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ELECTRON DENSITIES OF HII REGIONS THROUGHOUT THE NGC 6946 DISK

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RESUMEN

Hemos usado el filtro sintonizable de OSIRIS para observar las lineas del doblete de [SII] a $\lambda\lambda$617.7 and 673.1nm en emisión a través del disco de NGC 6946, y estimado la densidad electrónica in situ de 387 regiones HII hasta el momento. Los valores muestran un declive constante entre 350 cm^{-3} a $\sim$1/3 R_{25} y cerca de 175 cm^{-3} a 2/3 R_{25}.

ABSTRACT

We have used the tuneable filter system of OSIRIS to observe the [SII] doublet lines at $\lambda\lambda$617.7 and 673.1 nm in emission across the full face of NGC 6946, and estimated the in situ electron densities for 387 HII regions, so far. The values decline steadily from over 350 cm^{-3} at $\sim$1/3 R_{25} to around 175 cm^{-3} at 2/3 R_{25}.

Key Words: HII regions — galaxies: individual: NGC 6946 — galaxies: spiral

We used the OSIRIS tuneable filter (Cepa et al. 2003) to scan the [SII] doublet lines at 671.7 nm and 673.1 nm in emission across the full disc of NGC 6946. The observations were carried out on the nights of August 22nd to 24th 2011 under seeing conditions varying between 0.5″ and 0.8″. Sky subtraction was performed by interleaving the pointings on the galaxy with three sky fields displaced N, S, and W by 12′. To allow for curvature of the surfaces of constant wavelength in the focal plane and to cover the full 8′ field, the spectral region was observed in 19 "slices", between central wavelengths of 670.4 nm and 681.2 nm, at intervals of 0.6 nm and with a FWHM of $\sim$1.3 nm. Each slice comprises 6 images, 3 on the galaxy and 3 on the sky. The total exposure time for the whole data set was 5130 s. Data reduction followed reasonably standard procedures, using combinations of dome flats and sky flats. Each set of 3 sky images was combined into a single image, and the galaxy sets likewise; in the latter case the astrometry used sharp galaxy sources plus their ghosts for alignment. These combined images were then used to give a sky-subtracted image for each slice. A "deep" image was produced by summing all 19 slices. The continuum was subtracted using the mode of the slices, scaling this to the "deep" image, and subtracting the two, giving a "detection" image, with the line emission from 847 HII regions. With the positions and extensions of the HII regions determined, their fluxes were extracted slice by slice, using *Sextractor*. The wavelength λ for a given HII region at a radial distance r (in arcmin) from the centre of the field in a given slice was found, (González et al. 2012) relative to the central wavelength λ_c, from the expressions:

$$\lambda = \lambda_c - 5.04\ r^2 + a_3\lambda^3, \quad (1)$$

where

$$a_3 = 6.0396 - 1.5698\times10^{-3}\lambda + 1.0024\times10^{-7}\lambda^2. \quad (2)$$

Using all the slices, a "pseudospectrum" for a given HII region, showing the [SII] doublet lines could be produced (see Figure 1 for examples). Using the line ratios for the 387 HII regions with lines sufficiently well deblended and of sufficient S/N to measure them, we made preliminary estimates of the in situ electron density n_e and plotted these as functions of HII region radius, r, and of the galactocentric radius, R. To a first approximation the values of this parameter show no trend with HII region radius. This is in contrast to the mean electron density $<n_e>$, (shown by Gutiérrez & Beckman (2010) to vary as $r^{-1/2}$), not unexpectedly as n_e is a property of the dense cooler clumps. However n_e does fall with galactocentric radius according to:

$$n_e = 580 - 680(R/R_{25}), \quad (3)$$

in units of cm^{-3}, where 580 cm^{-3} is the projected value of n_e on the central axis.

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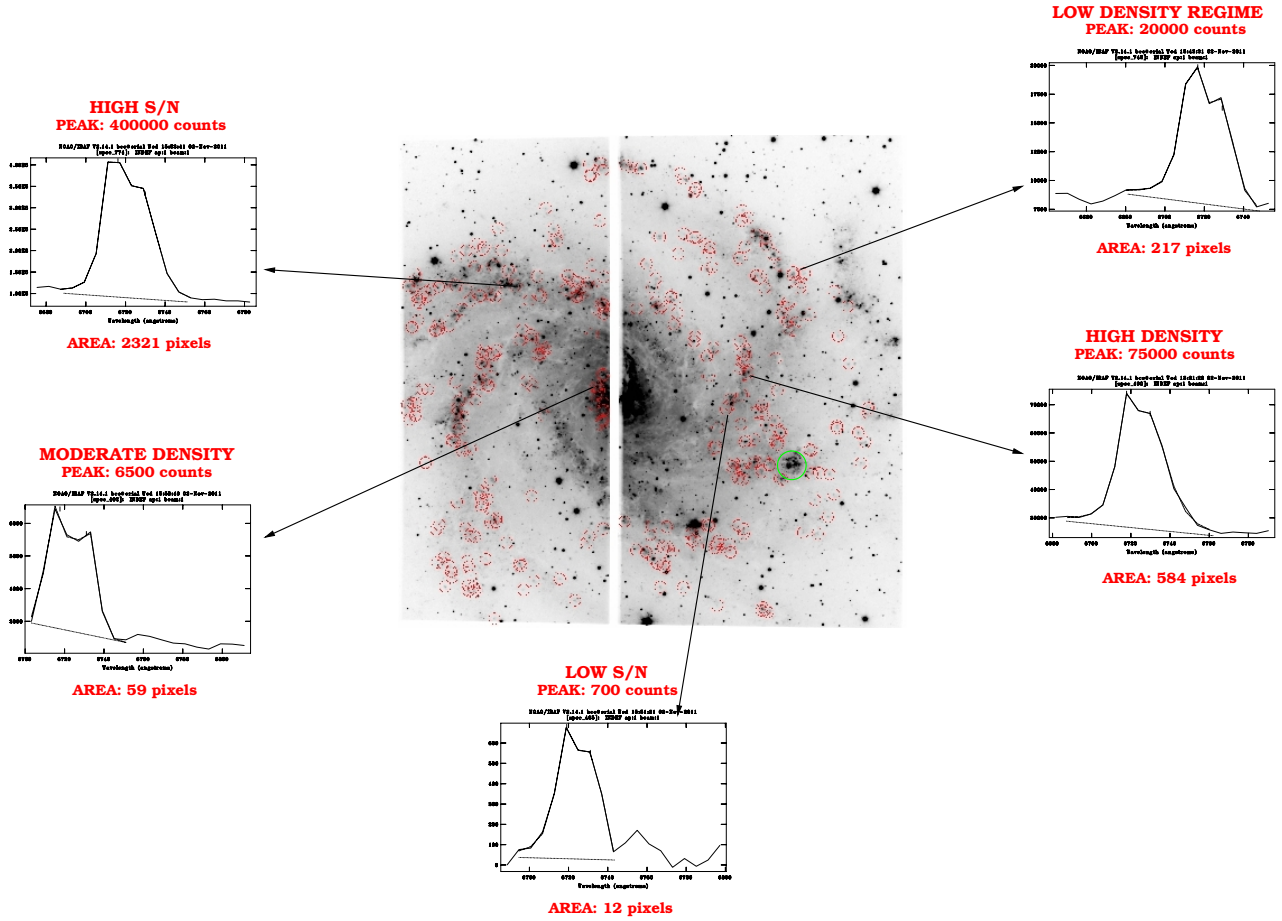

Fig. 1. Image of the galaxy NGC 6946, using a synthetic, custom filter, by co-adding all the slices in the scanned spectral range. The red circles indicate the postion of the detected H II regions where the [SII] doublet was deblended. The green circle indicates the position of the giant H II region NGC 6946-1347, which is a reserved target of the OSIRIS guaranteed time (not be studied here). Several "pseudospectra" for selected H II regions are shown. Clockwise from top right, we show the "pseudospectrum" of an H II region in the low density regime ($n_e < 100$ cm^{-3}), a high density region (n_e=950 cm^{-3}), a low signal to noise region, with a maximun peak of just 700 counts, a region with moderate density (n_e=450 cm^{-3}), and a region with good signal to noise, with a peak well over 400000 counts and an area of 2321 pixels. We note that the a "pseudospectrum" is a convolution of the real spectrum from the H II regions and the response of the instrument OSIRIS, an Airy function. As a first aproximation, the profile of the [SII] lines can be fitted using a Voight function. However, in order to obtain a better deblending and more reliable values for the density, it will be necessary to deconvolve the "pseudospectra", which is work in progress.

Further work in progress will refine these results.

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