) at TUBITAK National Observatory (TUG) in Turkey (Figures 1-4). Parameters of the galaxy are given in Table 1. Images were taken with TFOSC (TUBITAK Faint Object Spectrograph and Camera).We used narrowband interference filters centered on the lines of [SII] , Hα + 2 continuum filters to remove starlight from Hα and [SII] images. Characteristics of the interference filters used in these observations are listed in Table 2

4 THE METHOD

We used the technique described by Blair and Long (1997,2004) to identify the SNR candidates. The identification technique was constructed through comparison of continuum-subtracted [S II]$\lambda\lambda$6716, 6731 and Hα images. Eventually, emission nebulae with region integrated values of [S II]/Hα $\geqq$ 0.4 were identified as the SNR candidates. A preliminary search to find these candidates were carried out by comparing the continuum subtracted [S II] and the Hα subfield images by a blinking technique. In the process, a fullfield image of the galaxy was divided into regions of about $2^{'}$ by $2^{'}$ squares for the visual inspection and assessment of the fields for the candidates. When a pointlike source satisfied the criterion [S II]/Hα $\geqq$ 0.4, we then marked it as an SNR candidate. After the assessment of all $2^{'}$ by $2^{'}$ subfields of NGC 3344, continuum subtracted images were used to determine the ratio of [S II]/Hα counts. During this process, background counts were subtracted from the [S II]/Hα ratio images using annuli that were farther away, but centered on the selected candidates (Figures 5-6). The background extraction areas were also normalized to the source extraction areas.

Table 1. Parameters of NGC 3344

RA	$10^{h}\ 43^{m}\ 31.1^{s}$
Dec	$24^{\circ}\ 55^{'}\ 20^{"}$
App. dim.(V)	7.1^{1} x $6.5^{'}$
App. mag.(V)	10.5
Distance	6.9 Mpc(*)

* L. Verdes-Montenegro et al;2000

Table 2.Characteristics of the interference filters used in our observations

Name	Wavelength (Å)	FWHM (Å)
[SII]	6728	54
continuum	6964	350
Hα	6563	80
continuum	6446	123

Only one field image for each filter was obtained for NGC 3344 on November 17 and 19, 2007. We have exposure times of 1×1800 s + 2x900 s for the [S II],2x1800 for Hα filters, and 900 s for the two continuum filters. This way, we were able to obtain deeper field images with a higher signaltonoise ratio for the faintest objects.

Table 3.An observation log of imaging data for our target galaxy

Date	Filter	Exposure(s)
2007 Nov. 7/8	[SII]	1800
2007 Nov. 7/8	Hα	1800
2007 Nov. 7/8	continuum-6446	900
2007 Nov. 9/10	[SII]	2x900
2007 Nov. 9/10	Hα	1800
2007 Nov. 9/10	continuum-6964	900

We found 10 emission nebulae consistent with the [S II]/H$\alpha \geqq 0.4$ criterion for SNR identification with the technique described above. Llist of new SNR candidates flux ratios with corrected standard flux value are given in Table 4.

Table 4.New optical SNR candidates detected in NGC3344

SNR Name	RA (J2000)	DEC (J2000)	SII/Hα	I(Hα) (erg cm^{-2} s^{-1})
SNR1	10:43:41.1	+24:55:18.3	0.50	1.4E-16
SNR2	10:43:28.7	+24:55:49.3	0.52	1.3E-16
SNR3	10:43:26.6	+24:53:43.8	0.92	1.1E-16
SNR4	10:43:29.9	+24:57:09.1	0.62	1.2E-16
SNR5	10:43:25.2	+24:52:00.5	0.63	1.0E-16
SNR6	10:43:24.2	+24:52:00.4	0.47	1.1E-16
SNR7	10:43:28.5	+24:54:50.4	0.44	3.1E-16
SNR8	10:43:45.1	+24:54:50.4	0.67	3.6E-16
SNR9	10:43:45.0	+24:54:24.7	0.50	1.1E-16
SNR10	10:43:18.8	+24:54:54.9	0.62	1.0E-16

5 PRELIMINARY RESULTS

We conducted a survey of SNRs using optical imaging and spectroscopic measurements in the nearby spiral galaxy NGC 3344. In this survey, we used blinking

between continuum-subtracted Hα and continuum-subtracted [S II] images to deduce SNR candidates for a given ratio between the lines.10 SNRs were identified in NGC 3344 by our method within the [S II]/Hα ratio ranges from 0.44 to 0.92. The SNRs will be confirmed by additional spectroscopic observations and, finally, by comparison of the optically detected SNRs with archived Chandra observations. Our work is in progress.

Kaynaklar

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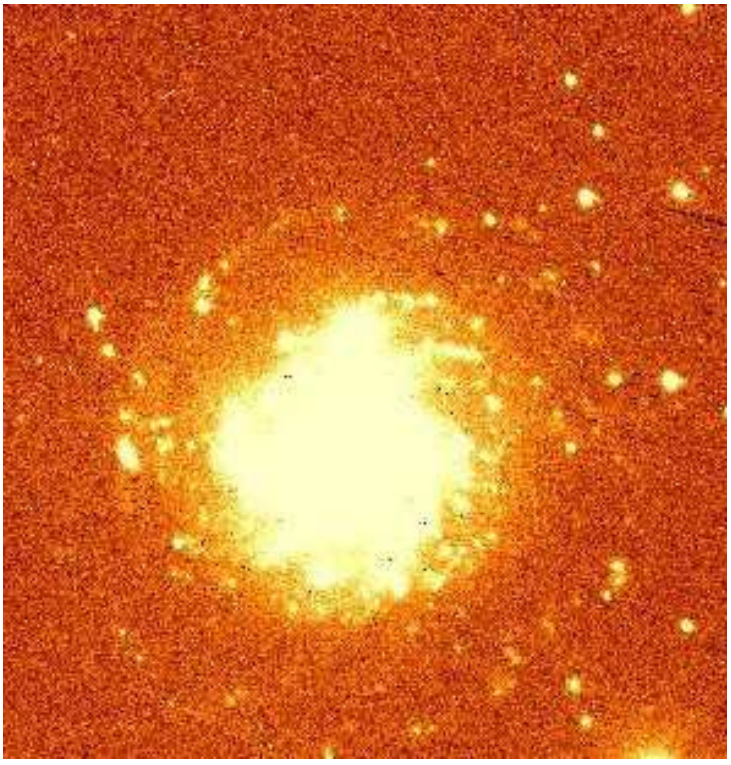

Figure 1. [SII] image of NGC3344

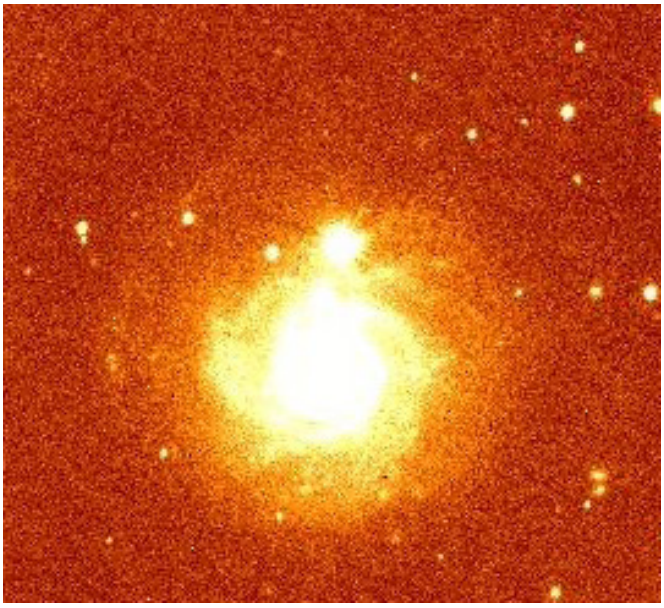

Figure 2. [SII-c] image of NGC3344

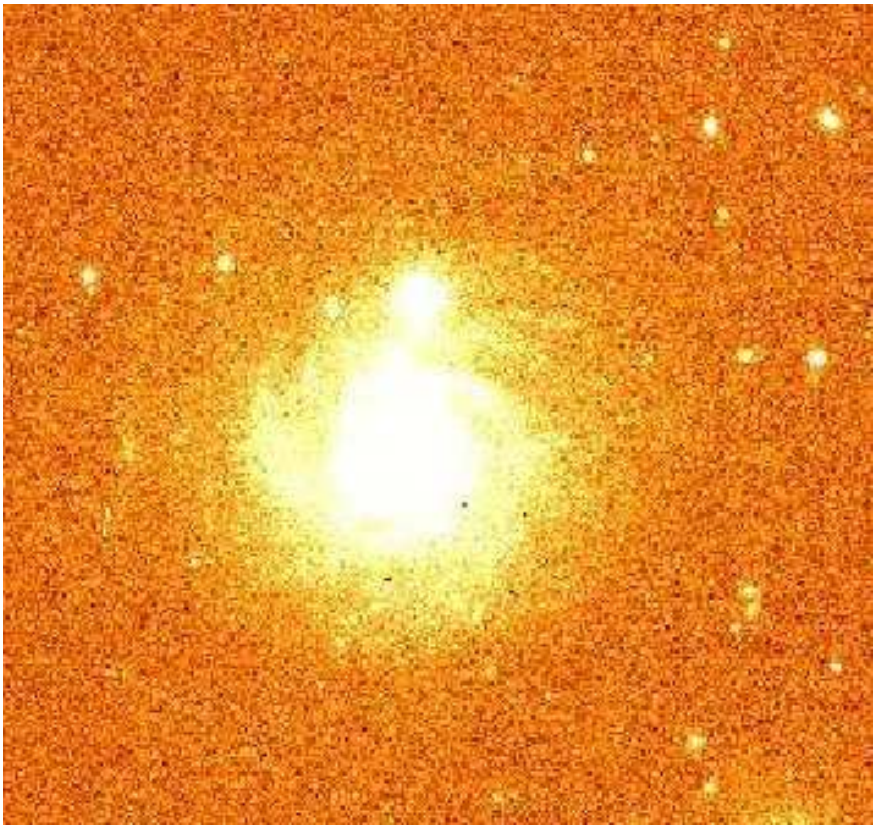

Figure 3. Hα image of NGC3344

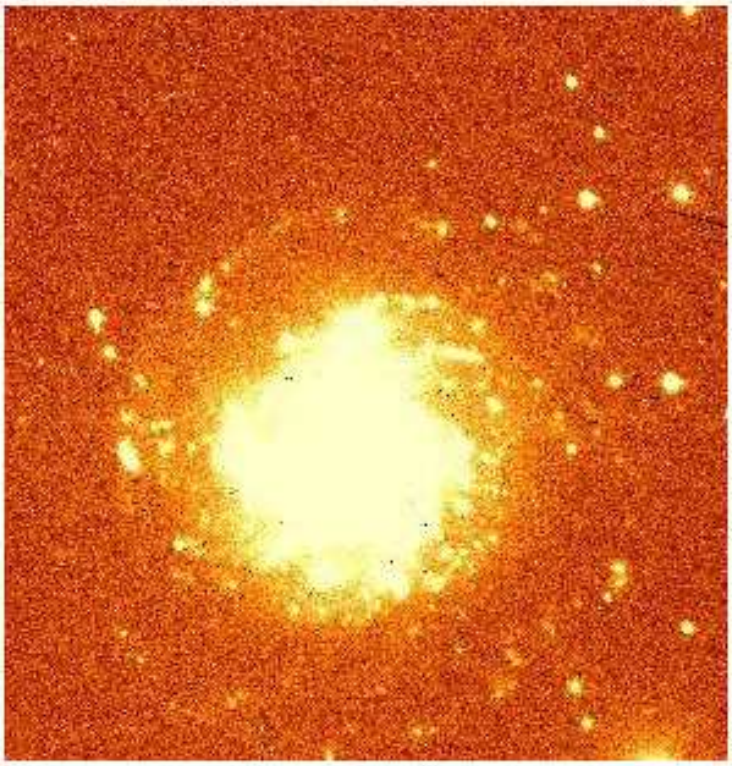

Figure 4. Hα-c image of NGC3344

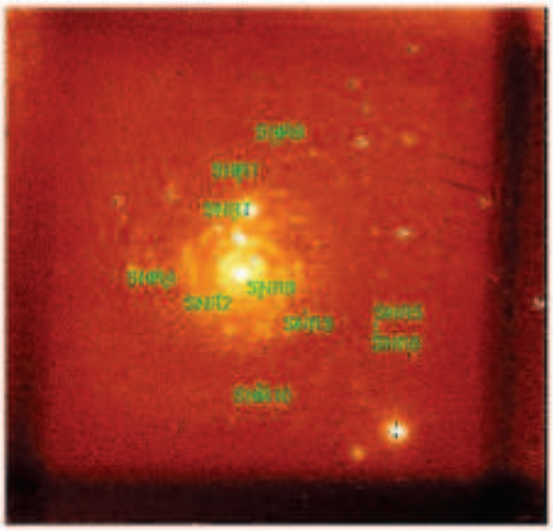

Figure 5. Full frame [SII] image of NGC 3344 with SNRs marked

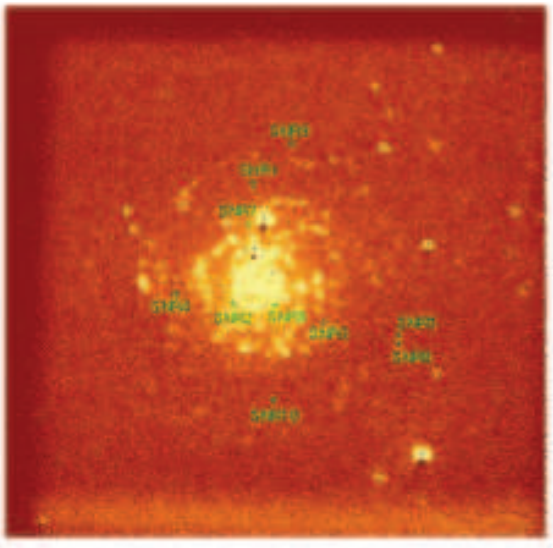

Figure 6. Full frame [Hα] image of NGC 3344 with SNRs marked