BIFURCATION IN TIDAL STREAMS OF SAGITTARIUS DWARF GALAXY: NUMERICAL SIMULATIONS

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RESUMEN

Se realizan simulaciones de N-cuerpos entre la galaxia enana Sagitario y la Vía Láctea. La galaxia Sagitario se modela con dos componetes: halo de materia oscura y disco estelar. La Vía Láctea se modela con tres componentes: halo de materia oscura, disco estelar y bulbo. El objetivo de este trabajo es reproducir las bifurcaciones en las corrientes de marea y las propiededes físicas de la galaxia enana Sagitario. Para ello se simula la interacción del progenitor de esta galaxia con la Vía Láctea. Aunque se reprodujeron las bifurcaciones, la posición y propiedades físicas del remanente de Sagitario no se puedieron reproducir simultáneamente.

ABSTRACT

We performed N-body simulations between Sagittarius dwarf galaxy and the Milky Way. The Sagittarius galaxy is modeled with two components: dark matter halo and stellar disc. The Milky Way is modeled with three components: dark matter halo, stellar disc and bulge. The goal of this work is to reproduce the bifurcations in the tidal tails and the physical properties of the Sagittarius dwarf galaxy. For it, we simulated the interaction of the progenitor of this galaxy with the Milky Way. Although bifurcations could be reproduced, the position and physical properties of Sagittarius remnant could not be obtained simultaneously.

Key Words: Bifurcations — Numerical simulations — Sagittarius dwarf galaxy — Tidal tails

1. INTRODUCTION

Sagittarius dwarf galaxy (Sgr) was discovered by Ibata et al. (1995). Located near to the Galactic plane, it has been disrupted under gravitational tidal forces that have produced tidal streams, showing bifurcations in the north tidal stream (Fellhauer et al. 2006). It is accepted that Sgr is a spheroidal galaxy, however Peñarrubia et al. (2010) consider its progenitor as a disc galaxy in order to reproduce the bifurcations located in the north tidal stream.

In this work the progenitor of Sgr is modeled as a stellar disc (Łokas et al. 2013) within a Navarro, Frenk & White (NFW) dark matter halo, with a virial mass of $1\times10^8 M_\odot$ and 6.0×10^5 particles. The Milky Way is simulated with stellar disc and bulge components within a NFW dark matter halo with a virial mass of $95.21\times10^{10} M_\odot$ and 3.0×10^5 particles. The initial structures were constructed using GalIC and the gravitational interaction was simulated with GADGET-2 for seven different angles (θ) between the angular momenta of the orbit and of the stellar disc. The initial orbit of Sgr has a pericenter of 11.35 kpc and an apocenter of 67.85 kpc. The initial radial and tangential velocity components were 171 km/s and −295 km/s, respectively. To achieve the theoretical calculation of the physical properties we used the method shown by Kroupa (1997) and Klessen et al. (1998).

2. RESULTS AND CONCLUSIONS

Figure 1 shows the tidal tails obtained in our simulations. We found bifurcations similar to the reported by Belokurov et al. (2006). The simulated bifurcations appear at almost the same position of the observed ones, but the remnants of the progenitors do not reproduce the current position or the physical properties observed. The closest simulated bifurcation to the observed corresponds to $\theta = 130°$ at $5.0\,Gyr$ (see Figure 1). In contrast, Peñarrubia et al. (2010) found bifurcations at $-20°$. This angle corresponds in our simulations to $\theta = 160^o$. Table 1 shows equatorial coordinates, distance and physical properties of the simulated remnant at $\theta = 130^o$. At $5.0\,Gyr$, we found that the mass-luminosity relation and σ_0 have close values to those observed. Bifurcations in the north tidal tail are present, although the simulated remnant is not found in the current position. At $6.2\,Gyr$ none bifurcation is detected and the distance obtained in our simulations is the shortest, far away to the actual distance of the remnant.

Our results do not reproduce the position and physical properties of Sgr simultaneously. The remnant mass of Sgr obtained in our simulations is one order of magnitude less than the estimated mass.

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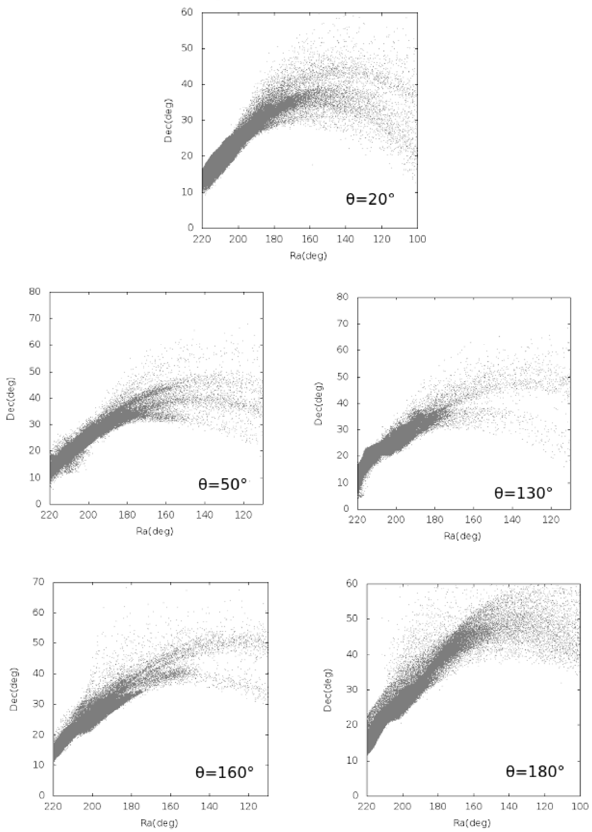

Fig. 1. Tidal tails obtained for different angles (θ) between angular momenta of the orbit and of the stellar disc of Sgr

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TABLE 1

t (Gyr)	Remnant position RA, dec, D (Kpc)	Physical properties
5.0	$224.07^o, 11.06^o, 49.67$	$\mu_0 = 10.52 \times 10^4\, L_\odot/kpc^2$ $M/L = 70.48\, M_\odot/L_\odot$ $r_{1/2} = 3.08\, kpc$ $\sigma_0 = 8.23\, km/s$
6.2	$282.82^o, -31.62^o, 72.20$	$\mu_0 = 23.07 \times 10^4\, L_\odot/kpc^2$ $M/L = 193.15\, M_\odot/L_\odot$ $r_{1/2} = 0.62\, kpc$ $\sigma_0 = 9.08\, km/s$

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