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# OSIRIS TUNABLE FILTER IMAGING OF THE LARGE SCALE SHOCK IN STEPHAN'S QUINTET

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RESUMEN

Se presentan imágenes preliminares en H$\alpha$, [NII] y [SII], así como cocientes de líneas del choque a gran escala (40 kpc de largo) descubierto en el grupo compacto más popular de galaxias: el Quinteto de Stephan. Las imágenes fueron obtenidas con OSIRIS/GTC. En este trabajo estudiamos la parte central del choque y mostramos que esta región está formada por cúmulos brillantes rodeados de un débil y difuso gas. Confirmamos que el gas chocado tiene un alto cociente (>1) de [NII]/H$\alpha$ y [SII]/H$\alpha$, característico de choques radiativos interestelares. Además hemos podido calcular densidades electrónicas a partir del cociente de líneas [SII]6717/6731.

ABSTRACT

We present preliminary OSIRIS H$\alpha$, [NII] and [SII] images and line-ratios on the large-scale shock (about 40 kpc long) discovered in the most popular compact group of galaxies: the Stephan's Quintet. The images were obtained by the instrument OSIRIS attached to the GTC. In this work we study only the central region of the shock and show that the shocked region is formed of bright clumps embedded in faint, diffuse gas. We confirm that the shocked gas has high (larger than one) [NII]/H$\alpha$ and [SII]/H$\alpha$ line-ratios, characteristic of interstellar radiative shocks and we are able of estimating electron densities from the [SII] 6717/6731 line-ratio.

*Key Words:* galaxies: interactions — galaxies: kinematics and dynamics — intergalactic medium

## 1. INTRODUCTION

The Stephasn Quintet, SQ (Hickson Compact Group HCG 92, Hickson 1982) is formed by four galaxies with accordant redshifts: NGC 7317 ($V$=6563 km s$^{-1}$), NGC 7318a ($V$=6620 km s$^{-1}$), NGC 7319 ($V$=6650 km s$^{-1}$) and NGC 7320c ($V$=6583 km s$^{-1}$), a galaxy with a discordant redshift: NGC 7318b ($V$=5765 km s$^{-1}$) which is considered as the "New Intruder", NI (in contraposition with NGC 7320c considered as an "Old intruder" and also member of SQ) and a galaxy seen along the same line-of-sight but that given its so discordant redshift is only seen projected foreground the SQ members: NGC 7320 ($V$=800 km s$^{-1}$; also known as the "Interlooper"). This later galaxy is not a member of SQ.

The interaction between the remaining group gas and the new intruder produces an intergalactic shock of huge dimensions (~40 kpc) that has been identified by the correspondance between extended X-ray/radio continuum/[NII] optical emission which confirms the existence of a large scale shock in SQ (Sulentic et al. 2001).

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The shock of velocity about 400 km s$^{-1}$, with velocities varying from 6000 to 6400 km s$^{-1}$ seems to be inducing a starburst in the pre-shock gas (at SQ systemic velocity of 6600 km s$^{-1}$) which is distributed along an arc of huge dimensions (about 100 kpc long) with the starburst galaxy A in its northern tip as shown by Sulentic et al. (2001).

In the optical range, Xu et al. (2003) work presents long-slit low spectral resolution spectroscopy over very restricted places of the shock diagnose the optical shock region identified in Sulentic et al. (2001) by extending the observations towards other forbidden lines. They published five spectra for different locations of the shock along the long-slit. From these spectra they were not able of estimating the electron density and other physical parameters of the shocked region from the line-ratios because of the severe blending among [SII] and [NII] lines. Their line-ratios showed that the northern part of the shock had [SII]/Halpha ratios larger than 1 and [NII]/Halpha ratios larger than 3 and velocity widths between 500 and 1000 km s$^{-1}$, confirming characteristic shocked gas emission.

## 2. OBSERVATIONS, DATA REDUCTION AND FIRST RESULTS

Stephan's Quintet observations were carried out during 30 November of 2010 with the red Tunable

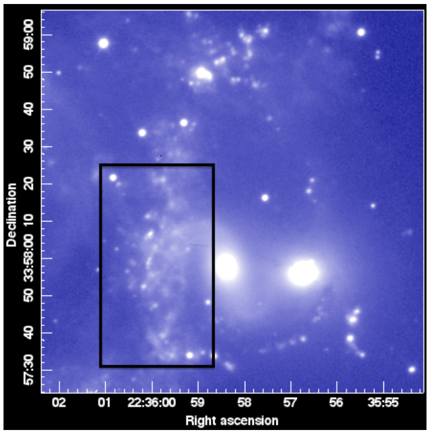


Fig. 1. OSIRIS-TF Hα image of the Stephan's Quintet. The black square depicts the region of our study corresponding to the central part of the large scale shock.

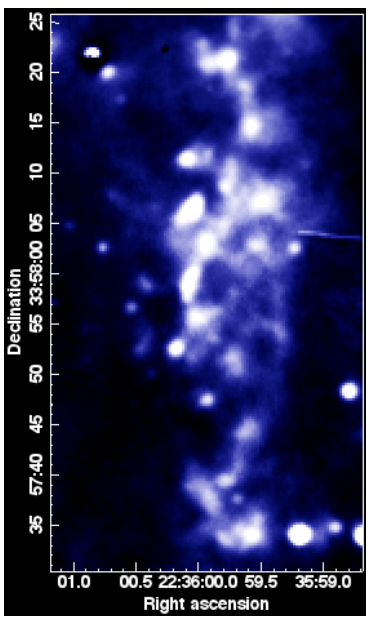


Fig. 2. Close-up of the rectangular region depicted in Figure 1.

Filter (TF) of imager/spectrograph OSIRIS (Cepa et al. 2011) at the Gran Telescopio Canarias (GTC) of the Observatorio del Roque de los Muchachos (La Palma, Canary Islands). We have obtained standard Tunable Filter,TF images in Hα, [NII]λ6583 Å and [SII]λλ 6717,6731 Å redshifted at the velocities of the group. For each emission line, we have taken three exposures centered in three different wavelengths to cover the velocity range. Additional continuum images with f648/28 and f694/44 (for scans at 668.5, 670.5 nm and 684.8, 686.2 nm, respectively) were taken on 5 July 2011.

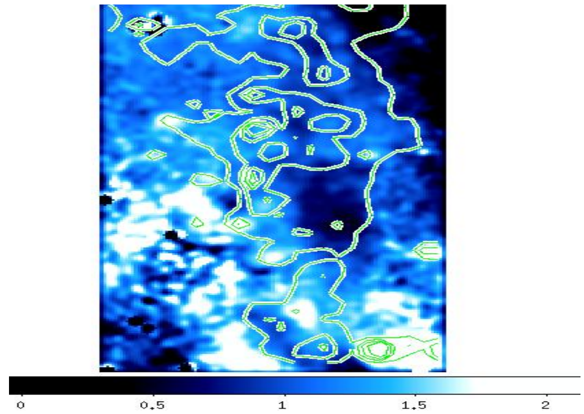


Fig. 3. Bidimensional [NII]/Hα line-ratios of the high velocity shocked gas in the same region as displayed to the left. Superimposed to this line-ratio are the isocontours of Hα emission.

We carried out standard bias and flatfield correction and sky subtraction using IRAF and other more dedicated software. We have also subtracted the continuum in order to have pure monochromatic images. More dedicated reduction has removed the night-sky interference rings. On the other hand, to calibrate in wavelength, we used the expression derived in Cepa et al. (2011) taking into account that the change in wavelength along distance to the optical center is a parabolic surface whose mathematical expression is given in the above reference, based on first OSIRIS observations and calibrations.

Figure 1 shows the TF Hα image of the Stephan's Quintet. The rectangle shows the central region of the shock. As it can be appreciated, the optical shock is formed of bright clumps embedded in faint, diffuse gas.

Figure 2 shows a close-up of the central region of the shock and Figure 3 shows the 2D [NII]/Hα line ratio of this region. It is confirmed that the line-ratio is higher than typical values for HII regions. However, the value is not as high as previously thought. Also, it is appreciated that the faint, diffuse gas has higher line-ratios than the clumps.

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