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# DYNAMICS OF INTERGALACTIC CLOUDS IN THE GALAXY–ANDROMEDA NEBULA SYSTEM

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Computer models for the dynamics of the infall gas clouds in the gravitational field of the Local Group are presented.

KEY WORDS The Local Group, gas infall, computer models

## 1 INTRODUCTION

Theoretical and observational evidence suggests that gas infall into the disc of the Galaxy can play a significant role in galactic evolution. Clouds of intergalactic gas affect the chemical composition of the interstellar gas as well as the process of star formation in the disc (see, for instance, Alfaro and Delgado, 1995). Here we present computer models for the cloud dynamics in the gravitational field of the Local Group which is mainly due to two major bodies of the group – the Galaxy and the Andromeda Nebula.

## 2 COMPUTER MODELS

We assume the Kahn–Woltjer (1959) classical model for the Local Group in which the Galaxy and the Andromeda Nebula move towards each other along a straight line connected their centres. The present measured separation of the galaxies is $700 \pm 10$ kpc and their relative velocity is $-120\pm$ km $s^{-1}$. The total mass of the group is $(2-3) \times 10^{12} M_{\odot}$ and its age is $15 \pm 3$ Myr. Figure 1 shows possible variants of the model for the Local Group. In the variant which is used below, the masses of the galaxies (their dark matter halos included) are $0.93 \times 10^{12} M_{\odot}$ and $1.4 \times 10^{12} M_{\odot}$ for the Galaxy and the Andromeda Nebula, respectively. The galaxies have zero

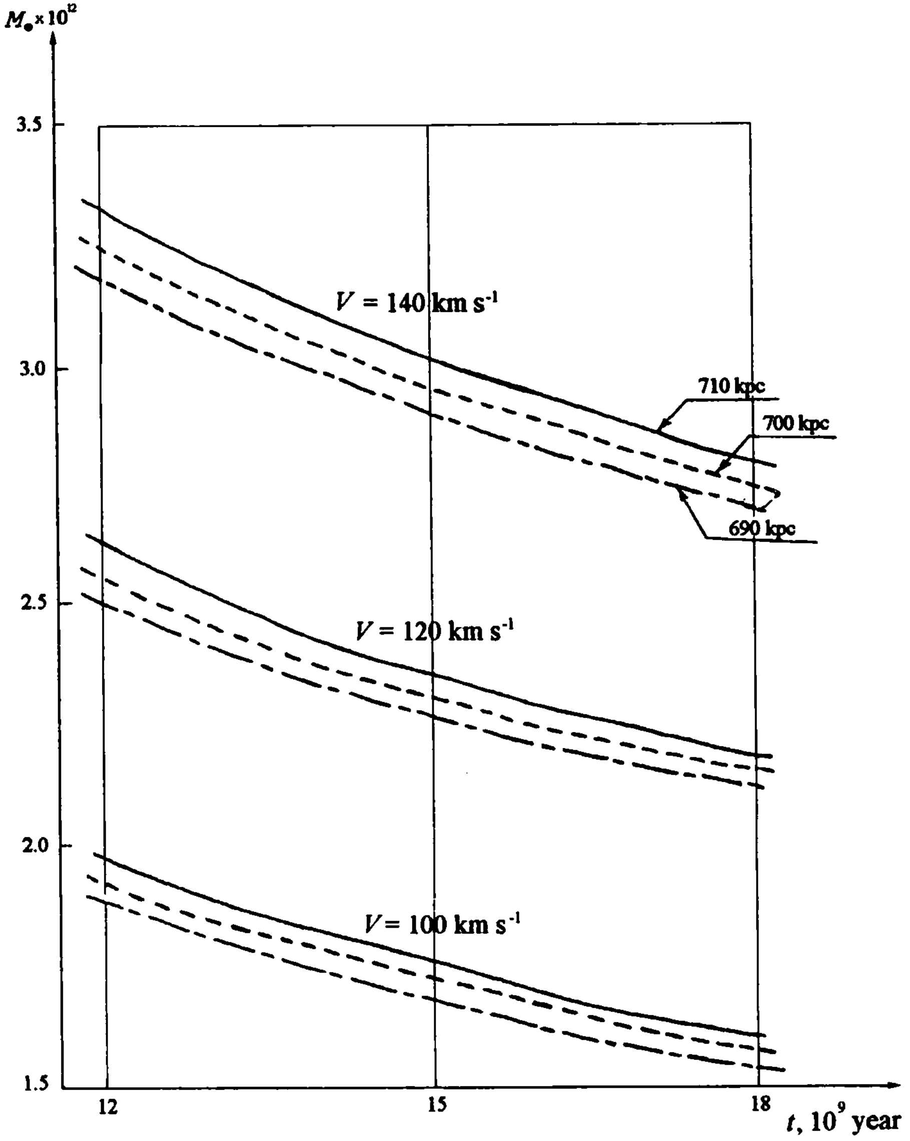

**Figure 1** Possible variants of the model for the Local Group.

velocity, and separation $a = 1428$ kpc along the line which is chosen as the $Ox$-axis of rectangle coordinates, at the "initial state". After 15.4 Myr, the separation is 706.7 kpc and the relative velocity is $-120.2$ km s$^{-1}$.

We also assume that the masses of the intergalactic clouds moving in the Local Group are much less than the mass of the group, so the clouds may be considered as test particles, to a first approximation.

Both assumptions enable us to use the simple scheme of the well known restricted three-body problem with a linear orbit of the two major bodies. Computer integration of the eigth-order system of the equations of motion has been performed for a set of probable "initial conditions" for the clouds, which are considered at rest with different distances from the major bodies of the group, initially. The variety of the initial positions of the clouds is represented by a rectangle symmetrical with respect to the $Oy$-axis with the sides $a \times 0.5a$, the larger one of which coinides with the $Ox$-axis.

## 3 RESULTS

The total number of integrated trajectories of the cluds is about 500. There are found to be three characteristic types of trajectories: (1) regular trajectories with no close approaches to the major bodies of the group; (2) trajectories with close approach to the Galaxy; and (3) trajectories with close approach to the Andromeda Nebula. Actually, close approaches mean here "collisions" of the clouds with the galaxies; we will call them collision trajectories.

The variety of regular trajectories is generated by the set of initial positions designated as the OBD area in Figure 2. The figure assumes that the Galaxy moves towards the centre of coordinates from the left, and the Andromeda Nebula moves towards the centre from the right. The outer border of the OBD area is similar to a parabolic curve shifted to the smaller mass (to the Galaxy). The OBD area has a quasi-symmetry axis parallel to the $Oy$-axis. Typical regular trajectories are shown in Figure 3.

The other possible initial positions generate a variety of collision trajectories. If a cloud starts its motion within the strip $y < 120$ kpc, it will eventually be captured by one of the galaxies. These trajectories are found to be of two classes: (1) short collision trajectories which correspond to approach to one of the bodies from the upper semi-plane ($y > 0$), and (2) long trajectories which correspond to approach from the lower semi-plane ($y < 0$) (the motions start from the upper semi-plane in both cases). The short trajectories start in the area which is above the OBD area, and the long trajectories start under the OBD area in Figure 2.

The long trajectories reveal local dynamical instability: they are very sensitive to the initial position. Just a small difference in the initial position near the quasi-symmetry axis (Figure 2) alters the final fate of the cloud – it may be captured by the Galaxy or by the Andromeda Nebula, depending on this "uncontrolled" difference. This is an obvious example of the stochstem. In the latter case, the orbits are continued for a further 0.1 crossing times of the original group, and the two-galaxy system (binary) is taken as a member of the binary sample. In all, one third of the groups ended up in this way. For details of the numerical method, see Valtonen (1988) and Zheng *et al.* (1993).

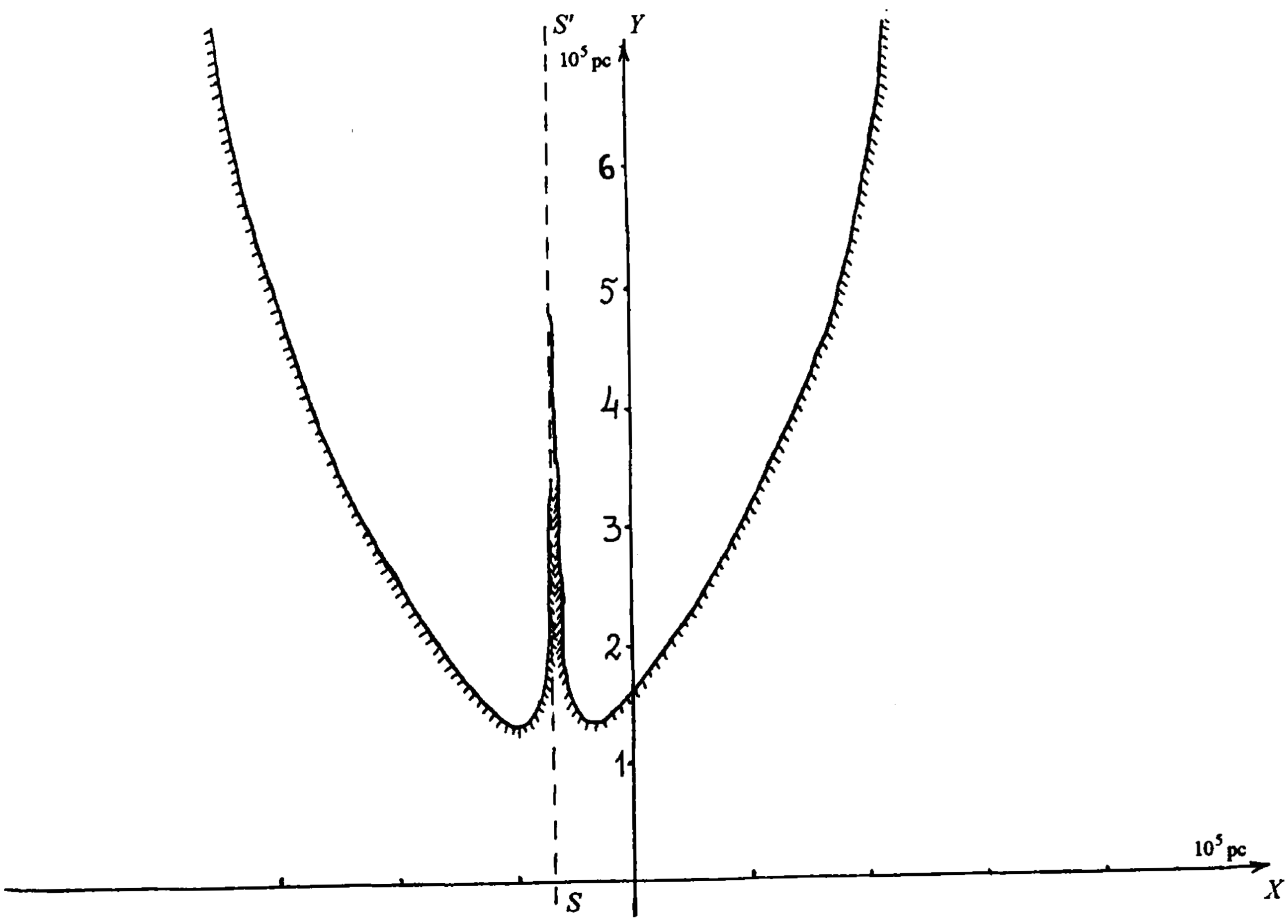

**Figure 2** The variety of regular trajectories: $SS'$ is the axis of quasi-symmetry of the OBD area.

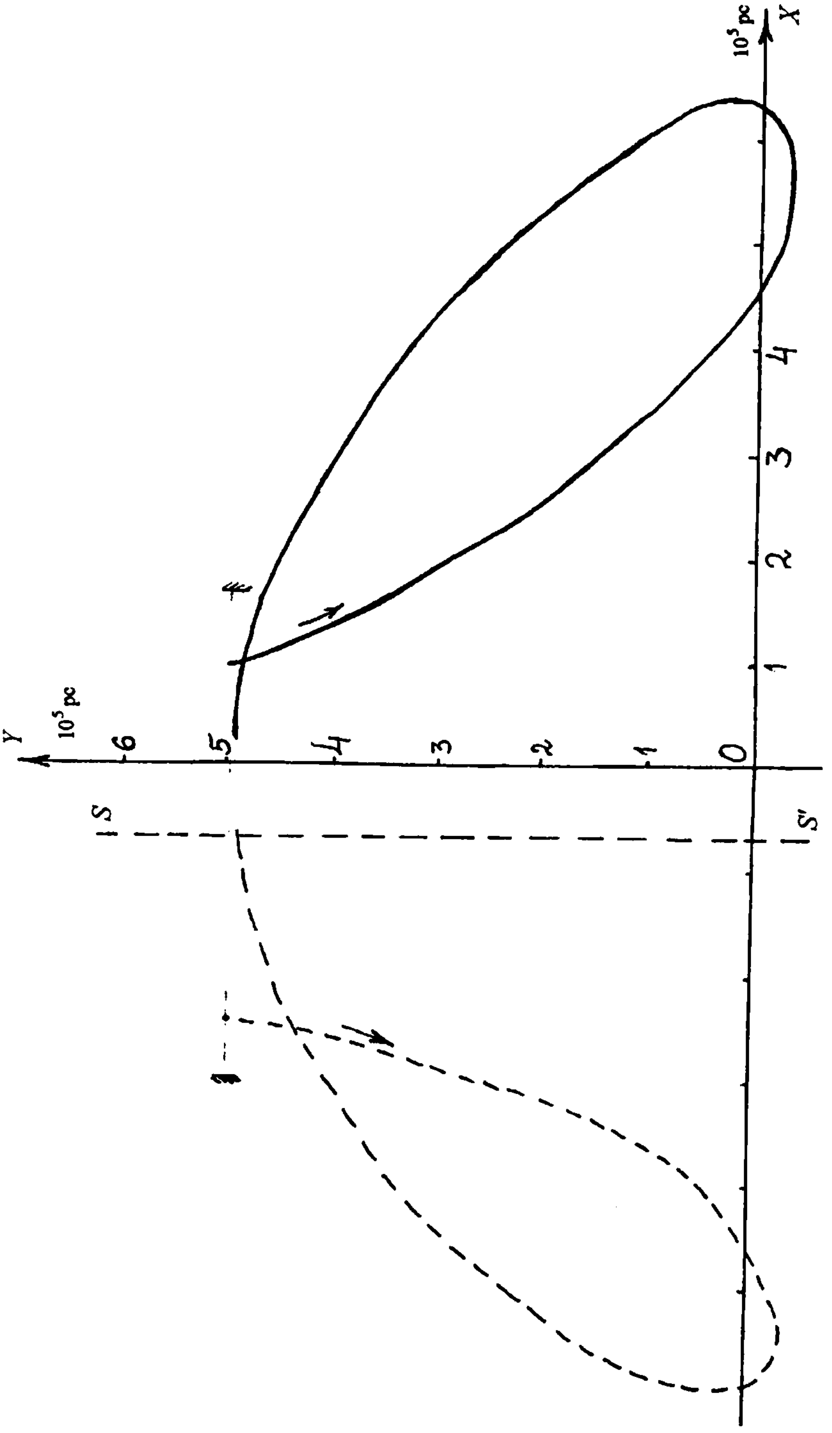

**Figure 3** Typical regular trajectories.

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