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Two Zones of the big circle of the Magellanic stream and their study in the neutral hydrogen radio line at 21 cm

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Abstract. We present preliminary results of observations of two vast Zones of the big circle of the Magellanic Stream carried out at RATAN-600 in the radio line of neutral hydrogen at the 21 cm wavelength. Zone II was chosen as azimuthally oposite to Zone I. A comparison has been made of the character of warps of the Magellanic Stream and of the layer of neutral hydrogen in the Galaxy.

Key words: galaxies: magellanic clouds — radio lines: galaxies

1. Introduction

We demonstrated in our paper (Bystrova, 1995) possible warps in the distribution of neutral hydrogen in a part of the Magellanic Stream. The Stream is usually thought to be a gaseous flow that joins the Big and Small Magellanic Clouds and extending in the direction of the big circle of the Stream.

Beginning in 1996 this part of the Stream was observed again at RATAN-600 with increasing number of sections in declination and was denoted as Zone I. Initial conclusions as regards to Zone I were drawn on the basis of our Pulkovo Survey of the sky in the neutral hydrogen radio line from the charts of results. To avoid image distortions, all the charts were preliminary converted from the galactic coordinate system to a special Magellanic system. It will be noted that observations made with the Big Pulkovo radio telescope made it possible to study for the first time the emission of neutral hydrogen in the direction of the big circle of the Stream at low velocities with respect to the local standard of rest. Then another section of the big circle of the Magellanic Stream, Zone II, was chosen which has the same area as Zone I. The location of the big circle of the Stream in the galactic and equatorial coordinate systems and also the reason for selecting Zone II will be discussed in Section 3. For checking the inferences made in Section 4, observations with RATAN-600 were continued in the winter of 2001.

2. Observations with RATAN-600

The radio telescope RATAN-600 has a knife beam pattern of 2.5 arcmin per 2.5 degrees. 39 spectral channels record a spectrum portion of about 250 km/s. The bandwidth of a channel and the separation of the channels is 6.3 km/s (or 3 kHz). The mean square of fluctuations of the antenna temperature is equal to 0.25 K. The area of each sky Zones is approximately 1000 sq. degrees. The results of observations were the curves of transit of 6–7 hours derived with an interval of 5 degrees in declination and at some additional levels.

Measures were taken to reveal low-intensity signal on the records. The boundaries of Zones I and II in the equatorial coordinates are shown in Fig. 1. Zone 1 was observed for comparison with the data of the Pulkovo Survey of the sky; Zone II is also situated on the big circle of the Magellanic Stream but in the direction azimuthally opposite to Zone I.

3. Description of observational results

Fig. 2 gives an example of the records obtained with RATAN-600 in Zone I. Features of both types are present in them. The features whose half-widths do not exceed 20–30 minutes along the RA axis are details of the structural component of the radiation of galactic neutral hydrogen in this direction. Apart from the details of the structural component, one can also notice broad signals with half-widths of over two hours and an amplitude of a few Kelvins. These emission regions are noticeable on the curves of transit across the Magellanic Stream in at least 5–6 chan-

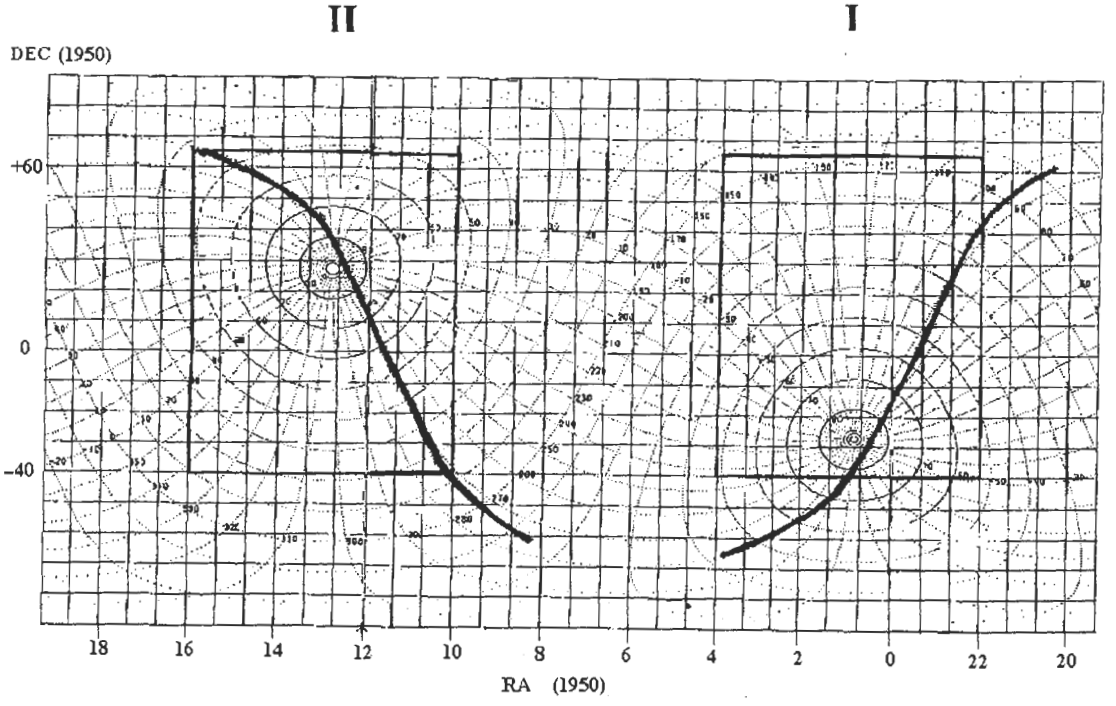

Figure 1: *Zones I and II where observations were made and the big circle of the Magellanic Stream in the equatorial coordinate system.*

nels, which yield a velocity dispersion of 30–40 km/s for broad signals. As one can see in Fig. 2, these signals shift with increasing magnitude of negative velocities towards increasing right ascension (RA). Exactly the same is observed in the galactic radiation of neutral hydrogen for the northern warp (N-warp) in the gaseous disc of the Galaxy. However, the shift in the Magellanic Stream is several times larger than in the Galaxy.

Selection of Zone II for observations. Battaner (1995) gives the following definition of the disc warp: "A disc is said to be warped if there is a smooth and moderate rise in a part of its outer region, accompanied by a descent in the azimuthally opposed region". In order to find the position of the Zone on the big circle of the Magellanic Stream, the location of the circle on the sky map was first calculated (displayed in Fig. 1). The coordinates (in degrees) of the pole and of the ascending node of the big circle were determined in the galactic coordinate system.

$$\begin{aligned} \mathrm{AP} &= 4.053 \\ \mathrm{BP} &= 4.988 \\ \mathrm{AO} &= 290.410 \\ \mathrm{BO} &= -72.783 \end{aligned}$$

The same in the equatorial system is:

$$\begin{aligned} \mathrm{AP} &= 263.31 \\ \mathrm{BP} &= -22.84 \\ \mathrm{AO} &= 17.41 \\ \mathrm{BO} &= -44.11 \end{aligned}$$

As reported by Wannier and Wrixon (1972), the radiation of neutral hydrogen is within 4 degrees from the big circle of the Magellanic Stream. Thus, the coordinates of the Zones are as follows:
Zone I RA — from $-330°$ to $+60°$, Dec — from $-40°$ to $+62.5°$;
Zone II RA — from $-150°$ to $+240°$, Dec — from $-40°$ to $+62.5°$.

Fig. 3 presents an example of transit curves derived at RATAN-600 in observing Zone II.

4. Preliminary discussion of observational results

To determine the position of the plane of maximum warp of the Magellanic Stream visual comparison of the derived sections in the Zones was performed and it was established that it should be referred to the sections at declinations $-20°$ and $+41.25°$ (Figs. 2 and 3). Their positions on the big circle of the Magellanic Stream differ by about 180° when viewed from the north Magellanic pole.

At least in Zone II, emission of neutral hydrogen is seen in the vicinity of the big circle of the Stream, which falls inside the limits of 4° (Wannier, Wrixon, 1972).

It follows from Fig. 3 that a considerable part of emission has a positive radial velocity with respect to

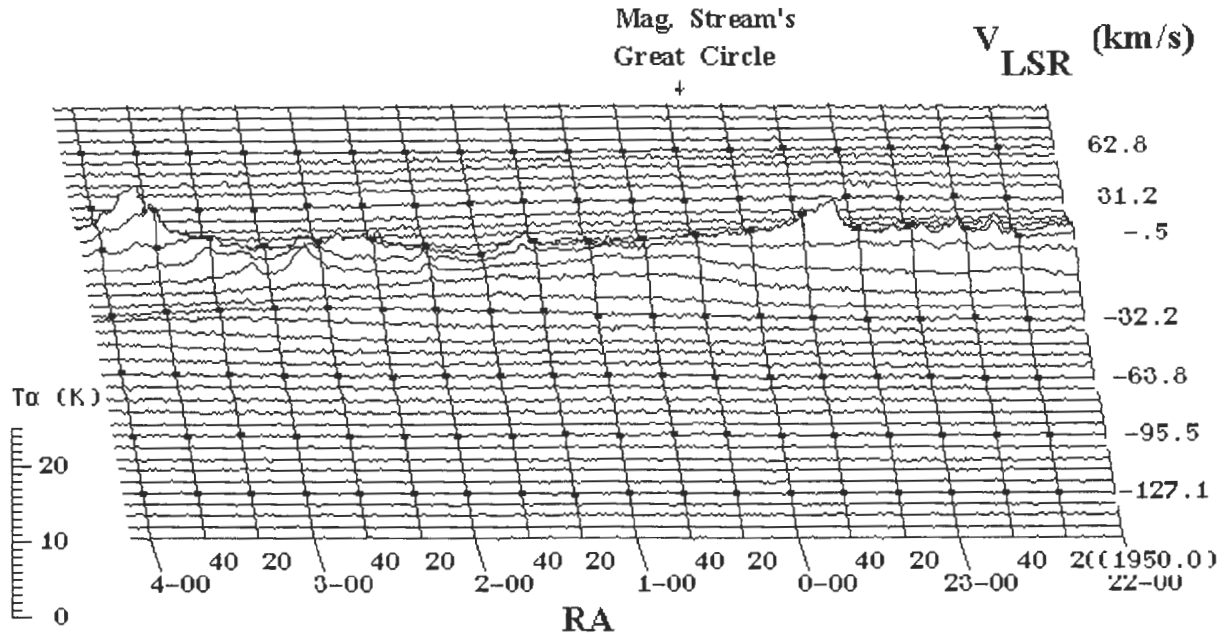

Figure 2: *An example of curves of transit in Zone I, declination is* $-20°$. *The arrow at the top indicates the RA at which intersection of the big circle of the Magellanic Stream occurs. All 39 channels are displayed. Their numbers are ordered from top to bottom.*

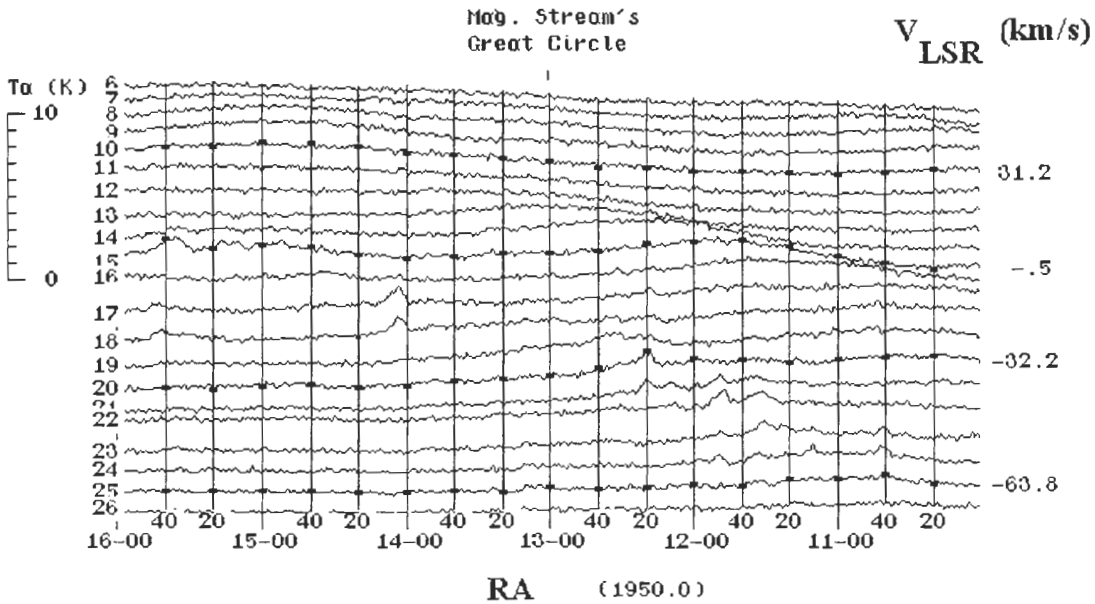

Figure 3: *An example of curves of transit in Zone II, declination is* $41.25°$. *The numbers of the channels are shown on the left. The figure does not show the channels in which no HI emission was recorded.*

the local standard of rest (LSR), while the positions of broad signals are shifted with increasing number of the channel, as compared to Zone I, in the opposite direction, i.e. towards descending right ascension. The shifts are not larger than in Fig. 2, while the velocity dispersion of the signals is somewhat higher than in Zone I. However, both the amplitudes and half-widths of the signals and their shifts are several times those in the gaseous disc of our Galaxy. The galactic gaseous disc and the Magellanic Stream plane

defined from their central parts have azimuthally opposite HI emission north and south of these planes. Estimations show that the shift of the broad signals in Zones I and II is about three times as large in observations of the Magellanic Stream as in crossing the Galactic gaseous disc. In either case these formations are of similar structure, which may suggest that the Magellanic Stream is a gaseous disc nearly perpendicular to the Galactic plane. Note for comparison that the polar ring of the outer galaxy NGC 4650 A is also a gaseous disc (Iodice et al., 2000) from optical observations with the Australian telescopes. After the reduction of all observational data including those of 2001, more rigorous conclusions can be drawn.

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