The Gas Dynamics of Shell Galaxies

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1. Introduction

It is widely accepted that shell galaxies may form as a result of a merger between an elliptical and a small disk galaxy. Simulations of the *stellar component* have shown that the shells or ripples are created either by "phase-wrapping" of debris on nearly radial orbits (Quinn 1984, ApJ, 279, 596), or by "spatial-wrapping" of matter in thin disks (Dupraz & Combes 1987, A&A, 185, L1; Hernquist & Quinn 1989, ApJ, 342, 1). Stars, often modeled as collisionless particles, which were originally bound to the merging companions are liberated and oscillate with different periods around the new common central potential. Before they relax and due to their different periods of oscillation, they accumulate near the apocenters of their orbits, to form shell-like features.

The fact that this scenario is indeed occuring has been questioned by the recent observations of neutral hydrogen in systems containing shells. Schiminovich et al (1994, ApJ, 432, L101; 1995, ApJ, 444, L77) have detected diffuse HI gas shells displaced just to the outside of the stellar ripples of Centaurus A and NGC 2865. These observational results were a priori surprising, since we believe that shells are phase-wrapped stellar structures and that the diffuse gaseous and stellar components do not have the same behavior when approaching the center of the potential well, in quasi-radial orbits (Weil & Hernquist 1993, ApJ, 405, 142). However, as it was pointed out (Kojima & Noguchi 1997, ApJ, 481, 132) the details of the gas dynamics depend strongly on the specific model adopted for the interstellar medium, and modeling of the gas using smooth particle hydrodynamics may not be very appropriate.

2. Numerical Simulations and Discussion

Our numerical simulations (Combes & Charmandaris, 1998, A&A, in preparation) indicate that these new HI observations can actually be accommodated within the standard picture for the formation of shell galaxies (see Fig. 1). We model the sinking disk galaxy using a realistic distribution of its stellar and gaseous component, taking into account dynamical friction and a proper treatment of the dissipation of the gas (using a cloud-cloud collision code). During the process of merging the tidal forces affect the gaseous component first since it is less bound than the stars, which in turn are liberated later. Due to the effect of dynamical friction the stars loose energy as the galaxy spirals inwards in the potential of the elliptical galaxy. By modifying the dissipation of the gas we can easily reproduce the observed spatial distribution of gaseous and stellar shells.

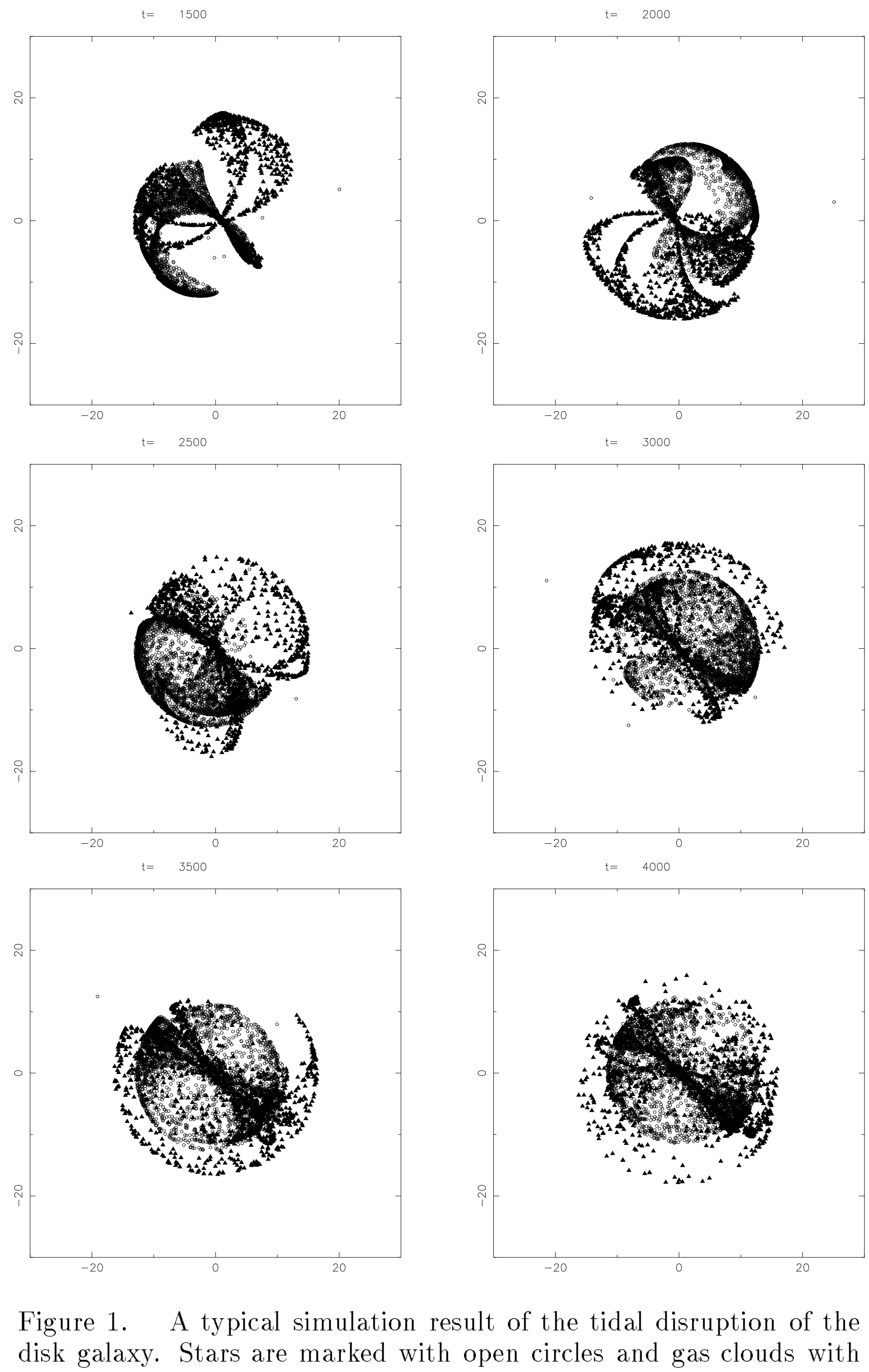

Figure 1. A typical simulation result of the tidal disruption of the disk galaxy. Stars are marked with open circles and gas clouds with filled triangles. Note the displacement between gas and stars.