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## Abstract

We present the first CCD images of the VRO 42.05.01 (G 166.0+4.3) supernova remnant in H $\alpha$ + [N II], [O III] 5007 and [S II] at a moderate angular resolution. Low and high-dispersion spectroscopy was also performed at selected areas around this extended remnant. Diagnostic diagrams of the line intensities from the present spectra and the new kinematical observations both confirm the supernova origin. Taking into account our results (i.e. shock velocities, morphological characteristics etc.) together with observations of other wavelengths (i.e. radio), we provide significant information on the interaction between this SNR and the surrounding Interstellar medium (ISM).

## Introduction

VRO 42.05.01 is a known SNR (van den Bergh 1960; Fesen et al. 1983, 1985) but because of its large size, it was never studied in detail. It is classified as a shell-type SNR, with a spectral index of  $\sim 0.37$  (Green 2014). Its angular size is  $55' \times 35'$  and using HI measurements the distance of the remnant was calculated at 4.5 kpc (Landecker et al. 1989). Our group performed many imaging and spectroscopic observations in order to study this SNR in detail in high angular resolution (see Boumis et al. 2016 and for similar work Boumis et al. 2005, 2008, 2009, Alikakos et al. 2012).

## Observations & First Results

**Imaging: Wide field:** VRO was observed with the 0.3m telescope at Skinakas Obs., Greece in 2001, 2005, using the H $\alpha$ + [N II], [S II] and [O III] filters (E.T.=2400s). **High resolution:** The 2.3m Aristarchos telescope at Helmos Obs., Greece was used in 2011, 2015, with the H $\alpha$ + [N II], and [O III] filters (E.T.=1800s). **Spectroscopy: Low resolution:** The 1.3 m telescope at Skinakas Obs. was used to obtain long-slit spectra (E.T.=3600s) in 2009, 2010. The data were taken with 1300 lines/mm grating covering the range 4750Å - 6815Å. The slit width was 7.7" and its length 7.9'. **High resolution:** The 2.1m telescope at San Pedro Martir (SPM) Obs. (Mexico) was used to obtain echelle spectra (E.T.=1800s) in 2010, 2011, 2016, 2017 with the MES-SPM spectrometer, using a slit 300 $\mu$ m wide ( $\sim 3.9''$  and 20 km/s).

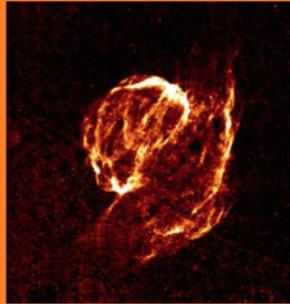
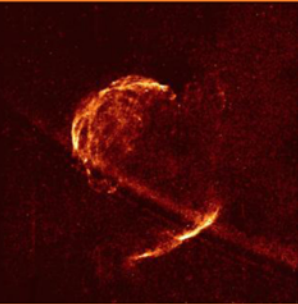
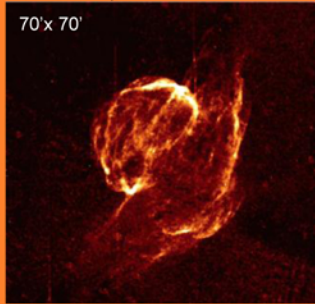
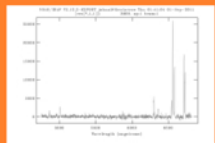


Fig. 1: The H $\alpha$ + [N II] image of VRO.

Fig. 2: The [O III] image of VRO.

Fig. 3: The [S II] image of VRO.



The low ionization images generally show strong filamentary structures, which are very well correlated with the radio emission and they are the remnant's outer edge. Strong filamentary emission has also been discovered in the medium ionization [O III] line. Both the calibrated images and the long-slit spectra suggest that the detected emission results from shock heated gas since the [S II]/H $\alpha$  ratio exceeds the empirical SNR criterion value of 0.4. We have also determined the electron density to be below 240 cm<sup>-3</sup>, by measuring the density sensitive line ratio of [S II]  $\lambda\lambda 6717/6731$ . The strong [O III] emission detected suggests shock velocities greater than 100 km/s (Cox & Raymond 1985) which was also found in the high resolution spectra. The remnant under investigation has not been studied in detail in the optical band (only the work of Fesen et al. 1983; 1985 presented images and spectra of selected areas), therefore, the current stage of its evolution is still unknown. In a forthcoming paper for VRO (Boumis et al. 2017, in preparation), imaging, low resolution and kinematical data will be presented for a first time, as well as diagnostics diagrams of the line intensities, which allow us to provide more information about its morphology and dynamics. Finally, the multiwavelength correlation will also be discussed and will give us a better indication about its evolutionary stage and its interaction with the ISM.

Fig. 5 (left): Typical low-res spectrum.

Fig. 6 (middle/right): [O III] and H $\alpha$ + [N II] high-res spectra at the same position, where the velocity features can be clearly seen.

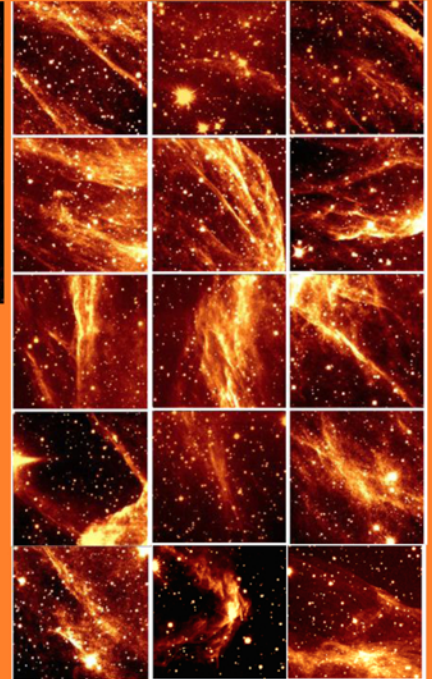


Fig. 4: High-resolution H $\alpha$ + [N II] images (5'x5') obtained with the 2.3m Aristarchos telescope in selected areas, where low and high resolution spectra were taken.

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