THE EFFECT OF THE MAGELLANIC CLOUDS ON THE MASS DISTRIBUTION IN THE GALAXY

G. X. SONG
Shanghai Observatory
Academia Sinica
Shanghai 200030
People's Republic of China

ABSTRACT. The disk of the Milky Way suffered from the tidal effect as the Magellanic Clouds were passing by. Numerical stimulations were performed to study the evolution of the mass distribution in this disk. These simulations were run with the galactic disk initially flat, and different sets of the initial position and velocity of the Magellanic Clouds were considered. One of the most conspicuous observational facts is the warp of the disk of the Milky Way. Results show that the characteristics of this warp are related to the orbit of the Magellanic Clouds.

1. Background

Radio observations on HI in the Milky Way show that around the Milky Way's disk there are warped hydrogen clouds like the tilted brim of a hat (Verschuuer, 1976). If the explanation of the warp of hydrogen clouds in our Galaxy relies upon the interaction with the Magellanic Clouds, it will fail, due to the small mass ratio of 0.05 of the two systems.

As there is more mass ratio of HI to stars in the Magellanic Clouds than to that in the Milky Way, the former might be less evolved than our Galaxy. This gives us motivation to study the warp further.

2. Basic idea

As we know, the protogalaxy was born in the expanding Universe. Because of density perturbation in the Universe, the local density in some regions of the Universe grows higher and higher with the lapse of time. As soon as the local density in some regions is several times higher than the background density, this association of mass will stop expanding and become a bound object, a protogalaxy (Gott and Rees, 1975). This protogalaxy will then collapse and the relaxation process will happen. After relaxation, it will settle down and the galaxy will form.

The main idea suggested in this paper is as follows. Our Galaxy formed earlier and has settled down to be a disk galaxy; the Magellanic Clouds formed later, and did not thoroughly settle down when the interaction between our Galaxy and the Magellanic Clouds came into effect. The numerical simulation of the galaxy relaxation tells us that in the process of relaxation, most masses will accumulate around the centre of the galaxy and form some radial density profile, but some mass points will be dispersed a long way from this system (Song and Chen, 1990). When the

R. Haynes and D. Milne (eds.), The Magellanic Clouds, 487–488.

gravitational interaction of the Clouds and Galaxy comes into effect, this dispersed mass will be pulled out of the disk, which provides the Milky Way with a warp.

3. Simulation

A numerical experiment was made to investigate the transfer of mass from the Magellanic Clouds to our Galaxy. The Milky Way has mass $10^{11}M_\odot$ with radius R = 25 kpc. The column density is $\sigma = \sigma_0 e^{-\alpha r}$, where $\alpha = 3.5$ kpc. The height distribution in the disk is $h_0(1-r^2/R^2)^{1/2}$, where h_0 = 200 pc. For simplicity, we consider only the gravitational potential generated by this mass distribution. As the mass ratio of the Magellanic Clouds to our Galaxy is very small, this simplification does not cause much error. The following model for the Magellanic Clouds is the best one to induce the warp.

The Magellanic Clouds are simulated by a spheroid with semi-axes a = 10 kpc, b = 5 kpc, in which the short axis is perpendicular to the disk plane. The centre of this spheroid is 45 kpc from the centre of the disk in the galactic plane and 35 kpc above the disk plane. The mass distribution in this spheroid is uniform. The initial state of this model is in nearly virial equilibrium with small rotation and Gaussian dispersion velocities. The directions of rotation in the disk and spheroid are opposite, induced by the tidal effect in the expanding Universe (Efstathiou and Jones, 1979). At the initial moment, the interaction of the disk with the spheroid is not considered. The relaxation of the spheroid is only taken when the relaxation lasts 8×10^8 yr. At that moment, the mass distribution of the spheroid is dispersed. After that the orbital velocity is given to this evolved system with a vertical velocity 150 km/s and a horizontal velocity 260 km/s towards the centre of the disk.

At the same time, the disk's evolution and interaction with the evolved system is included. Of course, the effect of a dark halo is included. When the evolved system is approaching the disk, the effect of the disk on this system will pull some mass, dispersed in the outer part during relaxation, towards the disk.

From this simple model we might be able to conclude that when a dwarf galaxy interacts with another galaxy, mass transfer can occur in certain cases.

4. References

Efstathiou, G. and Jones, B.J.T. (1979), *M.N.R.A.S.* **186**, 133.
Gott, J.R., III and Rees, M.J. (1975), *Astron. Astrophys.* **45**, 365.
Song, G.X. and Chen, X.M. (1990), *Acta Asyrophysica Sinica* . **10**, 256.
Verschuuer, G.L. (1976), *Astronomy* **4**, No. 12, 6.