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Deep Hα Survey of the Milky Way

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Abstract. An Hα Survey of the Milky Way is being led at La Silla with a small telescope equipped with a scanning Fabry-Perot interferometer and IPCS. This Survey gives detailed Hα maps with a 9" spatial resolution and radial velocity maps with a 5km/s resolution. About 200 fields (38'x38') have been already observed along the galactic plane. They furnish mosaics ranging from galactic longitude 234° to 350°. Combined with distances of exciting stars and radio data our kinematic data of the ionized gas enable to draw precisely the spiral arms of our Galaxy. Examples of the results obtained are given for galactic longitudes 234°, 283°, 290°, 298°, 328° and 338°.

Introduction

In 1990 we began an Hα Survey of the Milky Way to study in detail complexes of HII regions. A 36cm telescope equipped with a scanning Fabry-Perot interferometer and a photon-counting camera was installed at La Silla (ESO). This instrument, together with its acquisition and real time data reduction system has been fully described by Amram et al. (1991) and le Coarer at al. (1992). Spectral information is obtained in each of the 256x256 pixels of the 38'x38' field.

The aim of this Hα Survey of the Galaxy is to precise the design of the spiral structure traced by HII regions. A first sketch of this spiral structure has been already proposed by Georgelin and Georgelin (1976) but was only based on the brightest HII regions and needs to be confirmed and completed.

The high sensitivity and wide angle provided by our instrument allow to study in detail not only the individual HII regions but also the diffuse emission of ionized hydrogen all along the Milky Way. This faint emission allows to find the connection between sources (Hα or radio) forming the large complexes designing the spiral arms or to identify the signature of the crossing of a spiral feature not seen at radio wavelengths.

We choose to select areas covering mosaics of 10 to 20 fields along the galactic plane (Marcelin et al. 1994). No one of the areas studied up to now is void of ionized hydrogen, moreover the line of sight crosses regions with different radial velocities almost everytime. The aim is to find the distance and extension of each of these emissions.

Whenever the photometric distance of exciting stars within a given HII region is unknown its distance is derived from the radial velocity of its Hα emission using a model of the rotation of our Galaxy. Fig.1 shows isovelocity lines in the plane of our Galaxy for the mean rotation curve of Brand and Blitz

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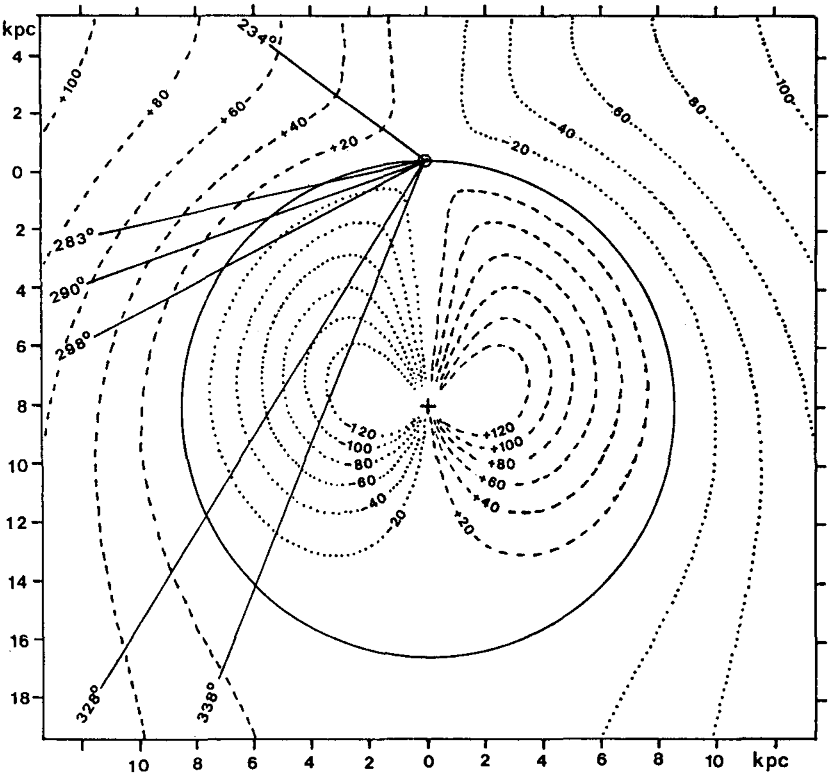

Figure 1. Isovelocity lines in the galactic plane for the mean rotation curve of Brand & Blitz (1993). The lines of sight studied here are indicated.

(1993) with $\Theta_0 = 220$ km/s and $R_0 = 8.5$ kpc. One can see that for a line of sight aiming at a given longitude the observed radial velocity gives the value of the kinematic distance (two values are possible when observing the inner part of the Galaxy). However in our Galaxy, likewise in other galaxies, there are local deviations from the circular rotation. It is thus necessary to connect kinematic distances with photometric stellar distances as well as possible. In this purpose we collect distances in the literature for OB stars likely to ionize HII regions and try to define along the line of sight a relation "average velocity of the gas versus stellar distance". Of course this is only possible for not too large distances, those measurable through spectrophotometric ways.

The velocity used for determining the kinematic distance must be the systemic velocity of the studied region. Some HII regions display peculiar motions or turbulent motions. That is why we make a detailed kinematic study of each HII region and, whenever possible, connect this study with that of the associated molecular cloud.

Radio data from the recombination line of ionized hydrogen complement the Hα data since they are not absorbed by interstellar dust and enable reaching large distances (Caswell & Haynes 1987). However they are only concerned with bright emission sources and ignore faint diffuse emissions. Moreover radio velocities are measured from profiles integrated over a 4 arcmin area centered on the maximum intensity of the source at radio continuum.

Both $H\alpha$ and radio data about ionized hydrogen are combined with CO data about molecular clouds (Grabelsky et al. 1988, Bronfman et al. 1989) in order to distinguish the large gaseous complexes, those tracing at best the spiral structure of galaxies.

We plotted on Fig. 1 the lines of sight studied hereafter.

l = 234°

The line of sight aims at the outer part of the Galaxy. The HII regions seem isolated and most of the exciting stars are known. The detailed study of the $H\alpha$ profiles reveals two faint emission components with velocities around 16 km s^{-1} and 44 km s^{-1}. Their intensity ranging from the geocoronal $H\alpha$ emission to one quarter of this emission. The first layer of gas observed seems to be connected with the HII region S302 found at the same velocity and for which an exciting star is known at 2 kpc. According to their velocities the HII regions S 299, S 300, S 306 and S 309 are situated in the second layer of gas associated with a molecular cloud around 4.2 kpc (average of the distances of the exciting stars). As for S 305 and S 307 their average velocity, around 37 km s^{-1} suggests at first that they do not belong to the same complex. However their $H\alpha$ profile may be split into two components, one main component at 43 km s^{-1} (that of the large complex) and a secondary one at 33 km s^{-1}, as if it were flowing out of the molecular cloud with a relative velocity of 10 km s^{-1} toward the observer. This could be explained by a "champagne" effect, with S 305 and S 307 really belonging to the same complex as the other HII regions.

l = 283° and 290°

At these longitudes the line of sight follows the Sagittarius-Carina spiral arm on a long distance (tangential to the outer part of the arm at 283° and to the inner part at 290°). The problem is quite complicate since the HII regions seemingly forming a single complex are in fact at various distances.

At l = 283° a general diffuse $H\alpha$ emission is found all over the area at V_{LSR} = 8 km s^{-1} whereas the individual HII regions exhibit velocities ranging from -15 km s^{-1} up to 20 km s^{-1}.

At l = 290° a component with V_{LSR} = -25 km s^{-1} at 3 kpc is seen all over the area. Three other components, corresponding to more distant gaseous complexes are found at V_{LSR} = 5, 15 and 22 km s^{-1}, in order of increasing distance.

l = 298°

The line of sight crosses the Sagittarius-Carina arm in 2 points at very different distances and perhaps reaches the Scutum-Crux arm tangentially between these 2 points. The main radiosources of this area have positive H 109α radial velocities (Caswell & Haynes 1987) corresponding to distances larger than 10 kpc (with a flat rotation curve). Almost all of these distant radiosources are detected on our $H\alpha$ Survey, behind a faint nearer ionized emission layer.

l = 328°

The line of sight theoretically crosses several spiral arms at this longitude. How-

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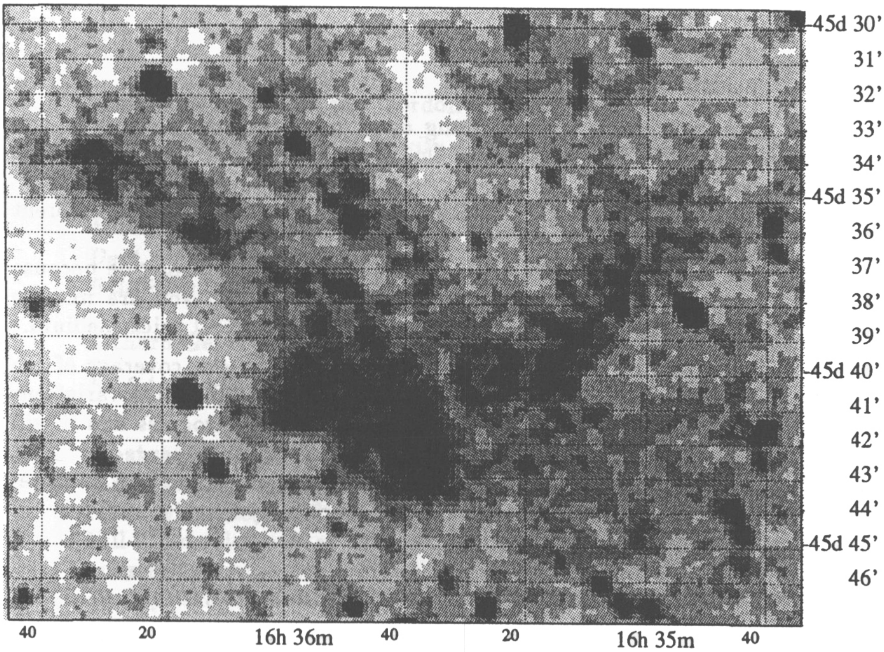

Figure 2. Hα detection of the radiosource 338.742+0.641.

ever up to now all of the optical HII regions observed in this direction seemed to belong to the same group located inside the Scutum-Crux arm. Our Hα observations bring interesting new informations (Georgelin et al. 1994). First of all we find a faint Hα component at V_{LSR} = -20 km s^{-1} all over the observed area. It appears reinforced around exciting stars at 1 kpc. This component had never been detected before, neither at optical wavelengths nor at radio wavelengths, and probably marks the Sagittarius-Carina arm at this longitude. Consequently the second gas layer around -40 km s^{-1} together with the HII regions RCW94, 95 and 98 (at the same velocity) all belong to the following spiral arm (Scutum-Crux). Other HII regions and associated radiosources have V_{LSR} around -47 km s^{-1} and probably are seen behind the previous group although probably belonging to the same arm. A more distant radiosource, with V_{LSR} = -72 km s^{-1}, has been detected at Hα wavelength for the first time behind all the emission layers mentioned here above.

l = 338°

Fig. 2 shows the radiosource 338.742 + 0.641 at V_{LSR} around -62 km s^{-1} (Caswell & Haynes 1987) detected at Hα wavelength. It appears as a bright HII region with a well defined shape and probably belongs to the third arm mean-

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while the crossing of the two first arms only appears as faint diffuse emissions without any outstanding feature.

Discussion

Ph. Stee: Have you made spectra along one (or more) arm because it can be interesting to follow the variation of the line profile when you are crossing different iso-radial regions ?
If the model you used is right the variation must follow roughly these different iso-radial regions.
If the variations of the profiles are quite difficult to interpret it may be because you are observing a line which is not optically thin and so you are missing kinematical effects with radiation transfert effects in an optical thick medium.

M. Marcelin: Indeed this survey enables an almost continuous coverage of the Milky Way along the Galactic disk so that it is possible to follow the variations of the line profile along any given arm. But the work is in progress and it will take years before having the detailed analysis for each arm.
Concerning the analysis of the profiles there is no problem about the interpretation since the Hα emission we are looking at is optically thin.

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