

## SIMULATION OF INTERACTING GALAXY PAIR ARP 82



### Physics

**KEYWORDS :** Arp 82, interacting galaxy pairs, simulation of NGC2535 and NGC2536.

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### ABSTRACT

*In the present work, the interaction between the two galaxies (NGC2535 and NGC2536) is simulated. And according to the simulation the interaction causes the two arc tails in the big galaxy NGC2535, in which the southern tail of the galaxy is bigger than the northern tail and the southern tail is connected with the smaller galaxy NGC2336 through a bridge. For the initial conditions, such as mass ratio, distance, and the radius of the two galaxies that I have put in this work, gives a best picture of the two interacted galaxies which named as Arp 82.*

### INTRODUCTION:

When galaxies interact they may merge into a large one or affect on each other without merging. These interactions make changes in the shape and the geometry of the two galaxies, in which the result is the construction of peculiar galaxies. Such peculiar galaxies are classified in atlas and catalog, Vorontsov-Velyaminov 1959 and 1977, Arp 1966, Karachentsev 1972.

Arp 82 which can be considered as M51-type galaxies, Laurikainen et al, 1998 is an example of two interacting pair of galaxies NGC2535 and NGC2536. The first is the big galaxy with long tails, while the second galaxy is the small galaxy which known as a companion of the big galaxy. The disk of NGC2535 has oval shape and seems as an eye with a pupil.

Through the interaction between the pair galaxies of Arp 82, a bridge constructs between them, which is the result of the gravitational force that affects them especially on the outer ring of NGC2535.

Arp82's bridge and tail were studied optically, Amram al et 1989 ;Hancock et al.2007. In addition of the optical studies of interacting galaxies, the computer simulation took the best role in present and the past in obtaining many properties of peculiar galaxies, such as processes of star formation, mass flow, velocity and morphology of the galaxies.

The first of interacting galaxies is created more than forty years ago for reproducing the structure of peculiar galaxies, Arp 295, M51 and NGC 5195, NGC 4647, and 4038/9, Toomer and Toomer; 1972. After that, many interacting and colliding galaxies were simulated for studying their properties and morphology, NGC4038/ NGC4039 Barnes 1988, NGC 7753/7752, Salo & Laurikainen 1993; Arp 82 Kufman et al.1997, Arp 119 Hearn and Lamb 2001, Colliding of NGC4038/ NGC4039, Kotarba et al.2010; Rasheed 2013.

### METHOD:

Simulations of interacting galaxies have been very successful in reproducing bridges and tidal tails. In the interaction stars and dark matter are collisionless point particles and they interact gravitationally.

According to the N-body simulation of this interaction the outer mass which includes stars; affects directly on each other. And the tidal interaction may construct the tidal and bridge between the galaxies.

Bridges and tails may have many shapes due to the mass ratio of the galaxies and the velocity of the stars, in addition of their geometry of view, Zwicky 1953. NGC2535 and NGC2536 were simulated with different initial conditions and models, Howard et al.1993 and Karic' 1993.

For simulating the two galaxies in the present work, IGMS model is used, in which based on Newtonian physics, Perley 2000. In this model, the particles which represent stars and gas of the galaxy, distributed on many rings in each galaxy. When the galaxies approach toward each other the outer rings of them affects

by the gravitation, and the rings distort gradually, therefore the distribution of particles of the outer rings dislocate at first, then the whole disks of the galaxies reshape to produce the peculiar galaxies.

The initial conditions of mass, position, and the distance that have been put in this work are:

For NGC2535 galaxy: the centroid mass = $2.51 \times 10^{10}$  Msun, radius=1.62 kpc, halo radius=9.72kpc. While for NGC 2536 galaxy: the centroid mass = $2.01 \times 10^{10}$  Msun, radius=1.62 kpc, halo radius =3.24 kpc.

The distance between the two centers of the two galaxies =26kpc. Inclination which is the angle that the orbital plane of NGC2535 galaxy makes with the rotation plane of NGC2536 galaxy =  $40^\circ$ .

These initial conditions that have been put in this work are not put before in simulation of Arp 82 and studying its morphology.

Figure1 shows the Sloan Digital Sky Survey (SDSS) image of Arp 82. In the figure, the big galaxy NGC2535 and its companion galaxy NGC2536 which situated in the south are shown.



Fig.1: Sloan Digital Sky Survey image of Arp 82

### RESULTS AND DISCUSSION:

Figure 2 shows the NGC2535 galaxy in the right and the NGC2536 in the left. The time  $t=0$ . The ring of the big galaxy NGC2535 is clearly shown, because the number of the particles are more in this galaxy.

This image of the simulation shows that; the two galaxies are still not affecting on each other, therefore there is no any distortion of the rings.

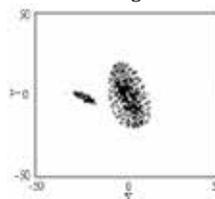


Fig.2: The two galaxies at  $t=0$ .

Figure 3 shows how the two galaxies approach toward each other under the influence of gravitation force at time  $t=50$  million years. Because of this force, the outer rings of the galaxies especially NGC 2535 which appear clearly that its out rings, suffer from distortion slightly.

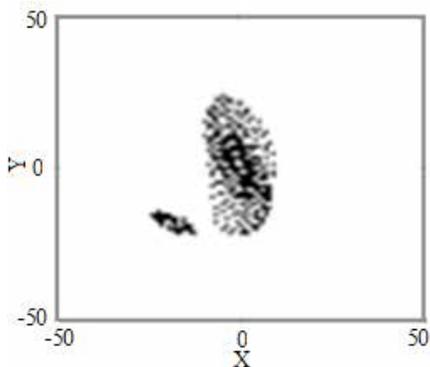


Fig.3: The two galaxies at  $t=50$  million years

In fig.4 which indicates the interaction of the two galaxies at  $t=70$  million years, the distortion in NGC 2535 is appeared more than before, and the outer rings of this galaxy is more affected by the attraction of the other galaxy.

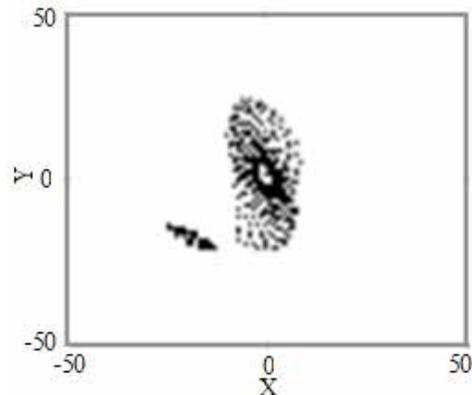


Fig.4: The two galaxies at  $t=70$  million years.

Figure 5 presents the interaction between the two galaxies at  $t=90$  million years. In the figure the southern tail of the big galaxy appears gradually.

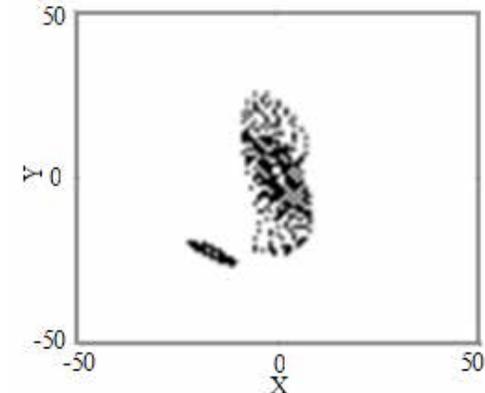


Fig.5: The two galaxies at  $t=90$  million years.

In fig.6 the distortion of the big galaxy is shown at time  $t=110$  million years. In the figure the arc shape of the big galaxy is appeared, especially with constructing the southern tail.

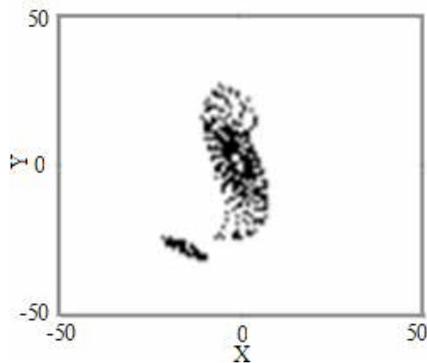


Fig.6: The two galaxies at  $t=110$  million years.

Figure 7 shows the interaction of the two galaxies at  $t=130$  million years. The figure clearly shows that; the northern tail of the big galaxy starts to appear, and the small galaxy moved more toward the south direction of the big galaxy which affects the shape of the big galaxy, especially in the southern tail because when the two galaxies approach, tidal forces pull stars out into the tidal stream.

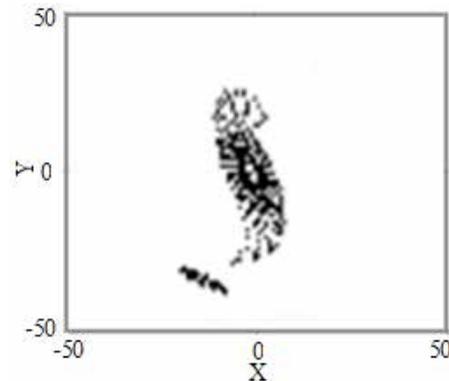


Fig.7: The two galaxies at  $t=130$  million years.

In fig.8 which indicates the interaction between the two galaxies at 190 million years, the northern tail is appeared, and the southern tail is arced and appears to be longer than before. The two galaxies affect more on each other, and they are in their way for constructing a bridge between them.

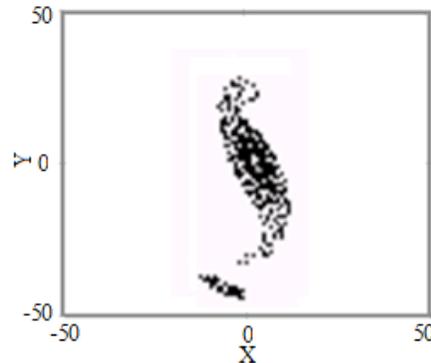


Fig.8: The two galaxies at  $t=160$  million years.

Figure 9 shows the connection of the two galaxies with each other through the southern tail of the big galaxy. This tail constructs a bridge of stars and gas between the NGC2535 and NGC 2536 galaxies. The shape of the two galaxies and the bridge between them gives the peculiar shapes which are named as Arp 82.

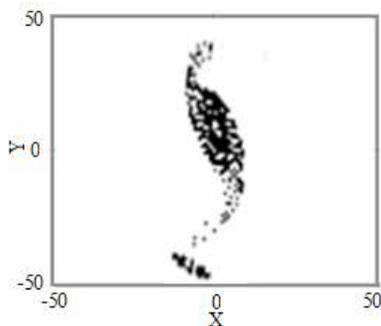


Fig.9: Arp 82 at  $t=190$  million years.

The morphology of Arp 82 which is obtained in this work by simulation of NGC2535 and NGC 2536, is similar to that observed by telescopes.

#### CONCLUSION:

From the simulation of the two galaxies NGC2535 and NGC2536, the conclusion reveals that; the two galaxies interact on each other and reproduce their shapes after 190 million years from the interaction to construct what is known as Arp 82. The interaction causes reshaping the disk of the big galaxy to an oval shape like the eye.

It also concludes that; the NGC2535 and its company are connected strongly with a bridge in the south.

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