Publications of the Korean Astronomical Society
30: 473 ∼ 474, 2015 September

pISSN: 1225-1534
eISSN: 2287-6936
http://dx.doi.org/10.5303/PKAS.2015.30.2.473

SUSSING MERGER TREES: THE IMPACT OF HALO MERGER TREES ON GALAXY PROPERTIES IN A SEMI-ANALYTIC MODEL

Jaehyun Lee & Sukyoung Yi
Department of Astronomy and Yonsei University Observatory, Yonsei University, Seoul 120-749, Republic of Korea
E-mail: yi@yonsei.ac.kr
(Received November 30, 2014; Reviced May 31, 2015; Aaccepted June 30, 2015)

ABSTRACT

Halo merger trees are the essential backbone of semi-analytic models for galaxy formation and evolution. Srisawat et al. (2013) show that different tree building algorithms can build different halo merger histories from a numerical simulation for structure formation. In order to understand the differences induced by various tree building algorithms, we investigate the impact of halo merger trees on a semi-analytic model. We find that galaxy properties in our models show differences between trees when using a common parameter set. The models independently calibrated for each tree can reduce the discrepancies between global galaxy properties at z=0. Conversely, with regard to the evolutionary features of galaxies, the calibration slightly increases the differences between trees. Therefore, halo merger trees extracted from a common numerical simulation using different, but reliable, algorithms can result in different galaxy properties in the semi-analytic model. Considering the uncertainties in baryonic physics governing galaxy formation and evolution, however, these differences may not necessarily be significant.

Key words: methods: numerical – galaxies: evolution – galaxies: formation – galaxies: haloes

1. TREE BUILDING ALGORITHMS AND A SEMI-ANALYTIC MODEL

The following is a summary of Lee et al. (2014). In this study, we used nine different halo merger trees generated from a halo catalogue by using various independently developed algorithms. The halo catalogue was extracted from a cosmological N-body volume simulation of structure formation run using Gadget-3 (Springel, 2005). The tree building algorithms can be classified into five groups according to their main features. The following list shows the halo properties that the various algorithms used to construct merger trees, as well as the name of the algorithms.

- Particle transfer between haloes in two sequential snapshots: MergerTree, TreeMaker, VELOCIraptor, ySAMtm
- Particle transfer and the boundness of particles to haloes in more than two sequential snapshots: D-Trees, SubLink
- Particle transfer and on-the-fly halo construction: HBT
- Particle transfer and halo trajectories: Consistent Trees
- Halo trajectories only: JMerge

The trees were implanted into a semi-analytic model written by Lee & Yi (2013). Galaxy properties were calculated by the semi-analytic model based on halo merger trees modified by tree cleaning processes which remove the branches of abnormal haloes that disappear without any descendants or are newly identified as subhaloes. By adopting the prescriptions described in Binney & Tremaine (2008) and Battin (1987), our semi-analytic model additionally computes the trajectories and masses of subhaloes identified as merged into their host haloes before reaching the central regions ($< 0.1R_{\rm vir}$) of the hosts. Further details of the tree building algorithms, the cosmological volume simulation, and the semi-analytic model are described in Srisawat et al. (2013) and Lee & Yi (2013).

2. RESULTS AND DISCUSSION

We investigated the evolutionary features and global properties of galaxies in semi-analytic models based on nine different trees and a common parameter set. The mean star formation histories of central galaxies with respect to the final M_{200} of haloes show noticeable differences, especially in the most massive groups and very early epochs. This is due to the fact that haloes at high redshifts are smaller and less clustered than at $z = 0$. Furthermore, bigger haloes are more likely to have grown over time via mergers of small structures. The evolutionary histories of satellite number density and galaxy merger rates also clearly demonstrate the effects of the different tree building algorithms on galaxy evolution. Algorithms developed to minimize the segmentation of merger trees have more satellite galaxies. These differences naturally lead to various stellar mass formation and assembly times; algorithms with lower merger rates or fewer subhaloes tend to have narrower gaps between stellar assembly and the formation time of galaxies. As the final products of these effects across cosmic time, the global galaxy properties at z=0, such as the stellar mass function, the stellar to halo mass ratio, and the contribution of merger accretion to total stellar mass also show slight differences according to the algorithms.

We confirmed that our semi-analytic model based on the different halo merger trees can be individually calibrated to match a galaxy stellar mass function, a popular calibration point of many semi-analytic models. The calibration reduces the discrepancies between the trees at z=0 while it slightly widens gaps between the trees in evolutionary features such as global or individual star formation history.

To summarize, semi-analytic models based on the various merger trees resulted in different model galaxy properties. However, they can be calibrated to reproduce some empirical data by adjusting the free parameters. Thus, we can conclude that although the variety of merger trees induces non-negligible differences, they do not seem to be as significant as those coming from uncertainties in the empirical data or other input prescriptions governing baryonic physics for galaxy formation and evolution.

ACKNOWLEDGMENTS

SKY acknowledges support from the National Research Foundation of Korea(Doyak 2014003730). This study was performed under the DRC collaboration between Yonsei University and the Korea Astronomy and Space Science Institute.

REFERENCES

Battin R. H., 1987, An Introduction to the Mathematics and Methods of Astrodynamics, New York: AIAA

Binney J. & Tremaine S., 2008, Galactic Dynamics: Second Edition, Princeton University Press

Lee, J. & Yi, S. K., 2013, On the Assembly History of Stellar Components in Massive Galaxies, ApJ, 766, 38

Lee, J., et al., 2014, Sussing Merger Trees : The Impact of Halo Merger Trees on Galaxy Properties in a Semi-Analytic Model, arXiv, arXiv:1410.1241

Springel, V., 2005, The Cosmological Simulation Code GADGET-2, MNRAS, 364, 1105

Srisawat, C., et al., 2013, Sussing Merger Trees: The Merger Trees Comparison Project, MNRAS, 436, 150