THE MAGELLANIC STREAM

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ABSTRACT. This model was devised in an attempt to resolve the discrepancy between the values derived for the mass of the Galaxy from distant satellites and from the Magellanic Stream. In contrast to most previous models, the orbit of the Magellanic Cloud system is *not bound* to the Galaxy, and the Stream was developed as the result of a tidal encounter between M31 and the Magellanic Cloud system about 6 Byr ago.

Lynden-Bell (1988) pointed out that there was a difference of at least a factor of 2 between the values of the mass inferred for the Galaxy out to a radius of ~50 Kpc from the kinematics and dynamics of Galactic satellites, and from the Magellanic Stream. The former is ~ 4 x 10^{11} while the latter is perhaps 1.8 x 10^{12} solar masses. This estimate from the Stream is based on an assumed eccentricity for the orbit of the Magellanic Cloud system about the Galaxy of 0.7 - a typical value in the tidal models of Murai & Fujimoto (1980) and Lin & Lynden-Bell (1982).

The approach taken here has been to assume that the value from the satellites is correct. It can then be shown, using Lynden-Bell's own arguments, that the value of Galactic mass inferred from the Stream is in agreement with this, provided the present orbit of the Magellanic Cloud system is *hyperbolic*, with an eccentricity of ~2.1.

The radial velocity of the Magellanic Cloud system has been reasonably well determined, but the transverse velocity is rather uncertain. In view of the fact that the "tip" of the Stream, represented by the HI concentration MSVI, is not far away in angular position from M31, an additional constraint imposed in this model has been to include the gravitational effect of M31 in such a way that the "timing argument" of Kahn and Woltjer (1959) is preserved, on a timescale for the Universe of ~13 Byr.

Accordingly, the mass of the Galaxy interior to 50 Kpc has been set equal to 3.6 x 10^{11} solar masses to conform to the satellite results, and both the Galaxy and M31 given stiff, extensive, isothermal halos with the total mass ratio being similar to the values adopted in recent work by Lynden-Bell.

The orbital plane of the Magellanic system was assumed to be defined by its centre of mass, the Galactic centre, and MSVI. It was then found that for an assumed Galactocentric transverse velocity of 355 km s^{-1} (Shuter 1990), the orbits of the Galaxy, M31 and the Magellanic system all converged at T=-12.6 Byr, consistent with an origin in a radially expanding metric.

In this attempt to model the Stream test particles were placed in *prograde* circular orbits about the Magellanic Cloud system 12 Byr ago, and these orbits were integrated forward in time to the present. They are shown in Figure 1, which displays a well-defined Stream trailing the Magellanic

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Clouds. In Figure 2 the Galactocentric radial velocities of the model Stream test particles are compared with observational values for the HI concentrations MSI - MSVI. Considering the preliminary state of this model, the results look very encouraging!

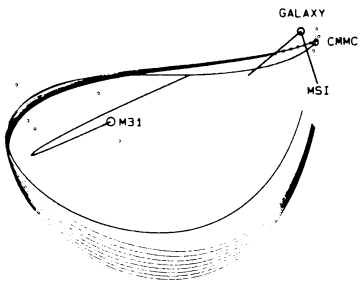

Figure 1. Orbits relative to the Galaxy of M31, the centre of mass of the Magellanic Clouds (CMMC) and test particles comprising the Stream, integrated from 12 Byr ago to the present. The open circles indicate present positions. The viewpoint is the same as in previous studies - i.e. looking back toward the Galactic centre from an infinite distance in the anticentre direction. The North Galactic pole is at the top, and $l = 90°$ at the left. The two diagonal lines from the Galaxy indicate the directions of the HI clouds MSVI and MSI, which define the major extent of the Stream.

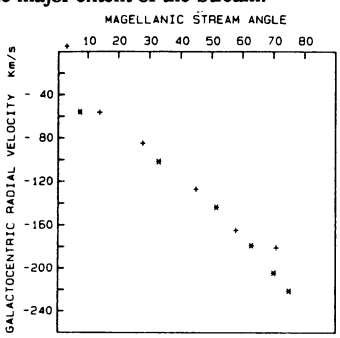

Figure 2. A plot of Galactocentric radial velocity vs Magellanic Stream angle for the test particles shown in Figure 1 (indicated by stars), and the HI clouds MSI-MSVI (indicated by crosses).

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