# GAS DYNAMICS AND STAR FORMATION IN MERGING GALAXIES

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ABSTRACT.Numerical simulations show that repetitive starbursts will occur in a merger of two gas-rich disc galaxies. These bursts are caused by the orbital motion of two dense gaseous cores which have been formed at the centres of the original galaxies during the early phase of the merger. Such repetitive starbursts are able to explain the observational result that merging galaxies show a wide range of star formation activity.

## 1. Introduction

Many observational studies suggest that merging pairs of galaxies are often the site of active star formation (starbursts) (Solomon and Sage 1988). We have carried out numerical simulations for the merger of two disc galaxies which contain gas clouds as well as stars in order to investigate the effect of mergers on gas dynamics and the star formation process. We present here only preliminary results. A full description of this study will be published elsewhere.

## 2. Models

The halo and disc components of a disc galaxy model are constructed by "stars" which correspond to the old stellar population in real galaxies. The Tree-code algorithm (Barnes and Hut 1986) has been employed to calculate the gravitational field made by stars. The disc also included "gas clouds", which correspond to molecular clouds. We assume that each collision between two gas clouds leads to energy dissipation and star formation (i.e., creation of an "OB star"). We thus equate the cloud collision rate to the star formation rate.

We have carried out several merger simulations using two identical isolated galaxy models. Fig. 1 shows snapshots for a prograde merger model. It is seen that the merging process has been nearly completed within one rotational period (= 6.28 time units) after the first close passage ($T$=0) of two galaxies. The solid line in Fig. 2 shows the time variation of the star formation rate. The most notable feature here is that the star formation rate changes by a large amount and shows a quasi-periodic behaviour as the merger proceeds. At the maxima the star formation rate is enhanced by one order of magnitude compared with the isolated state ($T \ll 0$). A closer look at the numerical results shows that this repetitive change is caused by the orbital motion of two dense gaseous cores which have been formed at the centres of the original galaxies. Fig. 1 indicates that gas clouds become strongly concentrated toward the central regions of the two galaxies shortly after the first close passage. The distance between the two gaseous cores does not decrease monotonically in the merger. They get closer to each other, moving on elongated orbits. Therefore the separation between the two cores shows a damped oscillation as shown by the dashed line in Fig. 2. It is clear from Fig. 2 that the star formation rate is at a maximum when



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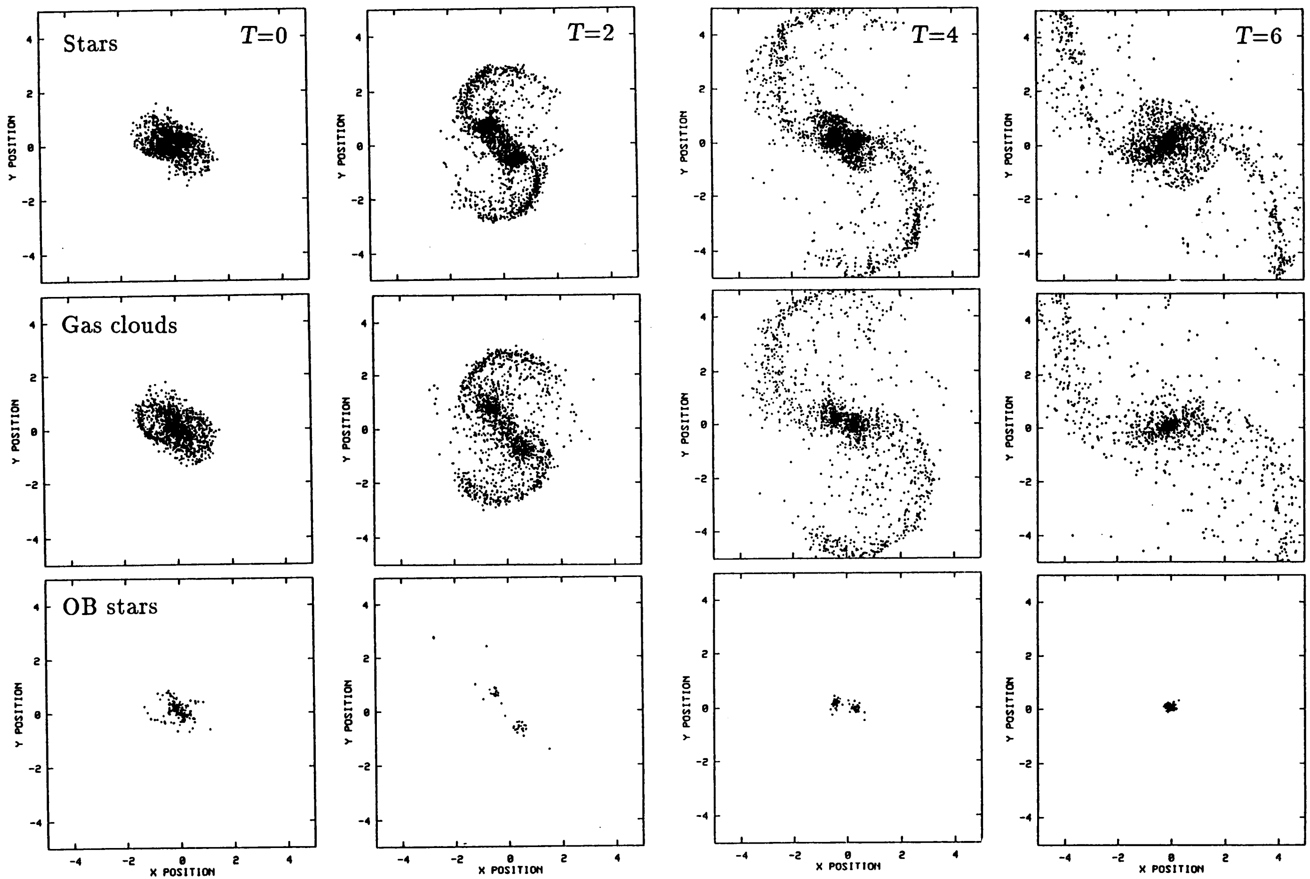


Fig.1 Separate snapshots for stars, gas clouds, and OB stars. Radius of initial discs is unity.

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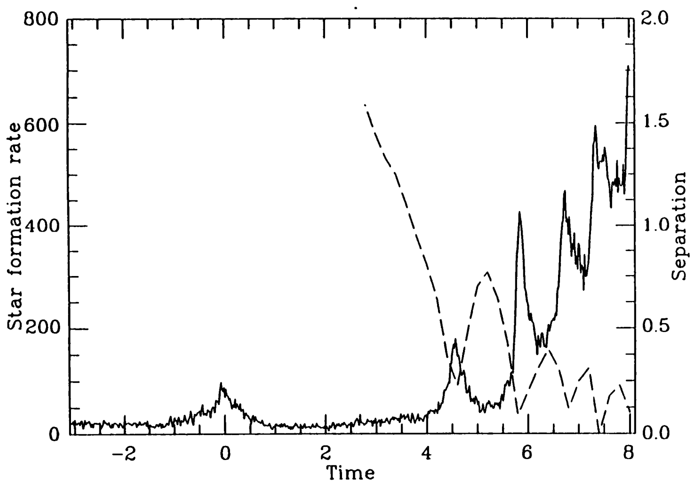


Fig.2 Time variation of star formation rate. $T$=0 is the time of first close passage. One time unit corresponds to roughly $10^8$ years.

the separation is at a minimum, and vice versa. When the separation is minimum, the gas clouds get the strongest disturbance, giving rise to a high cloud-cloud collision rate. Other models with different disc orientations show the qualitatively same results, although geometrical details and timescale are somewhat different.

## 3. Discussions

Solomon and Sage (1988) have noted that the star formation efficiency (SFE) measured by the ratio of far infrared luminosity to the molecular hydrogen mass in merging galaxies varies largely from pair to pair. Some galaxies (e.g., NGC 520, NGC 828) have a SFE similar to typical isolated galaxies, while others (e.g., Mrk 231, Arp 220) have a SFE roughly ten times larger than isolated galaxies. The repetitive starburst observed in the present numerical models is able to explain why mergers have a wide range in SFE. Mergers like NGC 520 may be at the quiescent period whereas Mrk 231, for example, may be at the peak of starburst phase at present.

It is frequently observed that the molecular gas distribution in merging galaxies has a double core structure (or a bar-like shape with two cores not separated), being consistent with the numerical result. Our numerical study predicts that the separation between two cores (or the length of the molecular bar) should be anti-correlated with the star formation efficiency.

## References


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