INTERACTIONS BETWEEN DWARF GALAXIES AND DARK SATELLITES

For movies see: http://www.astro.rug.nl/~ahelmi/dwarfs-morphologies.html

MOTIVATION

Within the ΛCDM-cosmogony small dark matter halos are predicted to be very abundant. A large majority of these small haloes will never get massive enough to form stars and will therefore remain 'dark', but may leave dynamical imprints in luminous galaxies. This motivates our poster on a suite of controlled simulations of mergers between a dark satellite and a disky dwarf galaxy, both with and without gas.

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1. DISK HEATING IN DWARF GALAXIES

Dark satellites perturb the disky dwarf galaxies, leading to significant thickening and important morphological changes. The thickening depends on the mass ratio of the satellite to the host disk (Helmi et al. 2012).

We perform a series of simulations of the merger between a dark matter satellite of mass 2×10^9 M_{sun}, and a dwarf galaxy embedded in a dark matter halo of $M_{vir} = 10^{10}$ M_{sun}. The dwarf galaxy is initially disky (with $z_0 = 0.05 - 0.1$ h_R), and we vary its stellar mass from 0.008 M_{vir} to 0.02 M_{vir} and 0.04 M_{vir}. We placed the satellite on a radial orbit, with $r_{apo}/r_{peri} \sim 40$, starting from $r_{apo} = 23$ kpc and with an inclination of 30 deg.

Figure 1.1: Strong morphological changes and heating

These figures show the strong perturbing effect the dark satellite (blue) has on the disk (black). The satellite merges with the host after 2-3 close passages.
Although $M_{sat}/M_{vir} = 0.2$, $M_{sat} = 25$ M_{disk} in this example. Such encounters are relatively common on the scale of dwarf galaxies because of their high M/L.

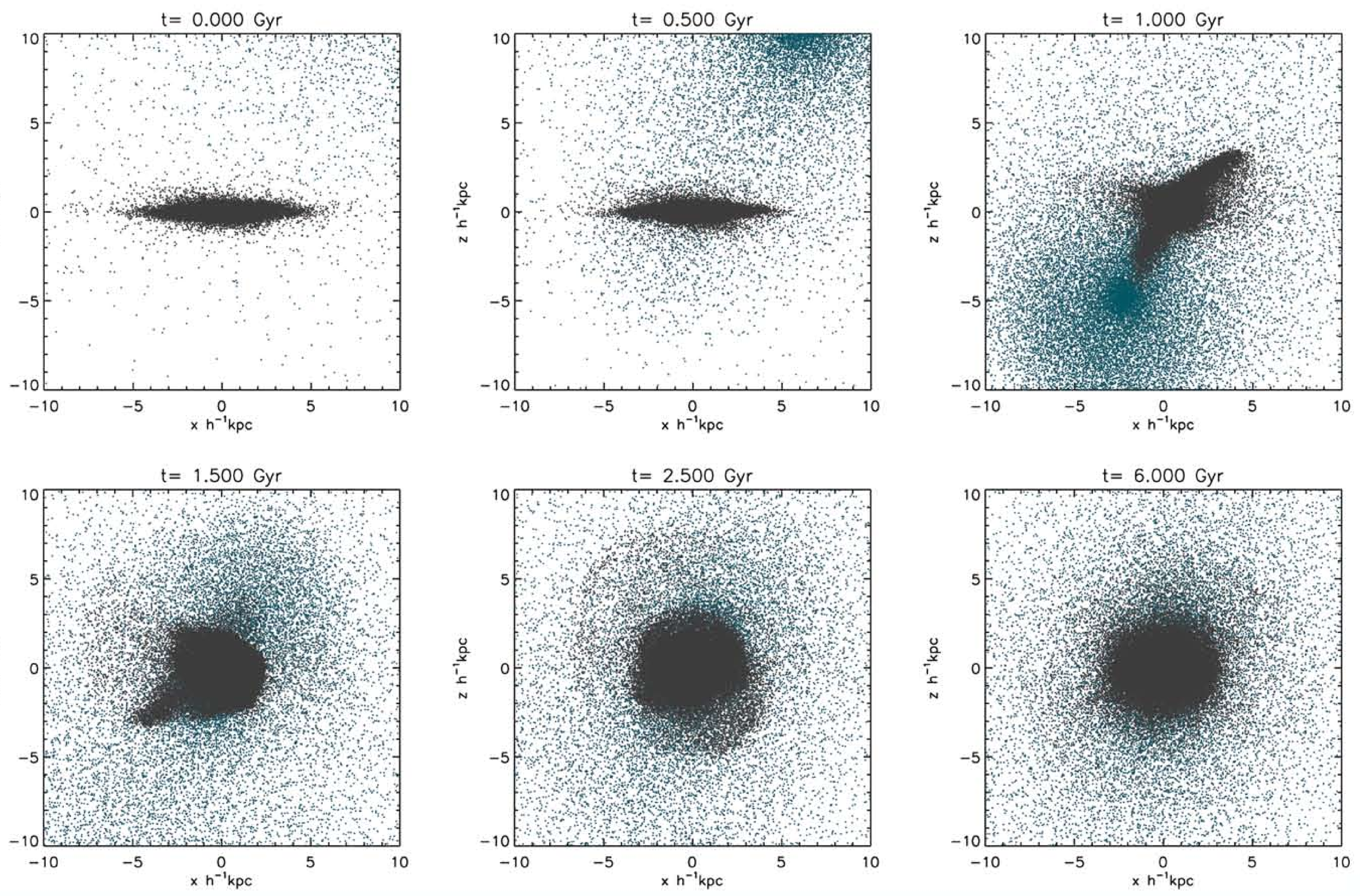
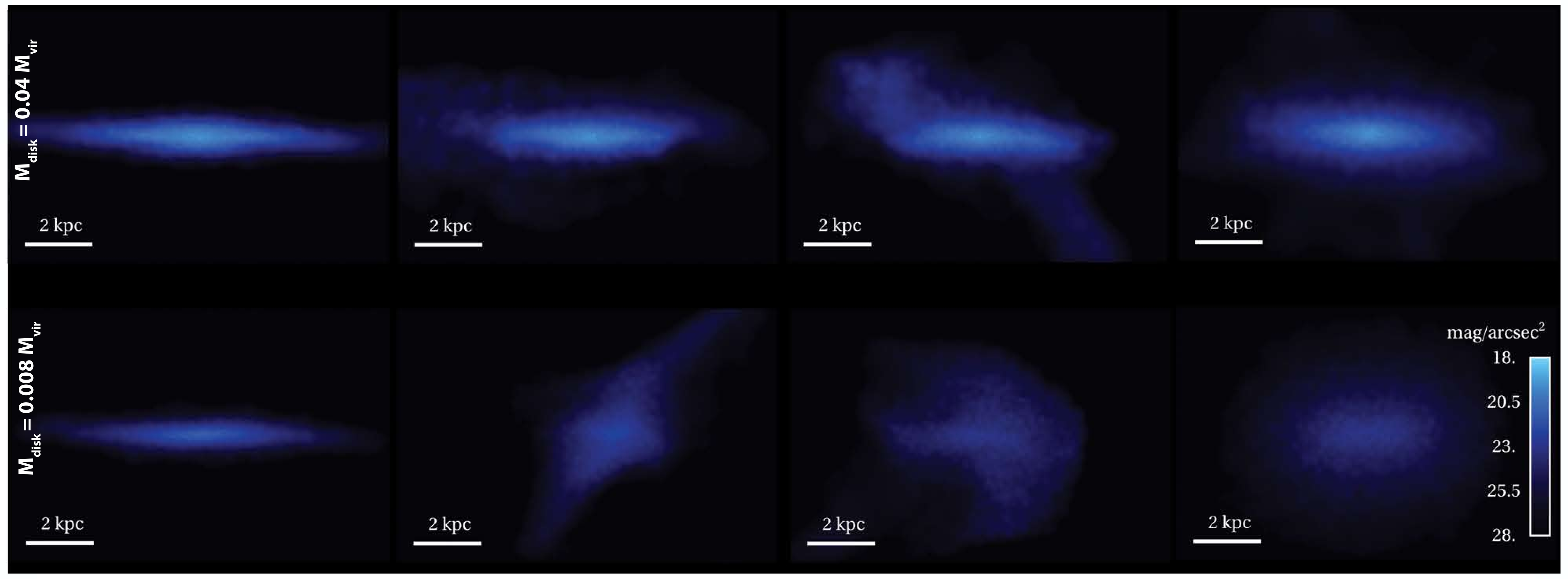


Figure 1.2: Surface brightness maps: different mass - different morphology

Surface brightness maps for the mergers between the satellite and the most (top) and least (bottom) massive disky dwarf; before (t = 0) and during the merger (t = 1 Gyr and t = 1.5 Gyr), and well after the merger is completed (t = 6 Gyr). Note: only the stars in the disk are shown (as the accreted object is dark). The lightest disk gets perturbed the most and it has a spheroidal morphology after the merger

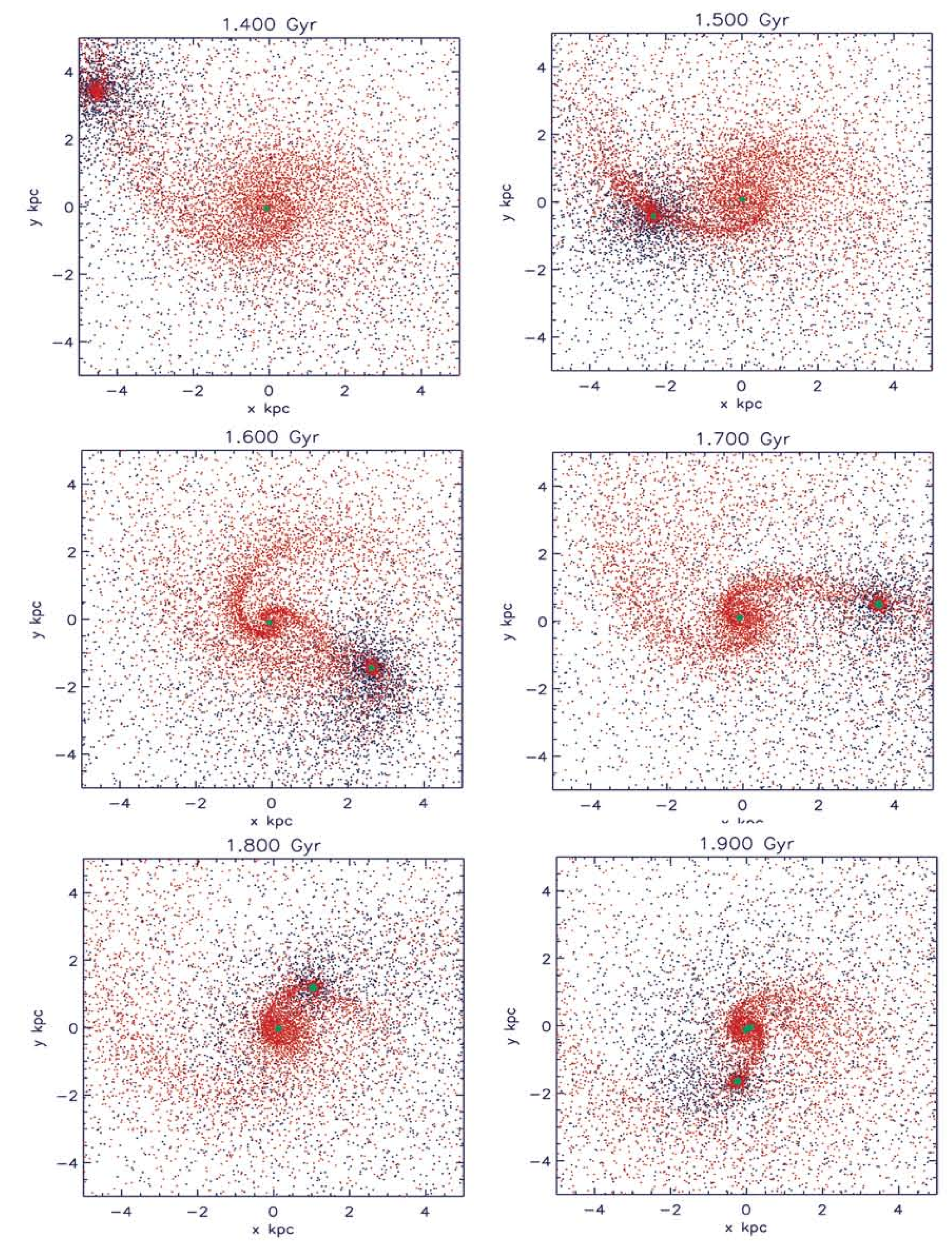


2. STARBURSTS

Our simulations with gas show that the accretion of a dark satellite can induce a starburst. The increase in the star formation rate ranges from a few to factors >10, depending on the orbital characteristics of the encounter. We use a modified version of the N-body SPH code GADGET (Springel 2005; Dalla Vecchia & Schaye 2008; Schaye & Dalla Vecchia 2008) and the galaxies were set up following the model of Springel et al. (2005). The dwarf galaxy has a gas fraction of $f_g=0.5$ ($M_{vir}=10^{10}$ M_{sun} and $M_{sat}=2\times10^9$ M_{sun}).

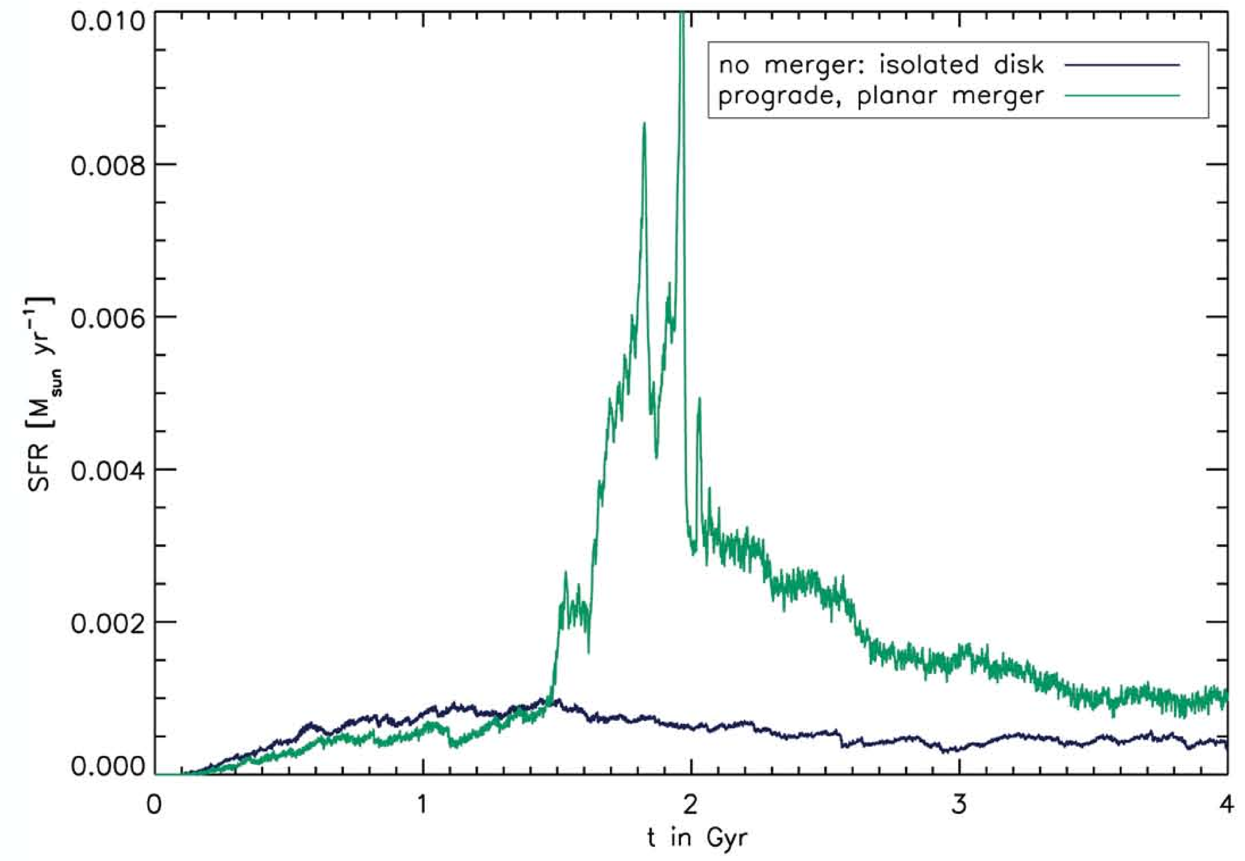
Interestingly, the dominant starburst is located in the center of the (eventually) accreted dark satellite, thereby lightening it for a brief period of time after which it finally merges with the dwarf.

Figure 2.2: Satellite accretes gas and lights up



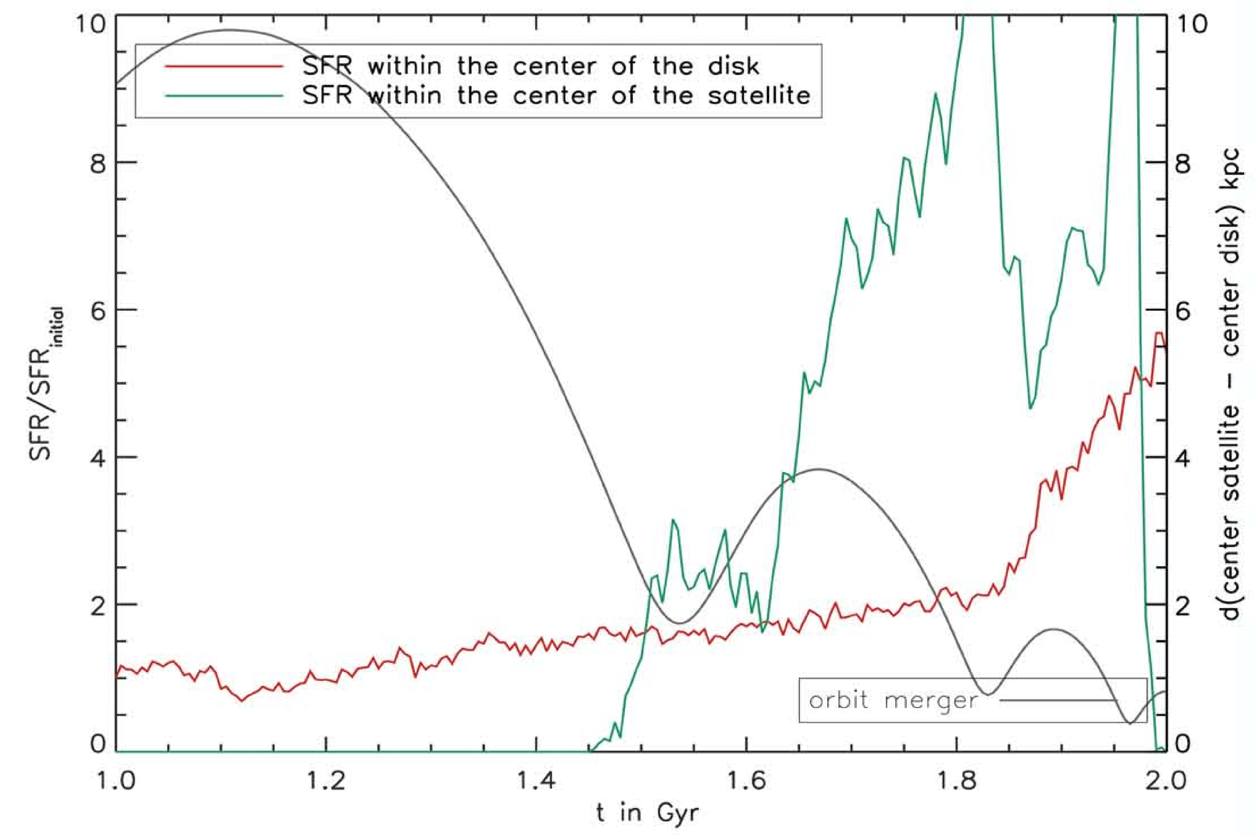
In these snapshots the gas particles of the dwarf galaxy (red) and the dark matter particles of the infalling satellite (dark blue) are shown together with the star-forming particles (in green). As the satellite goes through pericenter it accretes some gas from a tidal tail of the dwarf galaxy. This gas gets compressed in the center of the satellite and forms stars at a very high rate.

Figure 2.1: Dark merger induces a starburst



The star formation rates for one disky dwarf galaxy with and without a merger: the extreme increase in star formation is mostly due to the prograde orbit of the satellite in the plane of the disk. The major part of the starburst is in the satellite itself as is shown in Figures 2.2 and 2.3.

Figure 2.3: Starburst in the dark satellite



This figure shows the star formation in the satellite and disk during the peak of the merger. At t=2 Gyr the satellite has merged with the dwarf galaxy and the star-forming gas has returned to the inner region of the disk. The distance between the center of mass of the satellite and the center of mass of its host is overplotted for reference in grey.

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