Dark Matter in Galaxies
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Measuring Dark Matter Halos by Modeling Interacting Galaxies

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Abstract. The richness of tidal features seen in interacting galaxies allows for the determination of their characteristic parameters, provided one can deal with the extended parameter space. Genetic algorithm based methods – like our code MINGA – have proven to be such a tool. Here I discuss the implementation of dark matter halo descriptions in the restricted N-body simulations of MINGA. I show that the final morphology of a galaxy encounter strongly depends on the halo properties. Thus, modeling tidal features of interacting galaxies might allow also for conclusions on the galactic dark matter content.

1. Introduction

A major problem in modeling encounters of galaxies is the extended parameter space. Traditional grid-based fitting strategies suffer from very large CPU-requirements e.g., for a restricted 7-dimensional parameter space (an encounter of a disc with a point mass) and a resolution of only 5 values per dimension, one needs about 80 000 models, or about 27 years of integration time for a "complete" grid (assuming 3 CPU-h per simulation). More systematic search strategies like gradient methods depend strongly on the initial conditions, which makes them prone to trapping in local optima. An efficient alternative approach is evolutionary methods and especially *genetic algorithms* (GAs; e.g. Charbonneau 1995). In combination with fast *restricted N-body*-codes (e.g. Toomre & Toomre 1972) GAs allow for an efficient search in parameter space which can be used for both an automatic search of interaction parameters (provided sufficiently accurate data are available) and/or a uniqueness test of a preferred parameter combination (e.g. Theis & Kohle 2001).

Here I present the dark matter halo descriptions used in our genetic algorithm code MINGA for **m**odeling **in**teracting **ga**laxies and I demonstrate the dependence of the tidal features on the halo properties.

2. Dark halos in restricted N-body simulations

Usually *restricted N-body* simulations are applied to the motion of point masses. Their Keplerian orbits are well known; in particular they can be calculated semi-analytically (and quickly). However, in galaxies most of the mass is located in an extended dark matter halo, which acts – to first order – as a *softened* gravitational potential, provided the galactic halos overlap. In MINGA we use

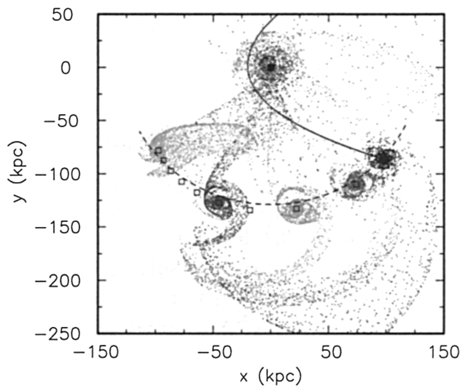

Figure 1. Final positions of encounters with different halo sizes. The solid line shows a Keplerian orbit with a minimum distance of 20 kpc. The open boxes show the final positions for different halo radii from $R_h = 10$ kpc (right) in 10 kpc steps up to $R_h = 100$ kpc. All simulations are performed over the same period of time with identical initial positions and velocities. Both galaxies have identical properties.

a consistent rigid-halo treatment, i.e. we determine the galactic orbits from the exact force of overlapping dark matter halos. They deviate significantly from the point mass approximation: with decreasing distances the forces vanish in homogeneous systems, they tend to finite values in isothermal spheres, and they diverge for point mass distributions. So far, we have implemented the following halo descriptions in MINGA: a singular isothermal halo; a two-component rotation curve with a rigid rotation in the center and a flat rotation curve in the outer regions; a (cuspy) NFW-profile; and a Burkert-profile (no cusp).

Fig. 1 shows the final positions of the galaxies and their test particle systems for different extensions of the adopted dark matter halos (rigid-flat rotation curve). The orbital deflections become weaker with increasing halo size, whereas the final distance is almost independent of the halo size. The morphology of the tidal features (arms, bridges) strongly depends on the halo properties. Therefore, the observed tidal structures might allow for conclusions on the galactic dark matter distribution.

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References

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