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PHYSICAL AND KINEMATICAL PROPERTIES OF NGC 4214

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RESUMEN

Se analizan los resultados obtenidos por espectroscopía óptica bidimensional de la galaxia irregular NGC 4214. Se utilizan observaciones múltiples con rendija larga para obtener mapas bidimensionales de propiedades físicas como la densidad, la extinción y la excitación de los distintos complejos de formación estelar. También se analizan la presencia de estrellas Wolf-Rayet, las propiedades integradas de los brotes de formación estelar y la existencia de estructuras cinemáticamente anómalas. Se identifican dos complejos de formación estelar. Uno es muy joven (3 Ma), con el gas ionizado situado junto a las estrellas masivas, con nubes de polvo cercanas a los centros de formación estelar y sin distorsiones cinemáticas aparentes. El otro, más evolucionado (4-5 Ma), presenta un medio interestelar más distorsionado, con el gas ionizado desplazado con respecto a las estrellas masivas, sin polvo en las cercanías de éstas y con importantes flujos de gas en movimiento.

ABSTRACT

The results obtained with optical bidimensional spectroscopy of the irregular magellanic galaxy NGC 4214 are analyzed. Multiple long-slit observations are used to obtain bidimensional maps of physical properties such as density, extinction and excitation of the different star forming complexes. The presence of Wolf-Rayet stars, the integrated properties of each starburst region and the existence of anomalous kinematical structures are also analyzed. Two star forming complexes are identified. The first one is young (3 Myr), with its ionized gas mixed with the massive stars, dust clouds close to the star forming centers and no apparent kinematical distortions. The other one is older (4-5 Myr) and shows a more evolved interstellar medium, with the ionized gas and dust displaced with respect to the massive stars and with important gas outflows.

Key words: **GALAXIES: IRREGULAR — GALAXIES: ISM — GALAXIES: STARBURST — GALAXIES: INDIVIDUAL: NGC 4214 – TECHNIQUES: SPECTROSCOPIC**

1. INTRODUCTION

The idea of mapping H II regions using classical long-slit spectroscopy at different positions in a nebula is becoming popular nowadays (e.g., Chu & Kennicutt 1994). The method used in this contribution is explained in detail in Maíz-Apellániz et al. (1996) and combines the acquisition of several long-slit frames with a parallel transport of the slit between each exposure. This method provides a complete spectral coverage, with very good spatial scanning in the slit direction, and coarse sampling in the sampling direction. Compared with other techniques, it has some advantages and disadvantages. Fabry-Perot interferometers provide a more complete spatial coverage, but they can map only a single emission line each time. Furthermore, broad underlying components might not be detected because of confusion with the local continuum. Multifiber spectrographs, on the other hand, have also a complete spectral coverage and a good spatial sampling, but are generally restricted to small regions in the sky and bright sources.

NGC 4214 was observed as a part of the GEFE (*Grupo de Estudios de Formación Estelar*) project, an international collaboration whose main aim is the characterization of the star formation mechanisms in galaxies which obtained 5% of the total observing time of the telescopes of the Observatories of the Instituto de Astrofísica de Canarias. Preliminary results were published in Mas-Hesse et al. (1994) and further work will be published in Maíz Apellániz et al. (1996) and Tenorio-Tagle et al. (1997).

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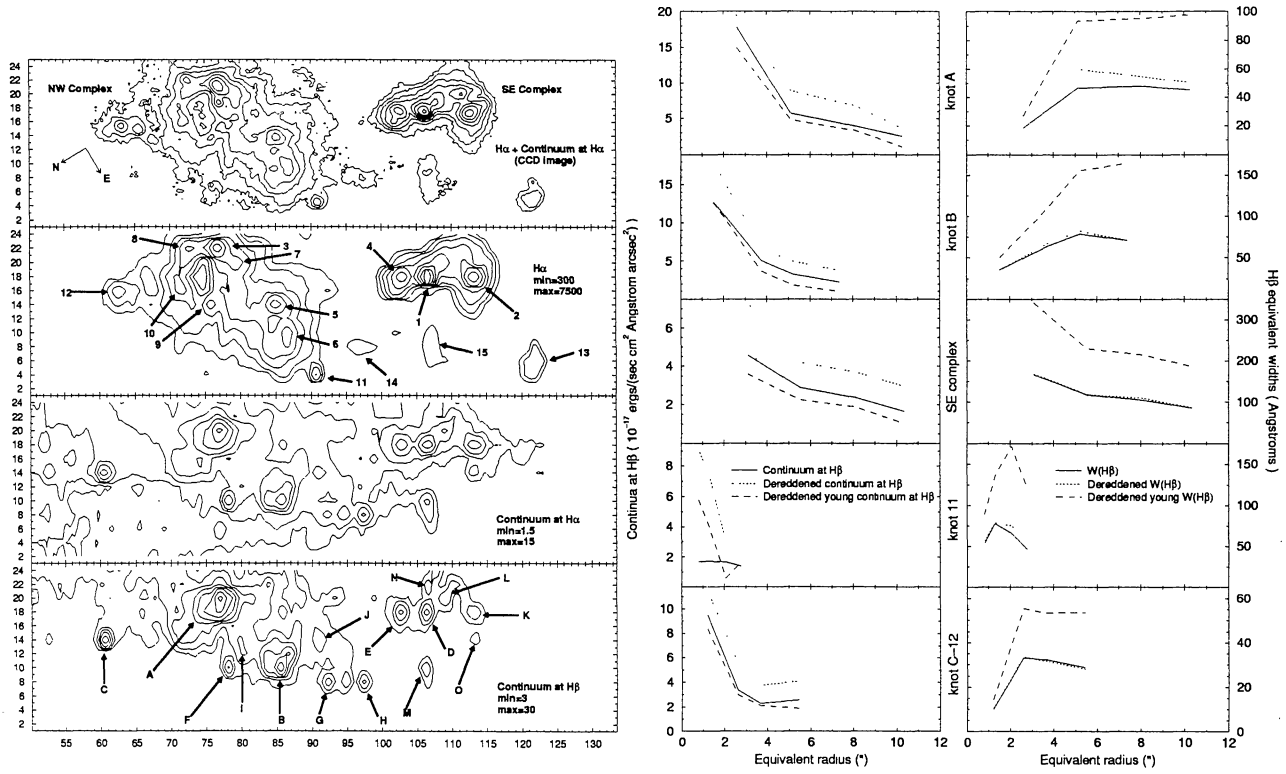

Fig. 1. *(a)* Hα and continuum synthetic maps compared with a (Hα + continuum at Hα) CCD image. Th units are ″. The extremes located at (67″, 17″), (76″, 18″) and (85″, 11″) in our coordinate system ar actually Hα minima. Hα is plotted in units of 10^{-17} erg s^{-1} cm^{-2} $^{-1}$ arcsecond^{-2} and the continua ar plotted in units of 10^{-17} erg s^{-1} cm^{-2} $Å^{-1}$ arcsecond^{-2}. *(b)* Left column: Continuum at Hβ, dereddene continuum at Hβ and dereddened young continuum at Hβ as a function of equivalent radius for five regions i NGC 4214. Right column: Integrated W(Hβ) as a function of equivalent radius for the same five regions. Thre cases are represented: Raw emission and raw continuum, dereddened emission and dereddened continuum, an dereddened emission and dereddened young continuum.

NGC 4214 is a SBmIII galaxy located at 4.1 Mpc. It has been analyzed recently by Leitherer et al (1996) and Kobulnicky & Skillman (1996). The galaxy shows a central bar with several star-forming knot clearly visible in Hα images as well as incipient spiral arms. NGC 4214 is a relatively gas rich galaxy with a important Wolf-Rayet population in the nucleus and a smaller one at a nearby continuum knot (Mas-Hesse & Kunth 1991, Sargent & Filippenko 1991). Leitherer et al. (1996) used HST to study this nuclear region an their UV image reveals the existence of a bright, compact starburst knot surrounded by more than 200 fainte point-like sources.

2. RESULTS

We have obtained twelve parallel transported long-slit red and blue high resolution spectra of NGC 4214 We have used those spectra to produce synthetic maps of several emission lines, continuum points (Fig. 1*a*) an line ratios (see Maíz-Apellániz et al. 1996). In those maps the slits are placed in the horizontal direction an transported in the vertical direction. We have also used the spectra to produce synthetic aperture photometr of Hβ emission, continuum and equivalent width (Fig. 1*b*) of the different star forming regions and to stud the existence of Wolf-Rayet features. Finally, we have analyzed the presence of anomalous kinematical feature in the spectra (Fig. 2).

Over a background with an important population of relatively old stars we have identified severa differentiated regions populated by young massive stars, spread over the central bar of the galaxy. Bubble devoid of gas and shell-like structures have also been found, together with significant gas flows at speeds aroun

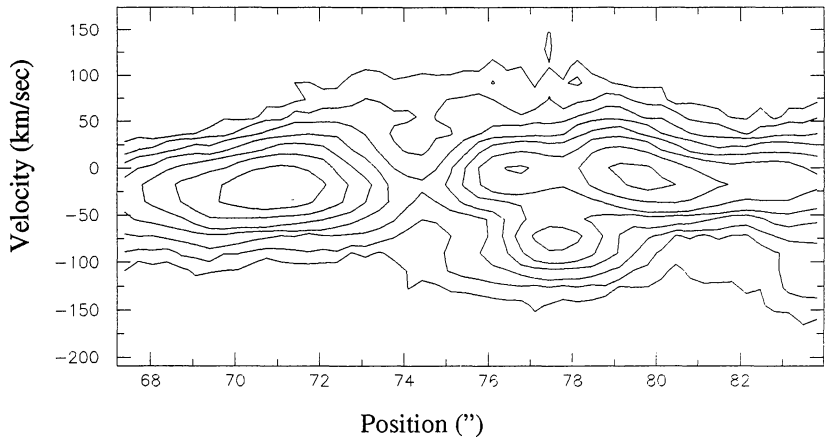

Fig. 2. Red spectrum around Hα plotted as a contour diagram corresponding to the continuum knot region A. The x axis indicates the position along the slit and the y axis indicates the relative velocity with respect to the center of knot A. The eight contours are logarithmically spaced, with a minimum value of 20 and a maximum value of 1000 erg s^{-1} cm^{-2} $Å^{-1}$ $arcsec^{-2}$.

100 km s^{-1}. Although all these regions seem to have experienced star formation processes in the last few million years, their physical properties show that the bursts have not been coeval.

The strongest star-forming complex (NW), located at the nuclear region of the galaxy, experienced a strong burst some 4-5 Myr ago. That age is consistent with the presence of Wolf-Rayet stars and with the measured young population Hβ equivalent widths (~100 Å). The interstellar medium surrounding it has been completely disrupted, with a clear spatial decoupling between stars, gas and dust. The morphology of the region together with the detection of several peculiar kinematical features around it (line splitting, broad emission components) strongly suggest that violent processes (most likely several supernova explosions) have been responsible for the disruption of the region. The decoupling between gas, stars and dust explains the differences in extinction found previously between the stellar continuum and the emission lines: the dust is concentrated at the boundaries of the ionized region, affecting mainly the nebular emission lines, but only weakly the stellar continuum, which itself is located in a region free of dust and gas.

Another strong star formation episode seems to have taken place at the SE extreme of the central bar of NGC 4214 more recently (around 3 Myr ago), as indicated by several measurements: Wolf-Rayet stars are detected but the young population Hβ equivalent width is higher ($\approx$ 215 Å) than in the NW complex. Also, the interstellar medium is less disrupted, with the stars located at the points where the gas emission is maximum and with dust clouds apparently close to them. Finally, no peculiar kinematical features are detected so violent processes do not seem to have played an important role yet in the evolution of this star-forming complex.

The distance between both complexes makes it very unlikely that the starburst in the NW region could have triggered the episode in the SE region. Also, a possible interaction with another galaxy would have likely produced coeval starbursts located at different points in the galaxy, rather than two episodes located in the bar with a 1-2 Myr age difference. Therefore, the most likely origin for both star forming complexes is the existence of dynamical instabilities in the bar.

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