Evolution of Late-type Galaxies in a Cluster Environment:

Effects of High-speed Multiple Encounters with Early-type Galaxies

Jeong-Sun Hwang (Sejong Univ.)

in collaboration with

Changbom Park (KIAS)
Arunima Banerjee (IISER, Tirupati, India)
Ho Seong Hwang (KIAS)

Research Background

★ Evolution of galaxies: Nature vs. Nurture

★ Relative abundance of galaxies with different types is closely related to the densities of the local environment

- fraction of spiral galaxies: field (~80 %)
  periphery of clusters (~60 %)
  centers of rich clusters (~ 0 %)

→ Environment plays a significant role

★ Observational study of [Park., C. & Hwang., H. S. 2009] Found:

THE ASTROPHYSICAL JOURNAL, 699:1595–1609, 2009 July 10

INTERACTIONS OF GALAXIES IN THE GALAXY CLUSTER ENVIRONMENT

CHANGBOM PARK AND HO SEONG HWANG
School of Physics, Korea Institute for Advanced Study, Seoul 130-722, Korea; cbp@kias.re.kr, hshwang@kias.re.kr
Received 2008 December 11; accepted 2009 May 11; published 2009 June 24

- Morphology-Clustercentric Radius-Neighbor Environment relation is working in clusters.
- Hydrodynamic interactions with nearby ETGs (early-type galaxies) is the main drive to quenching star formation activity of LTGs (late-type galaxies) in clusters.

Purpose of Our Numerical Study

★ LTGs falling into a cluster would evolve being influenced by the interactions with both the cluster and the nearby cluster member galaxies.

★ Most Numerical studies, *however*, tend to focus on the effects of the cluster with little work done on those of the latter.

★ Our work aims to study the evolution of LTGs via interaction with early-type cluster member galaxies having hot gas in their halos, using N-body/hydrodynamical simulations (Gadget-3).

★ To asses the influence of both the hot halo gas of the colliding ETGs and the hot cluster gas on the evolution of LTGs, we compare the results of our simulations with those of galaxy-cluster interactions in comparable simulation settings.

★ We are interested in cold gas depletion, star formation quenching, etc of LTGs.
→ J-S Hwang et al. 2018 (ApJ, 856, 160)

The Astrophysical Journal, 856:160 (14pp), 2018 April 1
https://doi.org/10.3847/1538-4357/aab3ce

CrossMark

Evolution of Late-type Galaxies in a Cluster Environment: Effects of High-speed Multiple Encounters with Early-type Galaxies

Jeong-Sun Hwang[1], Changbom Park[2], Arunima Banerjee[3], and Ho Seong Hwang[4]
[1] Department of Physics and Astronomy, Sejong University, 209 Neungdongro, Gwangjin-gu, Seoul 05006, Republic of Korea; hwang2k@gmail.com
[2] School of Physics, Korea Institute for Advanced Study, 85 Hoegiro, Dongdaemun-gu, Seoul 02455, Republic of Korea
[3] Indian Institute of Science Tirupati, Tirupati - 517507, India
[4] Quantum Universe Center, Korea Institute for Advanced Study, 85 Hoegiro, Dongdaemun-gu, Seoul 02455, Republic of Korea; hhwang@kias.re.kr
Received 2017 September 15; revised 2018 January 16; accepted 2018 February 28; published 2018 April 4

Numerical Simulations

★ We run the simulations for the cases where a Milky Way Galaxy-like LTG, flying either edge-on or face-on, experiences six consecutive collisions with twice more massive ETGs possessing hot gas in their halos, at the closest approach distances of 65, 55, 45, 35, 25, and 15 kpc/h, in order, at the relative velocities of 1500~1600 km/s.

★ In order to construct more plausible initial conditions (ICs) for the simulations of the interactions, we use the information about the spatial distribution of galaxies drawn from the galaxy catalog of Coma cluster (H. S. Hwang et al.).

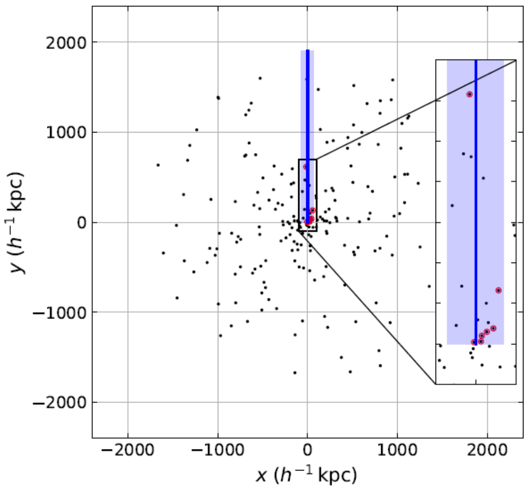
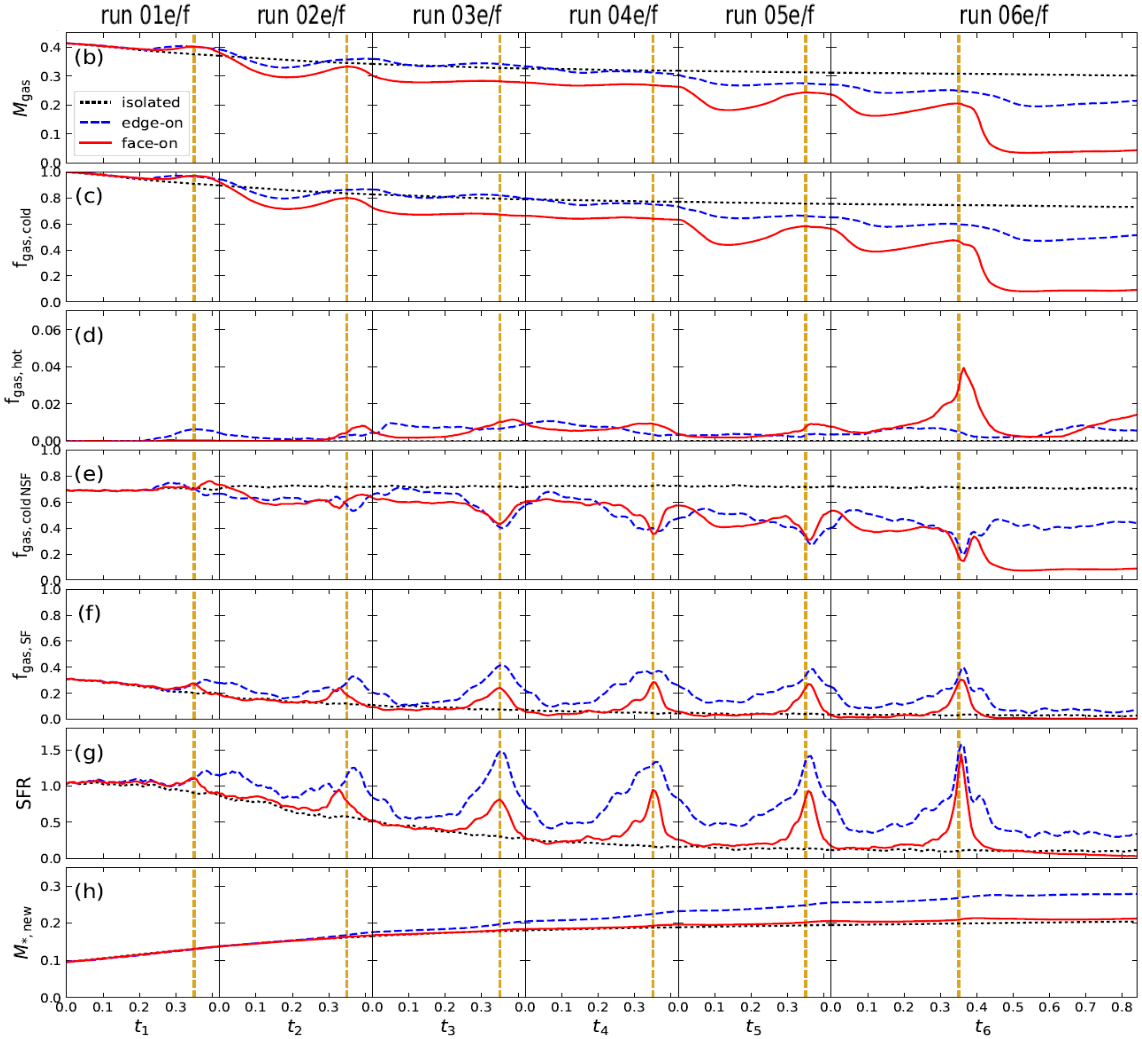


FIG. 2.— One of the deprojected 3D distributions of the 209 Coma member galaxies (black dots) shown in the x-y plane. The blue line drawn along the y-axis, from $y = 1900\ h^{-1}$ kpc to $y = 0$, is chosen for the radial path of an LTG galaxy (target galaxy) falling toward the cluster center. The blue shaded region is the axial cross section of the cylinder with a radius of $70\ h^{-1}$ kpc whose axis and height coincide with the y-axis and the orbital path of the target galaxy. Within the cylinder, seven galaxies (marked with red circles) are enclosed in this distribution. The rectangular region $|x| \leq 100\ h^{-1}$ kpc, $-100\ h^{-1}$ kpc $\leq y \leq 700\ h^{-1}$ kpc is magnified.



★ We find that the LTG can lose most of its cold gas after the six collisions and have more star formation activity during the collisions.

★ By comparing our simulation results with those of galaxy–cluster interactions, we claim that the role of the galaxy–galaxy interactions on the evolution of LTGs in clusters could be comparable with that of the galaxy–cluster interactions, depending on the dynamical history.