

확산계수를 적용한 해석적 모델과 수치적 결과가  $5 \leq M/(10^{12}h^{-1} M_{\odot}) < 10^3$ 의 질량범위에서 매우 근접히 일치하는 것을 보였으며 Bayesian and Akaike Information Criterion 검정을 통해  $0.3 \leq z \leq 3$ 의 범위에서 기존의 모델들보다 본 모델이 선호돼야함을 확인하였다. 또한 확산계수가 적색편이에 대하여 선형진화에 근접한 변화를 보임을 발견하였으며, 특정 임계 적색편이( $z_c$ )를 기준으로 확산계수가 0에 수렴함을 발견하였다. 더 나아가 두 Planck모델과 WMAP7모델에서 도출된 확산계수는 서로 상당한 차이를 보였다. 이 결과는 암흑물질 헤일로 splashback 질량함수가  $z \geq z_c$ 에서 매개변수가 없는 온전한 해석적 모델로 설명되고  $z_c$ 가 독립적으로 우주의 초기조건을 독립적으로 특징지을 수 있는 가능성을 지님을 시사한다. 이 초록은 The Astrophysical Journal의 Ryu & Lee 2021, ApJ, 917, 98 (arxiv:2103.00730) 논문을 바탕으로 작성되었다.

### [구 GC-20] Horizon Run Spin-off Simulations for Studying the Formation and Expansion history of Early Universe

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Horizon Run 5 (HR5) is a cosmological hydrodynamical simulation which captures the properties of the Universe on aGpc scale while achieving a resolution of 1kpc. This enormous dynamic range allows us to simultaneously capture the physics of the cosmic web on very large scales and account for the formation and evolution of dwarf galaxies on much smaller scales. On the back of a remarkable achievement of this, we have finished to run follow-up simulations which have 2 times larger volume than before and are expected to complementary to some limitations of previous HR simulations both for the study on the large scale features and the expansion history in a distant Universe. For these simulations, we consider the sub-grid physics of radiative heating/cooling, reionization, star formation, SN/AGN feedbacks, chemical evolution and the growth of super-massive blackholes. In order to do this project, we implemented a hybrid MPI-OpenMP version of the RAMSES code, 'RAMSES-OMP', which is specifically designed for modern many-core many thread parallel systems. These simulation successfully reproduce various observation result and provide a large amount of statistical samples of Lyman-alpha emitters and protoclusters which are important to understand the formation and expansion history of early universe. These are invaluable assets for the interpretation of current  $\Lambda$ CDM cosmology and

current/upcoming deep surveys of the Universe, such as the world largest narrow band imaging survey, ODIN (One-hundred-square-degree Dark energy camera Imaging in Narrow band).

### [구 GC-21] Horizon Run 5 Black Hole Populations and Pulsar Timing Array

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Merging of two supermassive black holes would generate gravitational waves that can be detected by the Pulsar Timing Array (PTA) in the nHz band. In order to assess the plausibility of GW detection with PTA and to develop the data analysis scheme, it is important to understand the underlying properties of black holes and black hole binaries. In this work, we present mass and redshift distributions of black hole mergers using the Horizon Run 5 (HR5) data and discuss their implications for GW detection. We find a general conjecture about the black hole merger tree is true with the Horizon Run 5. For example, a) relatively lighter black holes merge at higher redshifts and b) binary mergers do contribute to the formation of more massive black holes toward low redshifts. We also present our plan to use the black hole properties extracted from the HR5 data in order to generate simulated GW signals to be injected into actual PTA data analysis pipelines. Mass and distance obtained from the HR5 would be key ingredients to generate a more realistic PTA source data set.

### [구 GC-22] STag: Supernova Tagging and Classification

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