Part 7. Tidal Interactions

Section B. Poster Papers

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The Magellanic Stream and the History of the Tidal Interaction between the LMC and SMC

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Abstract. Adopting observed proper motions of the MC's and cluster formation histories of the LMC as observational constraints, we found a new binary orbit for the LMC and SMC in which the geometry and kinematics of the Magellanic Stream are well reproduced. In this orbit, the LMC and SMC experienced very close encouters 0.2 and 3 Gyr ago.

1. Introduction

It is widely accepted that the Magellanic Stream (MS) was produced by tidal interaction between the LMC, the SMC and the Galaxy (Murai & Fujimoto 1980; Gardiner et al. 1994; Gardiner & Noguchi 1995). However, the orbit in which the MS was formed has not been uniquely determined because of the lack of observational constraints on theoretical models. Here, we introduce two new observational constraints: the proper motion of the LMC and SMC observed by Hipparcos satellite (Kroupa & Bastian 1997) and the age distribution of star-clusters in the LMC (Girardi et al. 1995) which indicates two enhanced star-cluster formation epoch in the LMC at 0.1 and 3 Gyr ago.

2. Binary Orbits of the LMC and SMC

We searched for binary orbits of the LMC and SMC which endure around the galaxy for more than 10 Gyr, and then investigated the geometry and kinematics of the MS formed in each orbit by using test-particle simulations. We assumed a flat rotation curve for the Galaxy and used the present transverse velocities of the Clouds and the direction of the spin axis of the SMC as free parameters.

We first selected binary orbits of the LMC and SMC in which the geometry and kinematics of MS are well reproduced. Next, we checked whether or not the adopted model values of the present transverse velocities of the Clouds coincide

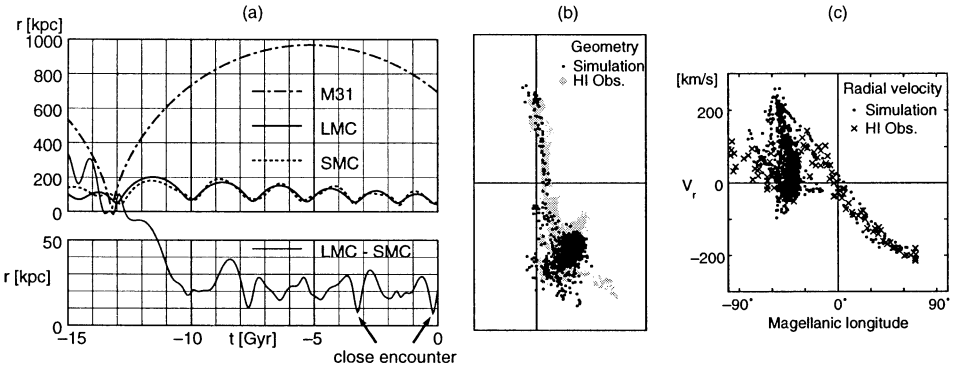

Figure 1. Our best model. (a) The time variation of the Galaxy-M31 and Galaxy-Magellanic Clouds distances. The LMC-SMC distance is given in the lower panel. (b) The geometry of the MS. (c) The radial velocity distribution of the MS along the Magellanic longitude.

with proper motions measured by Hipparcos, and accepted only orbits which satisfy this criterion. Finally, we examined time-variations in LMC-SMC separation for the past 15 Gyr, and chose the best model based on the coincidence between epochs of very close approaches in the model and those of enhanced cluster formation in the LMC. Figure 1 shows our best model: the LMC and the SMC experienced two very close encounters 0.2 Gyr and 3 Gyr ago, which gives satisfactory agreement with the cluster age distribution in the LMC. At these epochs, the considerable disturbance experienced by the LMC could have led to the formation of a huge number of clusters.

3. Effect of the Expanding Universe

Finally, we have traced back in time our best orbit until the early phase of the expanding universe when the Galaxy makes contact with M31 (Fujimoto et al. 1997). We find that the LMC and the SMC were already in a binary state in the Galaxy potential of the early universe, suggesting that they formed together and were then bound to the Galaxy.

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