36. A NEW INTERPRETATION OF THE GALACTIC STRUCTURE FROM H II REGIONS

G. COURTÈS, Y.P. and Y.M. GEORGELIN, and G. MONNET
Observatoire de Marseille, Laboratoire d'Astronomie Spatiale, Marseille, France

Abstract. From 6000 optical radial velocities of H II regions a new spiral structure (4 arms of pitch angle 20°) is found. The radial velocities of the observed H II regions are the same with the velocities of the H I regions. The kinematics of H II regions is similar to that of Cepheids and B stars.

A number of radial velocities of H II regions were first obtained by Courtès (1962, 1960); later Courtès *et. al.* (1968) collected 4000 optical radial velocities of 150 H II regions. Now, 6000 optical velocities have been measured and will be presented elsewhere (Georgelin, 1969). Figure 1 and Figures 2 and 4 of Courtès *et al.* (1969) show a comparison with recent surveys at 21 cm. There is a very close agreement between Hα velocities and the main maxima of the 21-cm line (as found by Courtès in 1959). The position of the main body of each spiral arm is then well defined from the distances of the H II regions. Those distances are, of course, those of the exciting stars which have been determined by spectrophotometric studies (Becker, 1963; Lyngå, 1964–65; Georgelin, 1969).

Radial velocities and spectrophotometric distances of H II regions give a model of the rotation curve of the Galaxy which is identical to the Schmidt curve (Courtès *et al.*, 1968). This agreement between the two rotation curves (Figure 5 of Courtès *et al.*, 1969) indicates that H II regions have the same rotational velocities as other population I components such as bright cepheids and neutral hydrogen. The constants of the solar motion (U_0, V_0, W_0), of the galactic rotation (A), and of the expansion (c and k) have been computed by the same method used by Kraft and Schmidt (1963) for the cepheids. The results of Georgelin (1969) are compared (Table 1 of Courtès *et al.*, 1969) with those of Kraft and Schmidt (1963) for the cepheids and those of Feast and Shuttleworth (1965) for the B stars.

The conclusion of a pitch angle of 20° (Courtès *et al.*, 1968) is of course in contradiction with the nearly circular arms given by the classical 21-cm model of Oort *et al.* (1958), but agrees with the details of the 21-cm data themselves, and we feel that this shortcoming of the earlier model is due to a misinterpretation of 21-cm data:

Kinematic distances inferred from 21-cm radial velocities are correctly defined only at angular displacements greater than 20° from the centre-anticentre direction. The existence of such an indeterminate sector leads to a fundamental ambiguity in the connection of the two fractions of each spiral arm across this sector. One can join, e.g., the Carina arm to the Cygnus arm (pitch angle 0° – 21 cm model) or to the Sagittarius arm (pitch angle 25° – optical model). In four sectors only, the distance of spiral arms is well known from radial velocities. But the pitch angle can only be marginally defined because this sector is too short in longitude (60°) and the precision of the kinematic distances at the extremity of each sector which defines the inclination.

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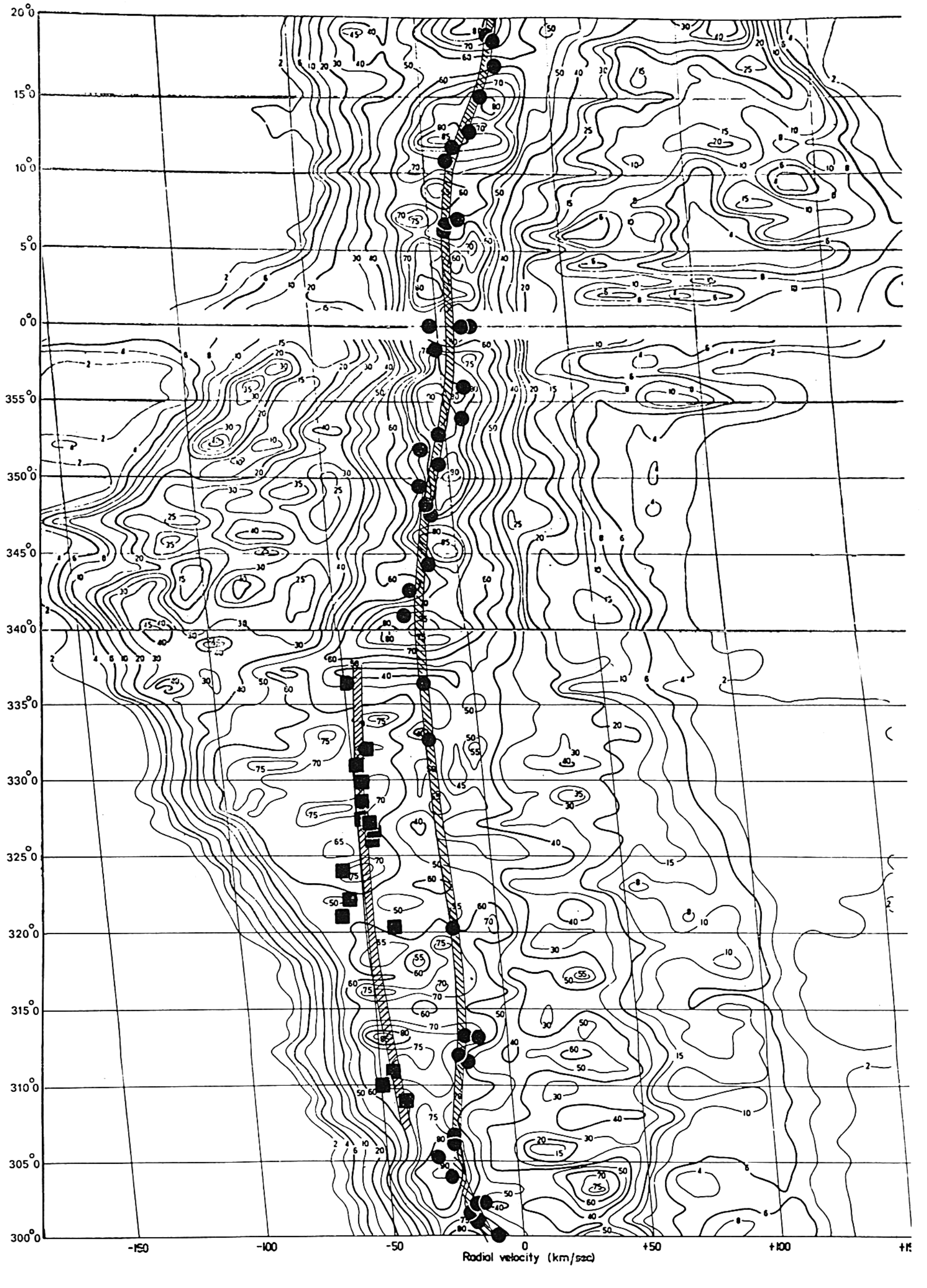

Fig. 1. Comparison between velocities of H I and H II regions. —— H I data from Kerr and Hindman (1966), Kerr (1969). ●■ H II data from Courtès (1960) Cruvellier (1967) and Georgelin (1969). ● Sagittarius-Carina arm. ■ Norma-Centaurus arm.

On the other hand, spectrophotometric distances for H II regions can be used through the full longitude range. In particular, a clear morphological continuity is obtained for an inner spiral arm reaching from Carina to Sagittarius. Because of this linear continuity, the distance of this arm can also be obtained by the slope of the differential rotation curve in the longitude range 0° – 33° (Cruvellier, 1967) and this distance agrees quite well with the photometric distances.

With this interpretation of 21-cm data, no large discrepancy remains. In the 305–333° range 21-cm observations give a broad H I distribution from 1 to 4 kpc which was interpreted differently by Oort *et al.* (1958) and Kerr and Westerhout (1965). On the other hand, H II regions give a clear separation between two arms at respectively 1.5 and 3.5 kpc.

From those data, four spiral arms can then be drawn with confidence (Table I and Figure 2).

TABLE I

Data on the four nearest spiral arms

Spiral arm	Longitude range (l^{II})	Distance	Remark
+I	103°–190°	3 kpc at 120°	Very conspicuous
Perseus	Sharpless 132 Early type stars		Between 140° and 168°
0	59°–254°	0.5 kpc at 180°	Quite poorly defined
Orion	NGC 6820 Rodgers 19		The sun is located at the inner edge of the arm
−I	274°–32°	1.5 kpc at 330°	Well defined
Sagittarius	Rodgers 42 Sharpless 69		
−II	305°–333°	3.5 kpc at 330°	Clearly separated
Norma	Rodgers 74 Rodgers 106		From the Sagittarius arm

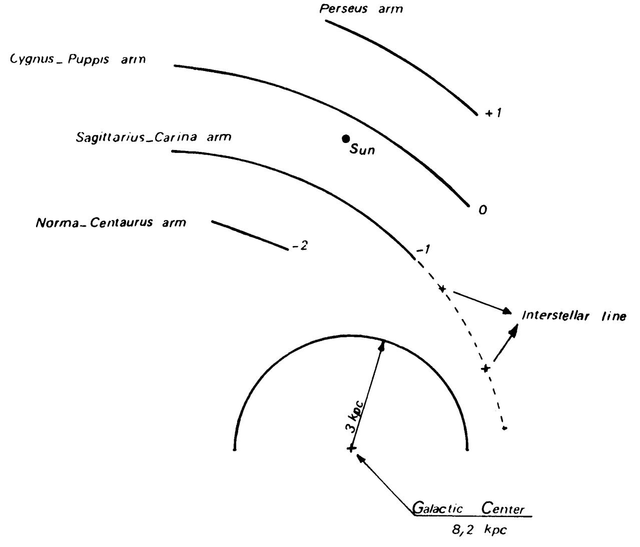

Fig. 2. Schematic sketch of galactic spiral arms.

It is particularly interesting that during this Symposium Dr. Weaver has presented a new interpretation of 21-cm radial velocities, which seems to be in close agreement with the spiral structure presented above – and thus strengthens this result.

The details of this work will be published by Courtès and Georgelin in *Vistas in Astronomy* (1970).

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