Abstract. The spiral structure of the inner parts of the Galaxy is studied using 21 cm line data and stellar data. To study the neutral hydrogen distribution in the galactic layer a parameter \( \eta = \tau \left( \frac{dV}{dr} \right) \) proportional to the mean densities is calculated using a first approximation for the velocity gradients due to differential rotation.

The obtained distribution \( \eta(R, Z) \) shows spiral features completely consistent with the early star distribution and with the \( \text{H} \text{II} \) regions. The corrugation effect of the galactic layer is observed in all the studied zones in neutral hydrogen and in the distribution of the OB stars in the Carina zone.

The pattern obtained indicates four spiral arms for the inner parts of the Galaxy, three of which are identified also in the stellar data (arms -I, -II, and -III) and the more distant -IV in \( \text{H} \text{II} \) regions.

The local arm according to the stellar data of Kilkenny et al. forms a feature completely similar to the arms -I and -II and there are no indications that this arm is a special material branch between two main spiral arms as has been supposed in order to conciliate the neutral hydrogen pattern with the stellar distribution.

The pitch angles for the spiral arms are approximately 13°–17°.

The observed wave form distribution of the hydrogen cloud layer is completely consistent with the theoretical predictions of Nelson (1976) but there are no indications of such an effect in the inter-cloud hydrogen. The corrugated cloud layer has a width of 100 pc, a wave amplitude of 70 pc, and a wavelength which grows with the galactic center distance (approx. 2 kpc in the zones next to the galactic nucleus and 2.6–3.0 kpc in the zones next to the Sun). To each wavelength correspond two spiral arms. The spiral features in our Galaxy show characteristics quite similar to the features in the Andromeda nebula, not only in the component materials (neutral hydrogen, \( \text{H} \text{II} \) regions and possibly also dust and stars) but also in their kinematics.

1. Introduction

In previous studies of the structure of our Galaxy a question that was not elucidated was the relation between the spiral structure observed in young stars in the zones relatively near to the Sun, and the spiral structure suggested by 21 cm line results. As one can see in the literature (Kerr, 1970; Weber, 1972) the 21 cm line picture for the inner parts of the Galaxy present two spiral arms, Sagittarius and Scutum located approximately at 8 and 5 kpc from the galactic center. From such a picture it is also suggested that a low pitch angle for the arms is in agreement with Lin’s (1969) theory in which approximately 6° is adopted. As the observed tilt in the local spiral arm is approximately 15° it was supposed that such a feature is a material branch formed by stars between the main spiral features in the pattern. This might be reasonable if one observed low pitch angles for the other spiral arms, but according to the results of Kilkenny et al. (1975) and Schmidt-Kaler (1975) these present tilts quite similar to the
local arm. On the other hand the mean distance between the optical arms is approximately 1.5 kpc while neutral hydrogen results suggest 2.5–3.0 kpc.

As we will see below, these discrepancies arise from the fact that spiral features have been usually associated with the maximum line intensity zones. This is not strictly correct: maximum line intensities do not necessarily mean maximum hydrogen densities. The line intensities depend also to a high degree on the velocity gradients in the neutral hydrogen: according to Rohlfs (1974) the intensities for the intercloud medium depend mainly on the inverse of the gradients in the galactic velocity field, while for the clouds, the gradients due to their intrinsic velocity dispersions predominate.

Another factor that one must take into account is the difference in the spatial distribution of both components of the neutral hydrogen. The cloud medium is a narrow layer of 100 pc width with a wave form distribution inside the galactic stratum formed by the intercloud medium which is three or four times wider and symmetrically distributed with respect to the galactic plane. There are no indications of wave form distribution for such a stratum and its spiral features are much less well defined than in the cloud layer (see Quiroga, 1974, 1975). It means that in order to study the spiral features we need to know not only the hydrogen intensity distribution inside the galactic stratum but also the velocity field in the Galaxy. We can thus calculate, at least in a first approximation, the relative distribution of hydrogen densities in such a stratum.

As is known from the literature, the hydrogen density \( n_H \) can be evaluated as a function of the optical depth \( \tau \) and the spin temperature \( T_s \) (not directly observable) on which depend the observed line intensities measured in brightness temperatures \( T_b \). We have thus:

\[
n_H = 5.95 \times 10^{-4} \tau T_s(K) \left( \frac{dV}{dr} \right)_r \text{ km s}^{-1} \text{ kpc},
\]

\[
T_b = T_s(1 - e^{-\tau}).
\]

The total gradient along the line of sight can be considered as the superposition of two components: i.e.,

\[
\left( \frac{dV}{dr} \right)_r \approx \frac{dV}{dr} + \frac{\sigma}{r_c},
\]

where \( \sigma \) and \( r_c \) are the intrinsic dispersion and the mean diameter of the hydrogen cloud respectively. This intrinsic gradient varies over a wide range and is not easily evaluated due to the complexity in the cloud distribution. We only know that it is a maximum for the dense and massive clouds and a minimum for the intercloud medium (see the Appendix).

The gradients due to the galactic rotation are evaluated to a first approximation from

\[
\frac{AV}{dr} \approx \frac{1}{2} \left( \frac{\Theta}{R} - \frac{\partial \Theta}{\partial R} \right) \sin 2L,
\]

where \( \Theta/R, \partial \Theta/\partial R \) are determined from the observed rotation curve.