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A Bayesian Approach To The Semi-Analytic Model Of Galaxy Formation

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Yu Lu, *University of Massachusetts - Amherst*

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First Advisor
Houjun Mo

Second Advisor
Martin D. Weinberg

Third Advisor
Neal Katz

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Abstract
It is believed that a wide range of physical processes conspire to shape the observed galaxy population but it remains unsure of their detailed interactions. The semi-analytic model (SAM) of galaxy formation uses multi-dimensional parameterizations of the physical processes of galaxy formation and provides a tool to constrain these underlying physical interactions. Because of the high dimensionality and large uncertainties in the model, the parametric problem of galaxy formation can be profitably

tackled with a Bayesian-inference based approach, which allows one to constrain theory with data in a statistically rigorous way. In this thesis, I present a newly developed method to build SAM upon the framework of Bayesian inference. I show that, aided by advanced Markov-Chain Monte-Carlo algorithms, the method has the power to efficiently combine information from diverse data sources, rigorously establish confidence bounds on model parameters, and provide powerful probability-based methods for hypothesis test. Using various data sets (stellar mass function, conditional stellar mass function, K-band luminosity function, and cold gas mass functions) of galaxies in the local Universe, I carry out a series of Bayesian model inferences. The results show that SAM contains huge degeneracies among its parameters, indicating that some of the conclusions drawn previously with the conventional approach may not be truly valid but need to be revisited by the Bayesian approach. Second, some of the degeneracy of the model can be broken by adopting multiple data sets that constrain different aspects of the galaxy population. Third, the inferences reveal that model has challenge to simultaneously explain some important observational results, suggesting that some key physics governing the evolution of star formation and feedback may still be missing from the model. These analyses show clearly that the Bayesian inference based SAM can be used to perform systematic and statistically rigorous investigation of galaxy formation based on various observations and help to design new observations that can effectively discriminate theoretical models.