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FRAGMENTATION OF TIDAL TAILS AND THE POSSIBLE ORIGIN OF TIDAL DWARF GALAXIES

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We investigate the formation of tidal dwarf galaxies in mergers of spiral galaxies. High resolution simulations of mergers have been run to investigate the formation of structure in the tidal arms of the merger remnant. We determine a set of properties for the bound objects detected in the tidal arms. We also compare mergers with mass ratios of 1:1 to those with 3:1.

We have used WINE, a new hybrid N-body / SPH code to simulate structure formation in the tidal arms of merging spiral galaxies. The code uses a parallel tree structure together with the special-purpose hardware GRAPE-5 for the computation of gravitational forces. Individual particle timesteps as well as various other features have been implemented (Wetzstein et al, in preparation).

The simulations included mergers with mass ratios of 1:1 and 3:1. Each progenitor galaxy consisted of a dark matter halo in which a gaseous and a stellar disk component as well as a stellar bulge were embedded. The encounters were prograde.

We use a friends-of-friends group finder in order to detect objects in the tidal arms. Then for each detected object, we extract the gravitationally bound particles for all later analyses.

Figure 1 shows the number of detected bound objects as a function of distance from the center of the merger remnant. In the 3:1 merger, the tidal arm of the smaller galaxy extends further outward because the tidal forces acting on this galaxy are stronger. Thus the objects outside ca. 100 kpc are all from this tidal arm.

Of course, the number of objects inside a tidal arm depends on the time of the considered snapshot. The objects in a tidal arm close to the progenitor fall back into the remnant on timescales of less than 100 Myr. For figure 1, the time of the completed merger of the central parts of the two galaxies was taken.

The mass of the individual objects changes also during the merger, as the objects accrete gaseous material out of the tidal arms. This, together with the inner objects falling back into the remnant, affects the number of objects with a given mass. The time evolution of this mass spectrum is more significant for the 3:1 merger than for the 1:1 merger. For the latter the population of bound objects covered a mass range from a few $10^6 M_\odot$ up to $6 \cdot 10^8 M_\odot$, with the number of objects for a given mass decreasing roughly exponentially with increasing mass. For the 3:1 merger, the masses of the objects range from a few $10^6 M_\odot$ to initially a few $10^8 M_\odot$. However by the time a new disk starts to build up in the remnant, the total number of objects has decreased by a factor $\approx 2-3$. In addition, the highest mass objects have fallen back into the remnant and were dispersed, resulting in a decreased upper mass limit of $10^8 M_\odot$ for the detected objects. The nature of these objects is still unclear at the current resolution of the simulations, but new simulations should allow us to discriminate between possible progenitors of globular clusters and / or tidal dwarf galaxies.

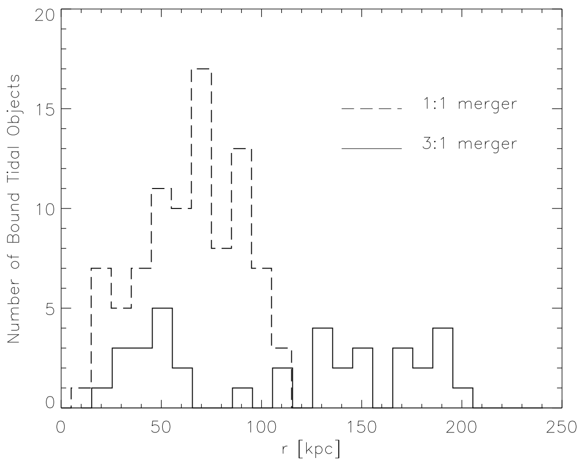

Fig. 1. Number of bound tidal objects as a function of distance from the center of the merger remnant at the time when the central parts of the two progenitors merge.

An analysis of the composition of the detected objects shows that gas and stars contribute almost equally to the total mass of any particular object. There is only a small amount of dark matter in just a few objects, but this result could be influenced by different mass resolution between the dark and gaseous components.

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