THE EFFECT OF MASSIVE STARS ON THE IONIZED MEDIUM OF EXTRAGALACTIC HII REGIONS

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I. Introduction

Giant extragalactic HII regions (GEHR) are centers of active star formation, ionized by populous clusters of OB stars. These objects are characterized by their low electron density ($N_e \approx 10^2$ cm^{-3}), linear dimensions of order of 10^2 - 10^3 pc, varied morphology and inhomogenous distribution of the gas (Kennicutt 1984). They are ideal laboratories to study the processes of interaction between the gas and the stars, that could then be extended to the study of HII and starburst galaxies. In collaboration with C. Muñoz-Tuñon and J. Vilchez (IAC), R. Terlevich (RGO) and M.V.F. Copetti (U. Santa Maria, Brasil), we are conducting an observational program on a selected group of giant HII regions with the use of one- and two-dimensional spectroscopy. Our aim is two-fold: to understand the internal structure of the regions and to study the kinematics and dynamics of the ionized gas. In this paper I give a short report of our ongoing research.

II. The Kinematics of the Ionized Gas

Giant extragalactic HII regions show supersonic line widths in their emission lines (Smith and Weedman 1970). The normal dynamical evolution of an HII region can not provide the observed internal energy in the form of supersonic mass motions (10^{51} ergs for a typical region) and several solutions for the source of random motions have been suggested, as for example virial equilibrium between the gas and the stars and stellar winds (Terlevich and Melnick 1981; Rosa and Solf 1984). To understand the source of the turbulent motion in the gas new observations with high spatial and spectral resolution are required.

Two-dimensional imaging spectroscopy in the lines of Hα and [OIII]λ5007 were obtained for a sample of regions in the Local Group using TAURUS II, the Fabry-Perot imaging spectrograph at the Cassegrain Focus of the 4.2m William Herschel Telescope at the Roque de los Muchachos Observatory, with the Image Photon Counting System (IPCS) as detector. The two-dimensional imaging spectroscopy allows the mapping of the velocity field over the entire extent of the HII regions.

A preliminary analysis of the data reveals that systematic motions in the form of velocity gradients have been observed in our velocity maps, confirmed by comparison of velocity maps in different emission lines. An example is NGC 588, and "egg-shaped" nebula in M33. The velocity map in the [OIII]λ5007 line shows a gradient of the order of 25 km s^{-1} between the inner and the outer zones. This is also the area where the dispersion along the line of sight is larger. Most previous kinematical studies were based on line profiles integrated over the whole of the region. That could explain why large aperture spectra sometimes shows a non-gaussian profile (Arsenault and Roy 1986).

The effect of the massive stars on the kinematics of the regions is not only limited to the turbulent motions of the gas. Supernova remnants within the complexes and the stellar winds from massive stars should accelerate gas to high velocities. We have conducted a systematic survey for the detection of high velocity gas at low intensity levels, with the use of CCD detectors, long slit spectroscopy, and high signal-to-noise ratio. Observations in the Hα line over ten regions associated with M101, M51, NGC6822 and NGC4861 only yielded one successful detection in NGC 5471: we detected a very broad (FWZI > 3000 km s^{-1}), low intensity ($\leq$ 2 % of line peak) for the Hα + [NII] doublet; a similar spectral feature has been reported recently in NGC 2363 (Roy *et al.* 1992). In both cases there is no conclusive evidence for the source of high velocity gas. The second part of this survey includes the regions of M33 and will be published in a forthcoming paper.

III. The Internal Structure of GEHR

To study the internal structure of the giant complexes, we have measured also the density gradient within HII regions (Castañeda, Vilchez, and Copetti 1992). The local density was obtained from the relative intensity of the [SII]$\lambda\lambda$6717,6731 doublet, measured with very high signal-to-noise ratio. In those regions where a density gradient has been found (as, for example, in NGC 5461), the measured density always peaks at the position of maximum surface brightness.

Theoretical models for the evolution of the insterstellar medium sourrounding massive stars predict that stellar winds and (sequential) SN explosions can blow a hot superbubble, and push out a large supershell of ionized gas. Since the gas in the superbubble will be too hot to emit in the optical range, a depression in the profile of the Hα flux should be expected to some extent but that is not observed in our data. There are several possible explanations for the discrepancy between our observations and the "superbubble" theory. The most likely situation is that the ionizing clusters are actually too young to reach the point of supernova explosions and develop the superstructures predicted by the models. For typical values of the mechanical luminosity L_w of order 10^{38} ergs s^{-1}, (where L_w is the total wind power of the whole association), the radius R of the corresponding wind-driven bubble can be written as $R = 269\ t_7^{0.6}\ n_o^{-0.2}$ pc, where t_7 is the time in units of 10^7 yr, and n_o is the density (cm^{-3}). The measured density in the brightest knots of NGC 5471, NGC 5461, NGC 5447 and NGC 5457 is of order 300 cm^{-3}. For this density value and time t_7 = 1 to 2, we would expect typical shell diameters of 5 to 10 arcsecs at the distance of M101. The presence of these structures in the regions is ruled out by the observations, and therefore, the most likely explanation of this fact should be that the ionizing clusters are very young and have not had time to develop large shells structures.

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