Possible Progenitors of the Andromeda Stellar Stream

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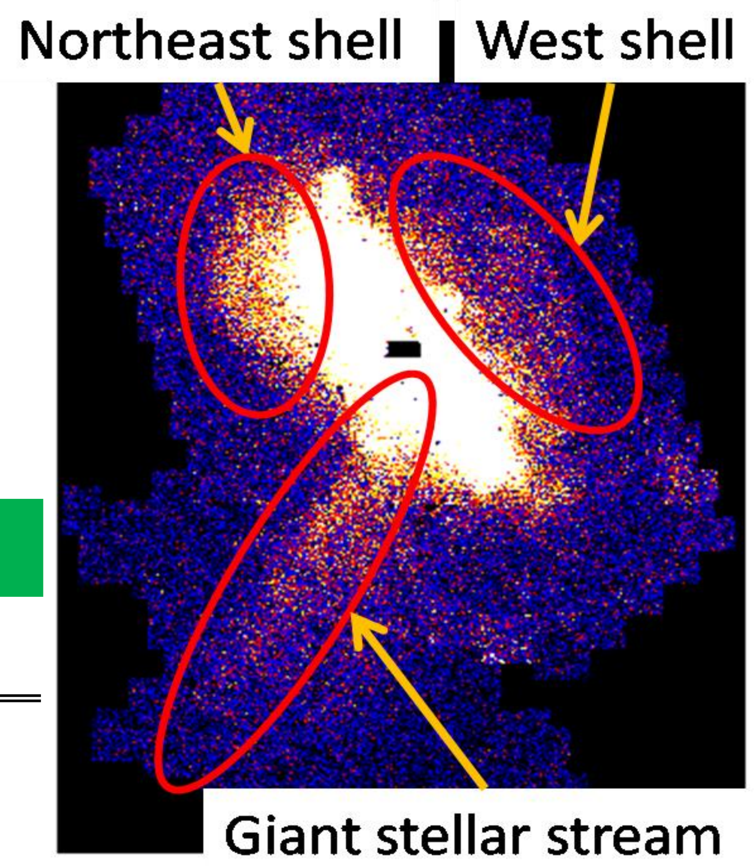
Abstract

Using *N*-body simulations of the interaction between an accreting satellite and M31, we have performed a parameter study in detail varying the size and mass concentration of the progenitor described by a King sphere which is inferred by observations of nearby dwarf galaxies. We show the necessary conditions on the size and mass concentration of the progenitor for reproducing the observed features of the stream and the shells at the east and west sides of M31's center.

1. Introduction

Recent observations of red giant stars near M31 exhibit a giant stellar stream, stellar shells to the east and the west of M31's center (Ibata et al. 2001, 2004, 2005; Ferguson et al. 2002; McConnachie et al. 2003; Guhathakurta et al. 2006). Furthermore, the giant stellar stream extends out to over 100 kpc away from center M31. So far, *N*-body simulations suggest that the stream and shells are the tidal debris formed in the last pericentric passage of a satellite dwarf galaxy (Fardal et al. 2007; Gilbert et al 2007; Mori & Rich 2008). These models successfully determine the orbit and mass range of the progenitor. However, earlier studies always assumed a Plummer sphere to represent the progenitor, and no models consider the possible effect of the size and mass distribution of the satellite.

We have performed a parameter study in detail varying the size and mass concentration of the progenitor.



data from Irwin et al. 2005

2. Numerical Simulations

•Models of progenitor dwarf galaxy and M31

King models with $1\times10^9 M_\odot \le M \le 5\times10^9 M_\odot$(Mori & Rich 2008), 0.5 kpc $\le r_t \le$ 6.0 kpc, $0.1 \le c \le 1.5$ (Irwin & Hatzidimitriou 1995; Woo, Couteau, & Dekel 2008; McConnachie & Irwin 2006; Ichikawa, Wakamatsu, & Okamura 1986) are assumed.

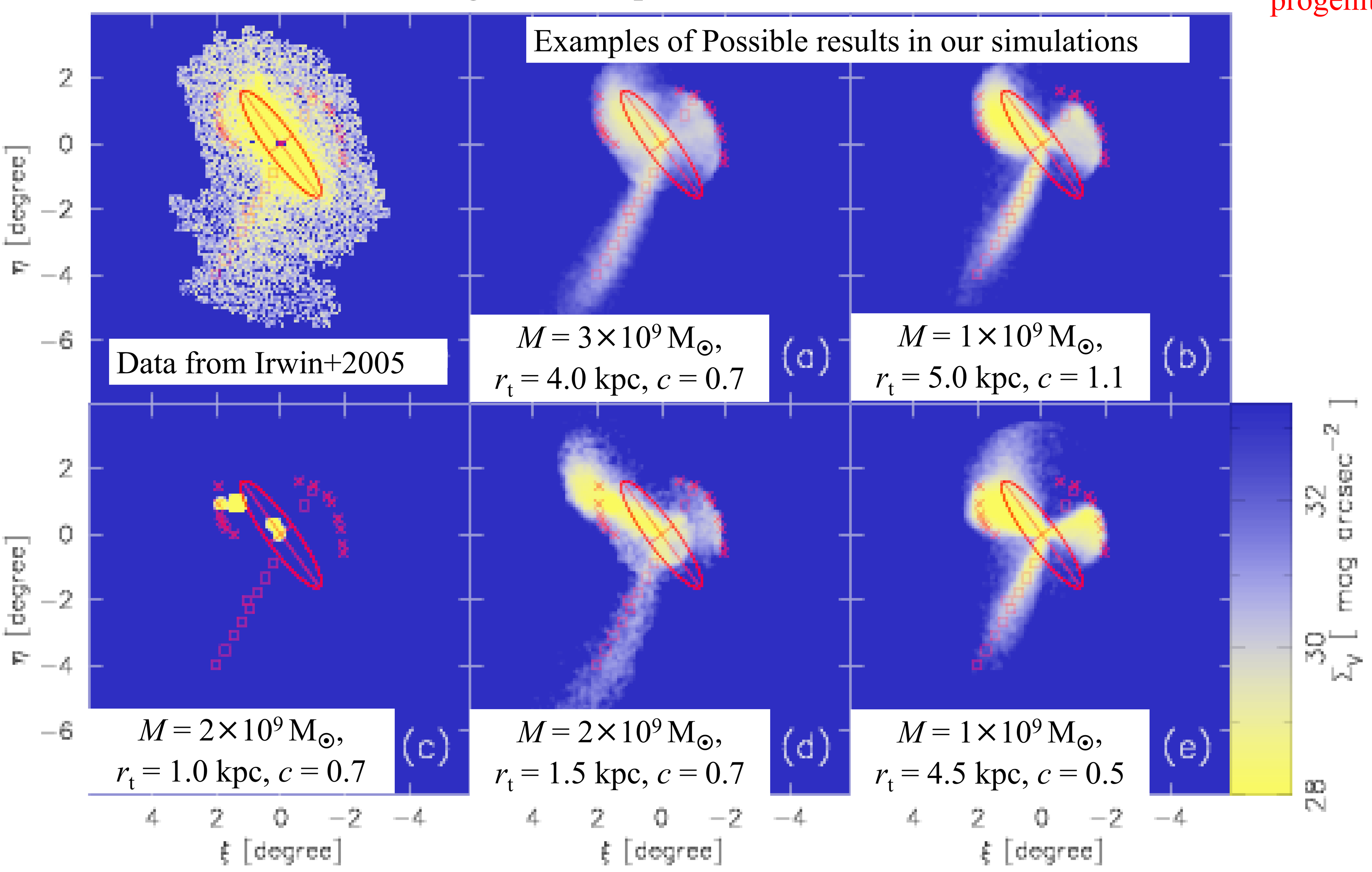
Satellite orbit is taken by Fardal et al. (2007).

N-body simulations with $N = 65536$ have been performed.

A fixed potential model by Fardal et al. (2007) is assumed as M31.

•Result 1: Examples of Surface Brightness maps

V-band surface brightness map of RGB stars

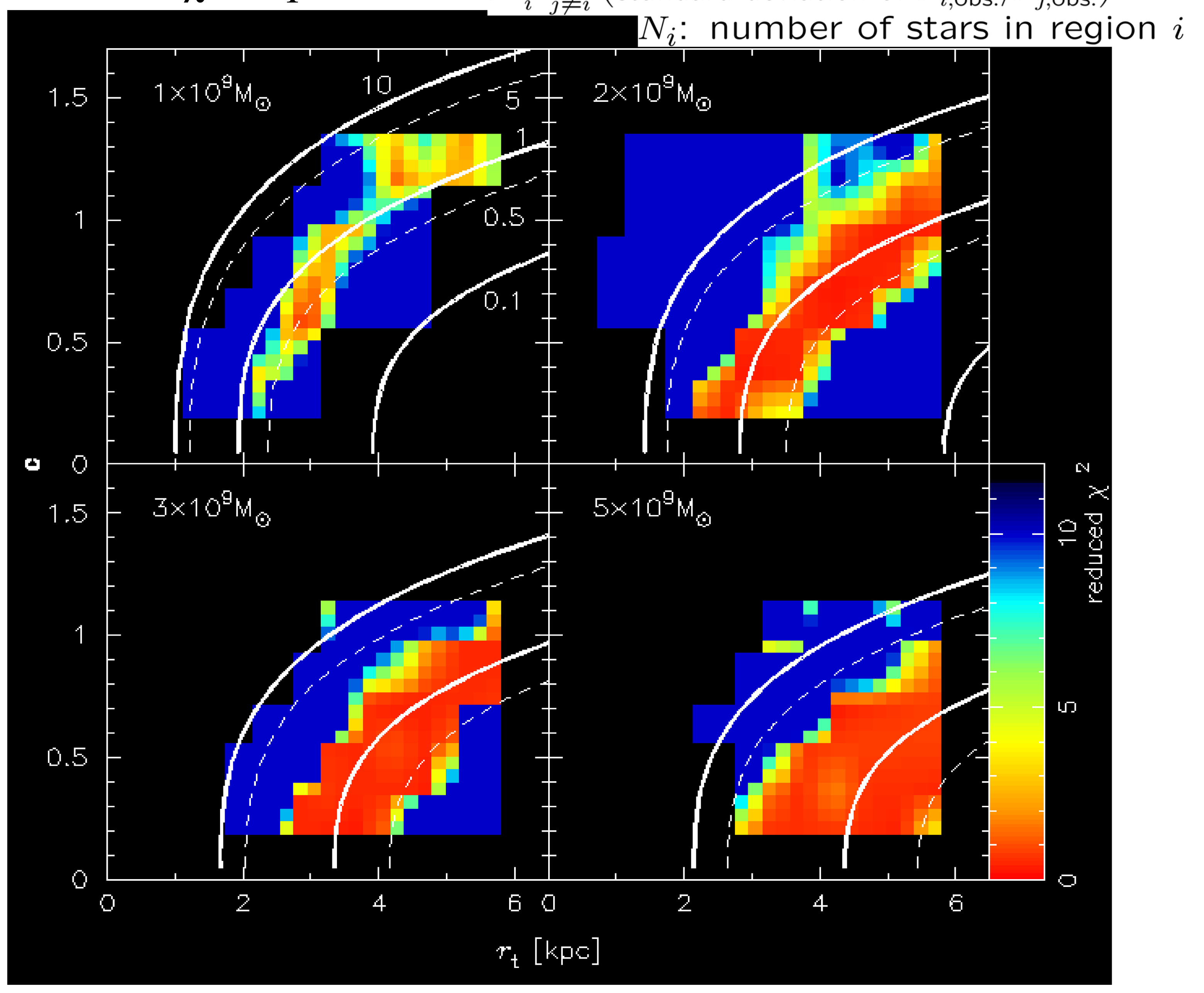


•Result 2: Distribution of Possible progenitors

Comparisons between simulations and observations are taken for 3 quantities: 1.velocity structure, 2.shapes of two shells, and 3.ratio of flux density among the giant stellar stream, the northeast shell, and the west shell. As a result, 3. (below figure) is the most severe restriction. Each curve corresponds the ratio of potential energy between dwarf and M31's bulge, unit is %. Therefore, we conclude progenitor has the potential energy of ~1% that of the bulge.

Reduced χ^2 maps about $\frac{1}{\nu}\sum_i\sum_{j\neq i}\left(\frac{N_{i,\mathrm{sim.}}/N_{j,\mathrm{sim.}} - N_{i,\mathrm{obs.}}/N_{j,\mathrm{obs.}}}{\text{standard deviation of } N_{i,\mathrm{obs.}}/N_{j,\mathrm{obs.}}}\right)^2$

N_i: number of stars in region i

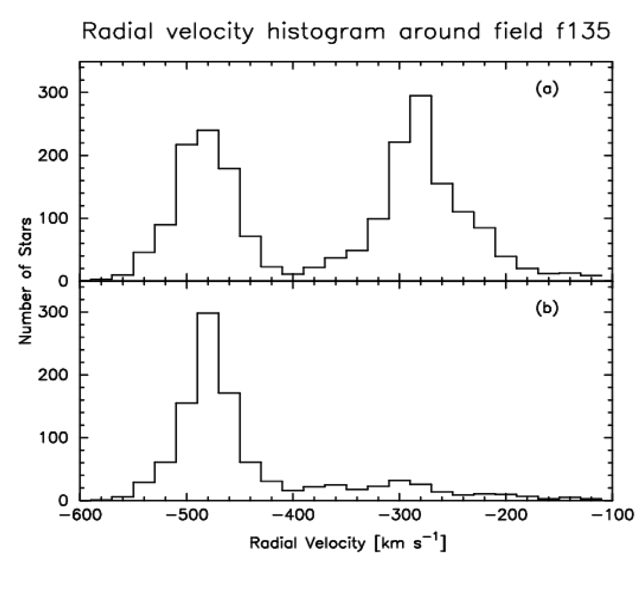


3. Discussions

•Existence of the Third Shell Component

Third shell component is predicted by Fardal et al. (2007), and the component was observed by Gilbert et al. (2007). It comprises 30-40% of the total population in observations, but order of 1% in simulations.

Most of our results exhibit the third shell component (model a). The cases without the third shell can also reproduce the observed stream and both shells (model b). The emergence of the third shell strongly depends on the physical properties of the progenitor. Therefore, detailed analysis of the third shell plays a role to constrain the progenitor.



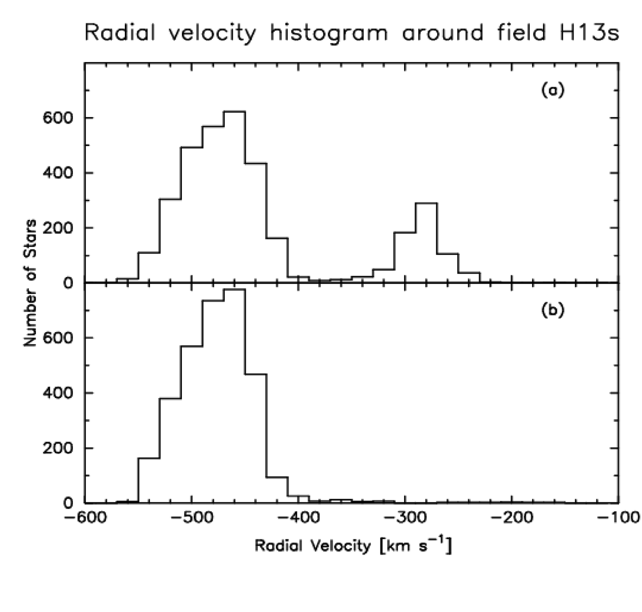
•Bimodality of the Giant Stellar Stream

Bimodality of the radial velocity in the giant stellar stream is reported by Koch et al. 2008: peak radial velocities are -520 and -400 km s^{-1}, respectively.

However, such a bimodality is not found in our simulations. The third shell component isn't the origin of the bimodality, because the peak radial velocity of the third shell is about -280 km s^{-1} (see model a).

Possible origins of the bimodality are below:

1. The progenitor has at least two cold components.
2. It is the remnant of other merger event.



4.Conclusions &Future studies

•We find a common property of possible progenitors of the giant stellar stream.
  • The potential energy of the progenitor is roughly 1% of the bulge's potential energy.
•We need the detail analysis of the third shell to constrain the progenitor properties.
•Origin of the stream bimodality is still open question.
•We are working on the detailed analysis of radial velocity profile of the giant stellar stream.
•We will study the possible progenitor's orbits and hydrodynamic model for the giant stellar stream.

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