*RevMexAA (Serie de Conferencias)*, **11**, 69–70 (2001)

# DETECTION OF PHOTODISSOCIATED GAS TOWARD THE H II REGION GGD 12–15

Yolanda Gómez, Mayra Lebrón, Luis F. Rodríguez, Susana Lizano, and Vladimir Escalante

Instituto de Astronomía, UNAM, Unidad Morelia, Mexico.

Guido Garay,

Departamento de Astronomía, Universidad de Chile, Chile.

Jorge Cantó

Instituto de Astronomía, Universidad Nacional Autónoma de México

RESUMEN

En este trabajo presentamos observaciones de radiocontinuo (2, 3.6, y 20 cm) y línea (H I 21 cm, H92$\alpha$, C92$\alpha$) hechas con el VLA hacia la region H II cometaria cerca de las nebulosidades ópticas GGD 12–15. Las observaciones de línea de recombinación de hidrógeno muestran que la región H II se encuentra en la fase de champagne. Se detectó emisión de la línea de 21 cm del hidrógeno y de la línea de recombinación de carbono, C92$\alpha$, hacia la región H II con velocidades similares a la de la nube molecular. Tanto la emisión de 21 cm del H I como la de C92$\alpha$ se interpretan como provenientes del gas fotodisociado que rodea a la region H II. Usando un modelo isotérmico para regiones fotodisociadas hemos estimado los parámetros físicos de la región fotodisociada.

ABSTRACT

We present VLA continuum (2, 3.6 and 20 cm) and line (H I 21 cm, H92$\alpha$ and C92$\alpha$) observations toward the cometary-like H II region near the optical nebulosities GGD 12–15. The hydrogen recombination line (RRL) observations show that the ionized gas is undergoing a champagne flow. The carbon RRL and the 21 cm emission detected toward the H II region have line center velocities similar to the velocity of the ambient molecular cloud. Both the carbon RRL and H I emissions are interpreted as arising from the photodissociated gas around the H II region. Using an isothermal model for photodissociated regions (PDRs) we estimate the physical parameters of this region.

*Key Words:* **ISM: H I REGION — ISM: H II REGIONS — RADIO: SOURCES — RADIO: RECOMBINATION LINES**

The compact H II region located near GGD 12–15 was first detected by Rodríguez et al. (1980), estimating to be excited by a B0.5 ZAMS star with a luminosity $\sim 10^4\ L_\odot$. Its radio continuum spectrum between 1.4 and 23 GHz is flat (Rodríguez & Cantó 1983), indicating optically thin ionized gas in that wavelength range. This H II region is located in an active star forming region embedded in the Monoceros molecular cloud, at a distance of $\sim$ 1.0 kpc (Racine & van den Bergh 1970; Rodríguez et al. 1980). High angular resolution radio continuum observations made at several frequencies have revealed a cometary morphology compact for the H II region (Kurtz, Churchwell & Wood 1994; Tofani et al. 1995; Gómez et al. 1998).

The main goals of this work are: to understand the relation between the neutral and the ionized medium, to accurately determine the physical conditions in the photodissociated region and to investigate the origin of the cometary structure of the H II region in GGD 12–15. All observations were carried out using the Very Large Array (VLA) of the NRAO (National Radio Astronomy Observatory). From the 3.6 cm data we observe that the H II region exhibits a cometary morphology with flux consistent with ionization by a B0.5 ZAMS

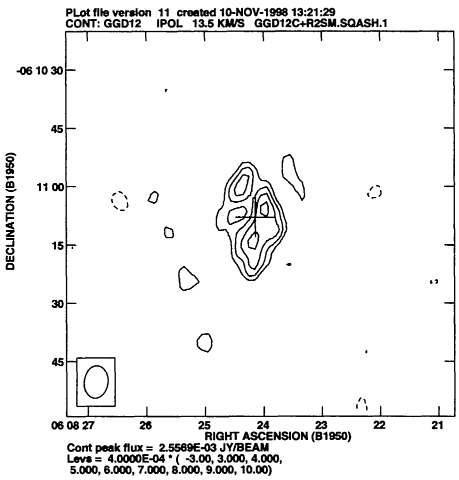


Fig. 1. Integrated C110$\alpha$ emission map toward the H II region GGD 12–15. The cross indicates the radiocontinuum peak position.

star ($L_\star \sim 1.1 \times 10^4\ L_\odot$) embedded in the molecular cloud. The velocity of the ionized gas at the head of the cometary region is similar to the velocity of the ambient molecular cloud ($\sim$ 11 km s$^{-1}$), and increases toward the tail where it reaches a velocity of $\sim$ 15 km s$^{-1}$. From the observed kinematics and morphology we suggest that this H II region is undergoing a champagne flow. Using the line-to-continuum ratio of the H92$\alpha$ line and non-LTE modeling, we estimate an electron temperature and density of $6700 \pm 700$ K and $1.5 \times 10^4$ cm$^{-3}$.

Emission in the C92$\alpha$ line was detected in the velocity range from 9 to 15 km s$^{-1}$. From a Gaussian fit we find that the line is centered at 11.9 km s$^{-1}$ and has a line width (FWHM) of 4.7 km s$^{-1}$. We suggest that the C92$\alpha$ emission detected toward the H II region is arising from the photodissociated region around it since the $C^+/H^+$ ratio is orders of magnitude higher than the cosmic C/H ratio and the central velocity of the C92$\alpha$ line is similar to the ambient molecular cloud velocity. It is known that stimulated amplification of the background continuum from the H II region contributes significantly to the carbon line emission (Garay et al. 1998). Recent observations of the C110$\alpha$ line toward this H II region (see Fig. 1) show a size of $\sim 22''$ and appears outside the H II region ($\sim 2''$) suggesting spontaneous emission.

In these environments, atomic hydrogen is the result of photodissociation of $H_2$ by UV radiation. Observations of the 21 cm H I line are not easy to do because of the confusion problem in the galactic plane. We detected H I radiation toward GGD 12–15 within a region of $\sim$23" (0.1 pc). The 21 cm H I spectrum toward the H II region shows a P-Cygni-like profile. The absorption component has a central velocity of 11.7 km s$^{-1}$ similar to the velocity of the ambient molecular cloud and lies in front of the H II region. The H I in emission has a central velocity of 15.4 km s$^{-1}$ and peaks to the east of the H II region, probably coming from the PDR that is accelerated toward the lower density regions as is the case for the ionized champagne flow. Using the 21 cm H I data observations and an isothermal PDR model (Escalante et al. 1999, in preparation) we estimate an excitation temperature of $\sim$330 K, a hydrogen column density of $\sim 6 \times 10^{21}$ cm$^{-2}$, an H I density of $\sim 1.5 \times 10^4$ cm$^{-3}$ and a H I mass of $\sim 5\ M_\odot$. The mass in photodissociated hydrogen is about three orders of magnitude larger than the mass in ionized hydrogen ($\sim 2 \times 10^{-3}\ M_\odot$).

## REFERENCES

Garay, G., Gómez, Y., Lizano, S., & Brown, R. 1998, ApJ, 501, 699
Gómez, Y., Lebrón, M., Rodríguez, L. F., Garay, G., Lizano, S., Escalante, V., & Cantó, J. 1998, ApJ, 503, 306
Kurtz, S., Churchwell, E., & Wood, D. O. S. 1994, ApJS, 91, 659
Racine, R., & van den Bergh, S. 1970, in IAU Symp. 38, 219
Rodríguez, L. F., & Cantó, J. 1983, RevMexAA, 8, 163
Rodríguez, L. F., Moran, J. M., Ho, P. T. P., & Gottlieb, E. W. 1980, ApJ, 235, 845
Tofani, G., Felli, M., Taylor, G. B., & Hunter, T. R. 1995, A&AS, 112, 299

# Focal Point 4a:

## Stellar Populations

José Franco