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Detection of Supernova Remnants in galaxy NGC 1313

M. Kopsacheili [1,2], *P. Boumis* [1], *I. Leonidaki* [1], *A. Zezas* [3]
[1]IAASARS, National Observatory of Athens, Greece
[2]Department of Physics,University of Athens, Greece
[3]Department of Physics, University of Crete, Greece

Abstract: Supernova remnants (SNRs) are objects of high importance since they provide major amounts of energy to the Interstellar Medium while at the same time depict the short-lived endpoints of massive stars (M>8 $M_\odot$). In order to investigate the physical properties of these objects and their interplay with their environment, we have embarked in an extensive investigation of the SNR populations, focusing on six nearby galaxies of different morphological types in the southern hemisphere. In this work, we present new candidate SNRs detected in the barred spiral galaxy NGC 1313, based on deep narrow-band H and [S II] images observed with the 4m Blanco telescope in La Serena, Chile. The new detections were achieved by calculating the $\frac{[SII](\lambda 6716,6731)}{H\alpha(6563)}$ flux ratios for every source. Sources with this ratio over 0.4 can be considered as candidate SNRs. Following this criterion, 95 candidate SNRs were detected, with fluxes down to 10^{-17} erg/s/cm^2.

1 Introduction

A supernova explosion is the endpoint of the evolution of stars with mass over 8 $M_\odot$. Observations have shown that two types of supernovae are evident: Type Ia which are caused within binary systems where a white dwarf receives mass from a donor companion exceeding the Chandrasekhar limit of 1.44 $M_\odot$ and Type II which are associated with the core collapse of massive stars. When a massive star runs out of thermonuclear fuel, it cannot sustain itself under its own gravity, so it collapses. Then a shock wave is created and propagates expelling large amounts of material outward. The interaction of this material with the Interstellar Medium (ISM) is observed as a supernova remnant (SNR).

SNRs are objects of high importance in astronomy. They enrich the ISM with heavy elements and large amounts of energy, while shock waves suppress the ISM triggering star formation. Therefore, the study of SNRs can provide us with information about the physical properties of ISM (density, chemical composition, temperature) as well as stellar evolution and star formation rate.

Studying extragalactic SNRs, instead of Galactic has important advantages. First of all, the galactic extinction is minimized. We have a wider sample, since we can study SNR populations in different types of galaxies, and we can detect a lot of SNRs with a single exposure of a galaxy. However, there are disadvantages too. Due to large distances the structures are indistinct and therefore, the detail study of nebula physics is difficult.

2 Survey

The detection of SNRs in nearby galaxies is an ongoing project that started by our team a few years ago. Up to now, we have studied a number of galaxies in the northern hemisphere (NGC 2403, NGC 3077, NGC 4214, NGC 4395, NGC 4449, NGC 5204), where 37 SNRs are detected in the X-rays [1] and 95 SNRs in the optical, of which 67 are spectroscopically confirmed (165 additional SNRs are going to be spectroscopically studied) [2]. One of the most intriguing results from this work is a systematic trend for more luminous SNRs to be associated with irregular galaxies (Figure 1). This indicates a difference of the SNRs population characteristics between the two samples. We attribute this effect either to the lower metallicity of irregular galaxies (which result in more massive progenitors) or their clumpy ISM. Because most of these galaxies are irregular, spiral galaxies are going to be studied (a sample of galaxies in the southern hemisphere has already been observed).

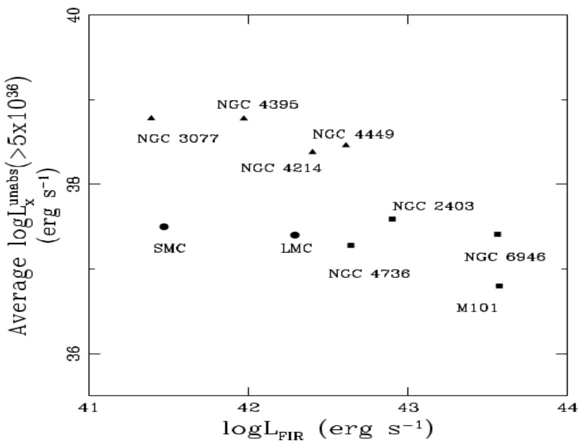

Figure 1: Distribution of SNRs

3 Observations - Data Analysis

The subject of the present study is the detection of SNRs in the galaxy NGC 1313. This is a barred spiral galaxy, about 4.6 Mpc far from Milky Way and is observed in the southern hemisphere sky. The observations were carried out at the 4 meter Blanco telescope in Chile, using the Mosaic II camera on November 15-17, 2011. The field of view of this camera is $36'$x$36'$ and the pixel scale is 0.27 arcsec pixel^{-1}. In order to get a large field of view with high angular resolution, this camera consists of eight CCDs and as a consequence there were gaps between the CCDs. These gaps were covered following a dithering procedure. In order to detect SNRs, narrow band filters Hα (FWHM: 80Å, CWL: 6563Å), [S II] (FWHM: 80Å, CWL: 6725Å) and broadband filter Continuum Red (FWHM: 1510Å, CWL: 6440Å) were used. We obtained five exposures for each filter. The exposure time for each exposure was set to 720 s, 1440 s and 120 s for the Hα, [S II] and Continuum Red filters respectively. The continuum images were subtracted from those of Hα and [S II] filters to eliminate the confusing star field.

The IRAF (Image Reduction and Analysis Facility) and Sextractor packages were used for the data reduction and photometry. All frames were bias-subtracted and flatfield-corrected using a series of well exposed twilight frames. The spectrophotometric standards stars PG 0216+32, PG 0310+149 and HZ 14 were used for the absolute flux calibration [3]. The detection was achieved with the calculation of flux ratio $\frac{[SII](\lambda 6716,6731)}{H\alpha(6563)}$. If this ratio is larger than 0.4, the source is considered as an SNR candidate [4]. This diagnostic tool is empirically known to differentiate the shock excited nature of SNRs from photoionized process of H II regions.

4 Results

Finally, 95 SNR candidates were detected. As we can see in Figure 2, most of them were found in the spiral arms of the galaxy. This is what we expected since stars are known to evolve in these regions.

As future goal, we are going to spectroscopically verify the shock excited nature of the above SNR candidates. In addition, we are going to detect and study SNRs in galaxies NGC 45, NGC 55, NGC 1672, NGC 7793 in the southern hemisphere. Having a more accurate sample, we will be able to investigate the interplay of SNRs with ISM and we will verify whether different SNRs populations occur in different types of galaxies.

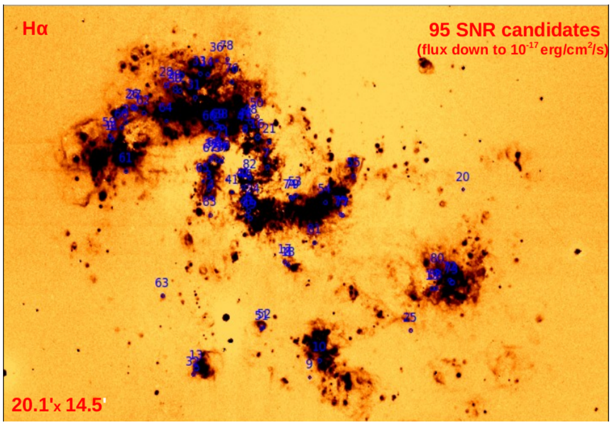

Figure 2: SNRs candidates in NGC 1313

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