Cosmological Parameters from N-point Correlation Function

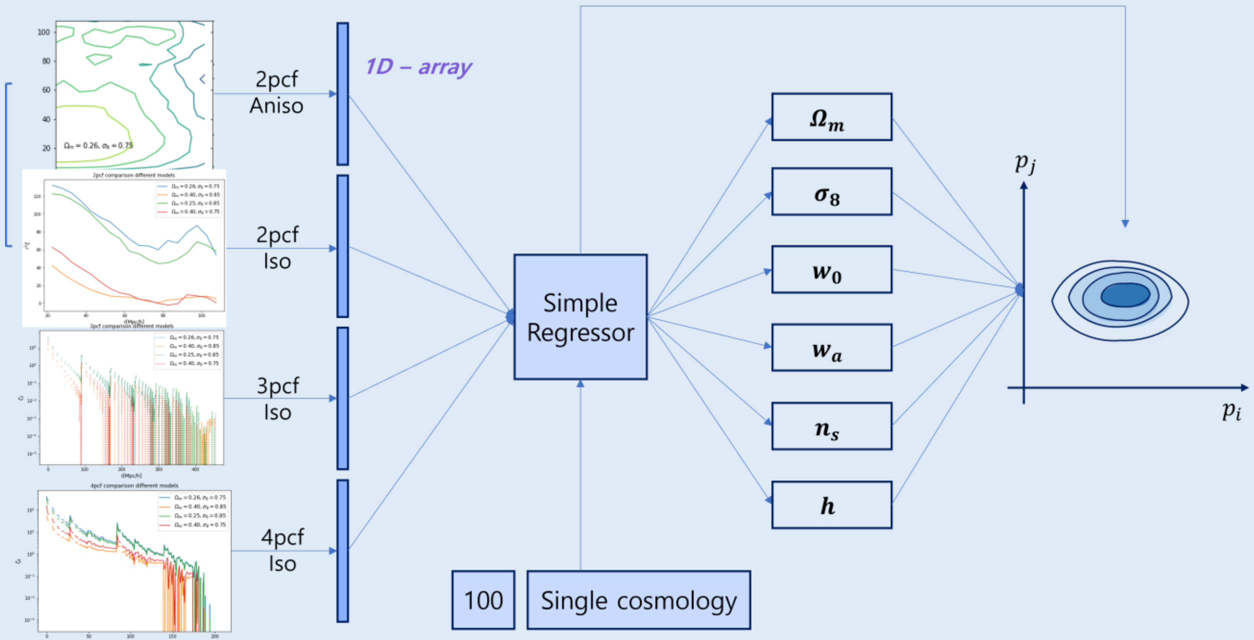
&

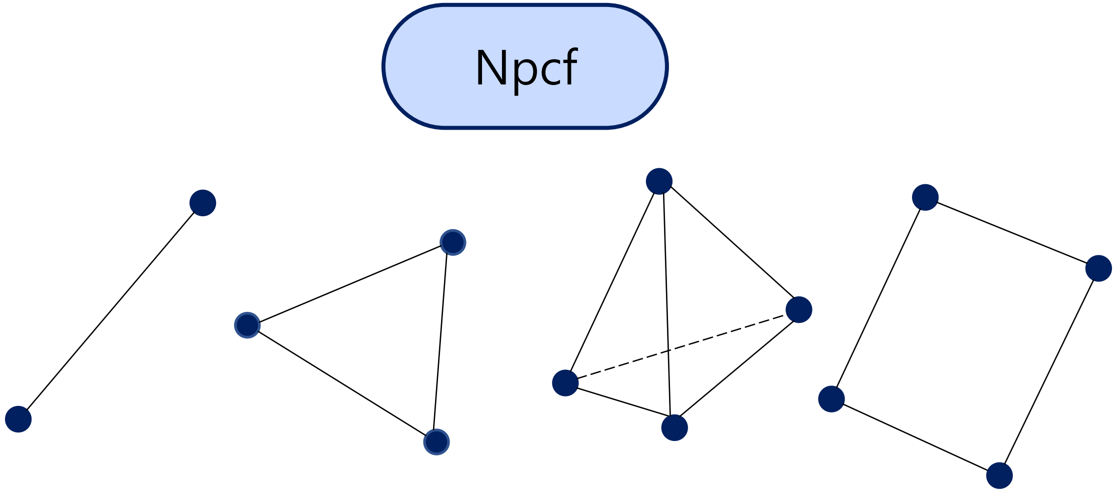
Distribution of Satellite Galaxies Depending on Supernova Winds

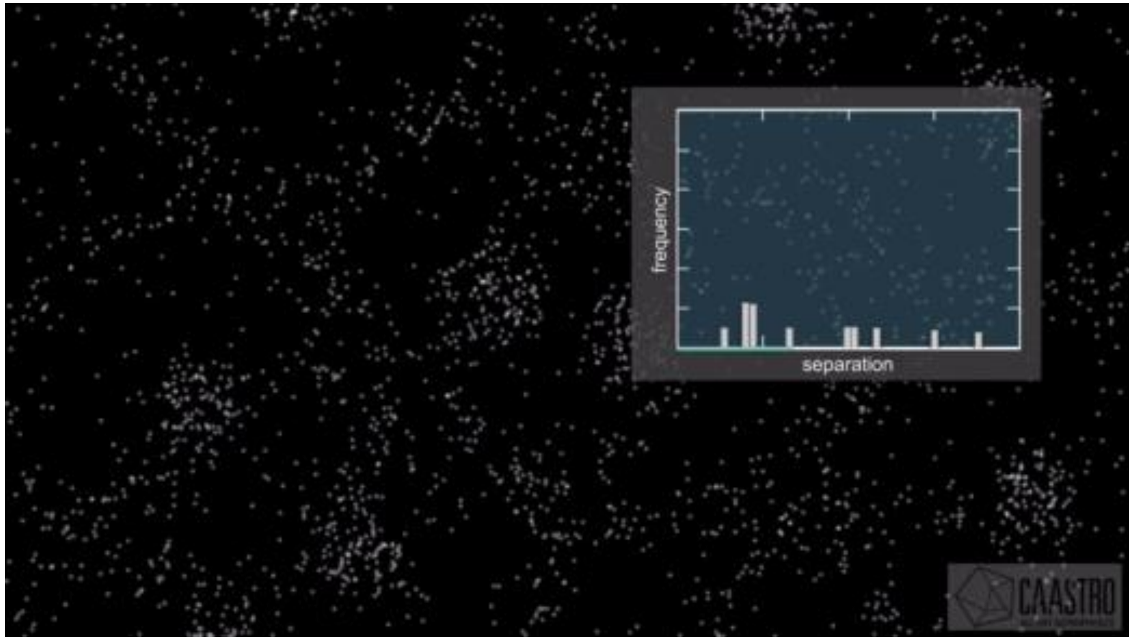
Sumi Kim
Cosmology Lab
University of Seoul

N point correlation function

우주 거대 구조의 공간적 특징을 계산하고
고차 상관 함수를 통한 통계적인 분석과
머신 러닝을 이용하여 우주론적 매개변수를 추정

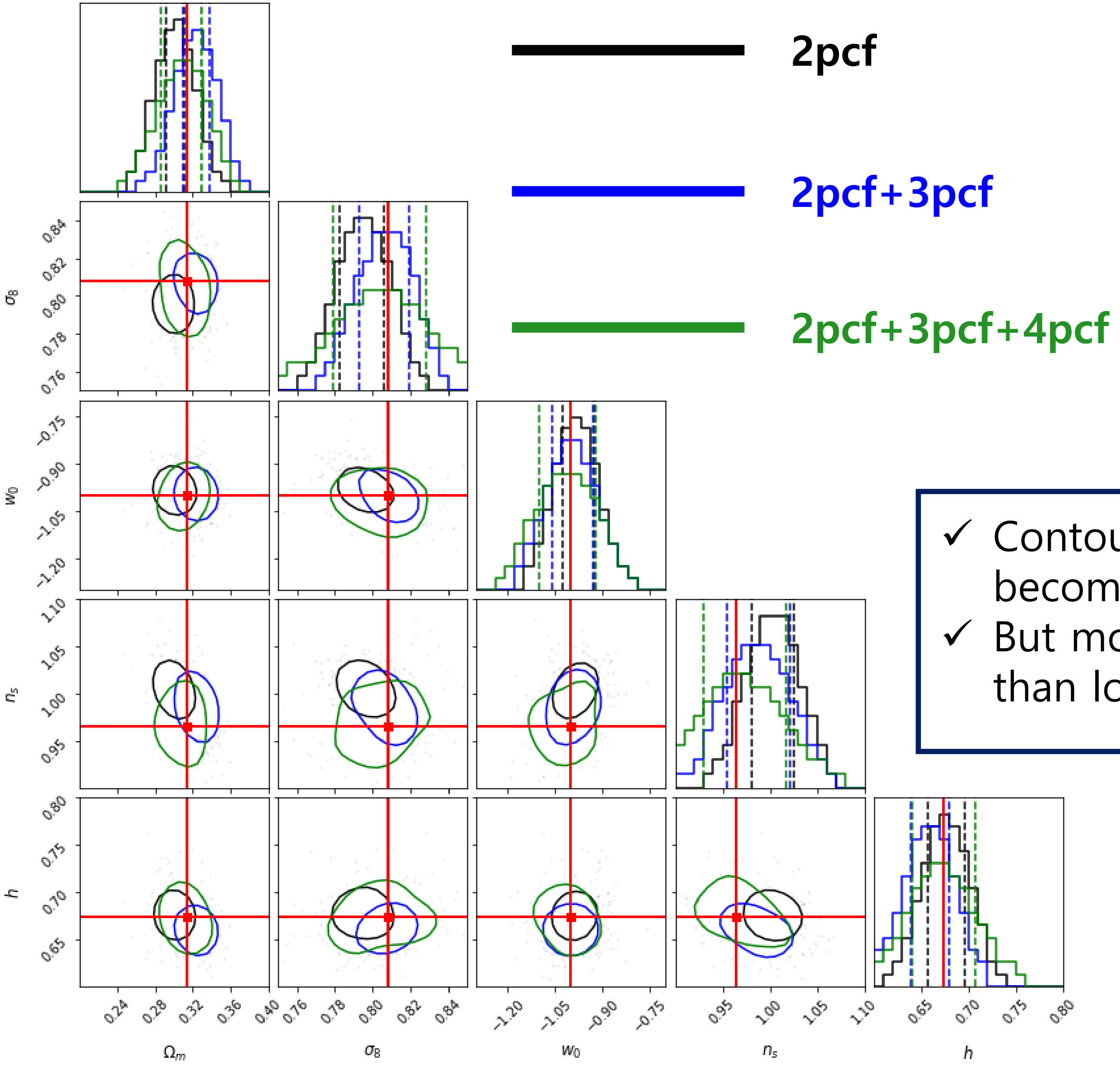






https://www.youtube.com/watch?v=jpXuYc-wzk4&t=1s

N point correlation function



고차 상관 함수에 포함된
우주 구조의 정보가
우주론적 매개변수를 추정하는 데
도움이 됨을 확인하는 것이 목표

- ✓ Contour size becomes larger
- ✓ But more centered than low order results

N point correlation function

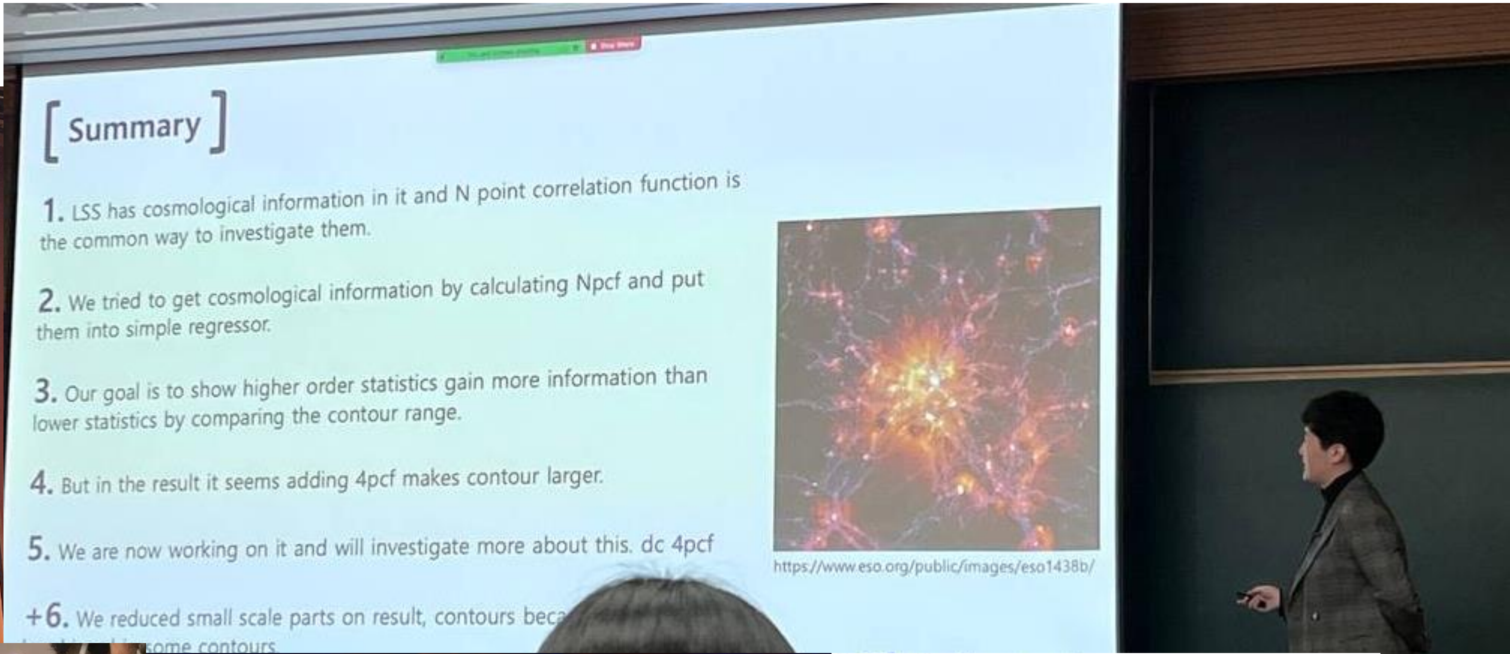
[Large Scale Structure]

How can we extract this?

Cosmological Information

$\Omega_m, \sigma_8, w_0, w_a, n_s, h$

https://www.eso.org/public/images/eso1438b/



[Summary]

1. LSS has cosmological information in it and N point correlation function is the common way to investigate them.

2. We tried to get cosmological information by calculating Npcf and put them into simple regressor.

3. Our goal is to show higher order statistics gain more information than lower statistics by comparing the contour range.

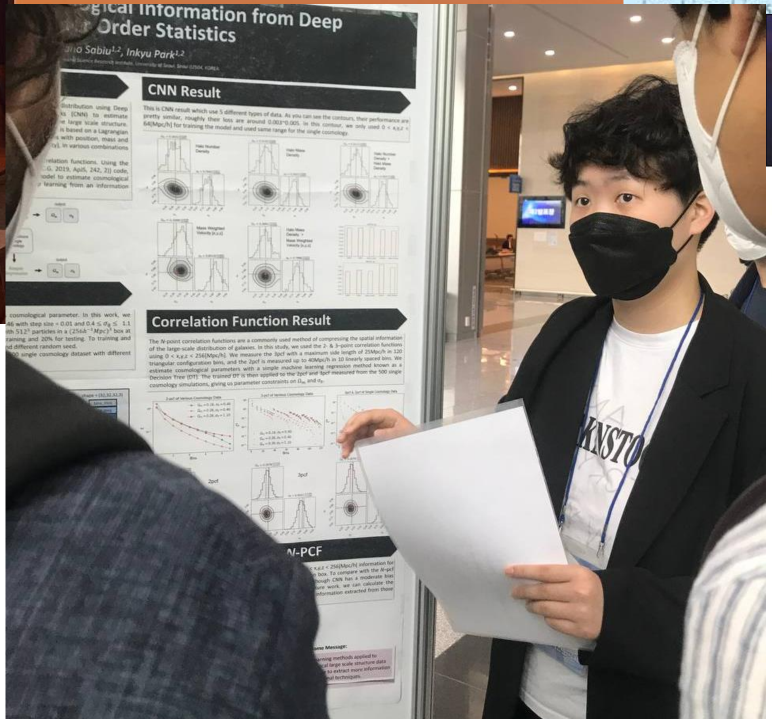
4. But in the result it seems adding 4pcf makes contour larger.

5. We are now working on it and will investigate more about this. dc 4pcf

+6. We reduced small scale parts on result, contours beca

some contours

https://www.eso.org/public/images/eso1438b/



gical Information from Deep

Order Statistics

no Sabiu[1,2], Inkyu Park[1,2]

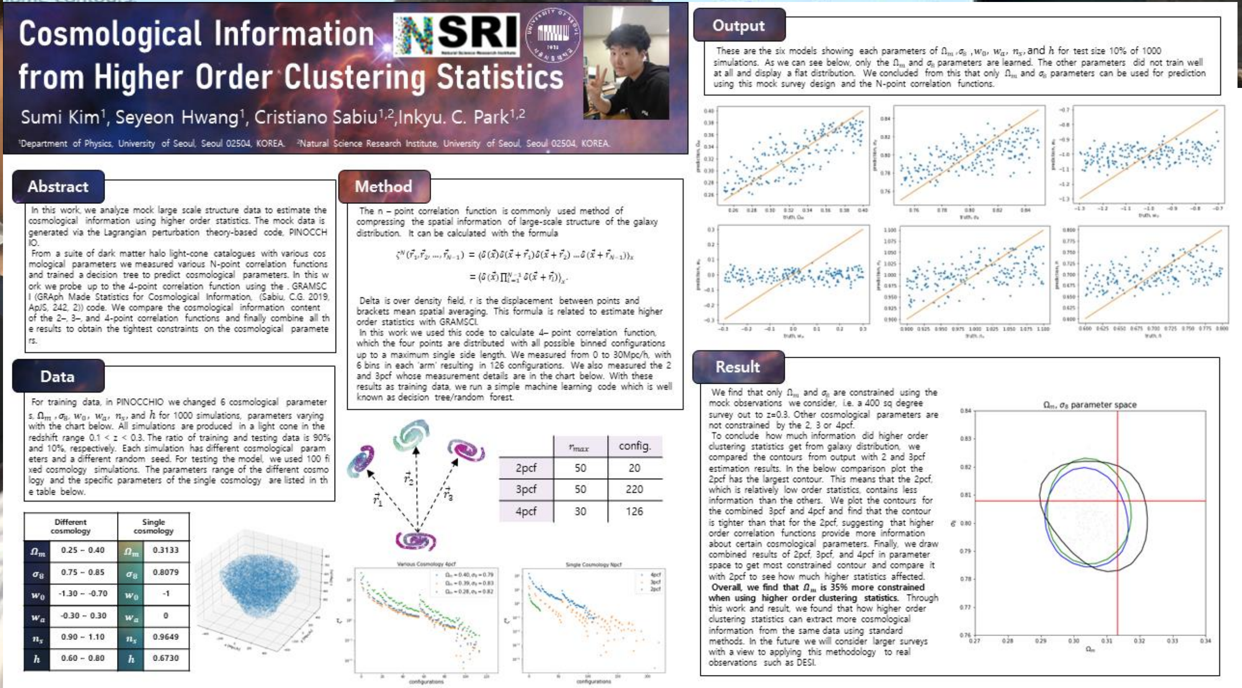
CNN Result

This is CNN result which use 5 different types of data. As you can see the contours, their performance are pretty similar, roughly their loss are around 0.003~0.005. In this contour, we only used 0 < x,y,z < 64[Mpc/h] for training the model and used same range for the single cosmology.

Correlation Function Result

The N-point correlation functions are a commonly used method of compressing the spatial information of the large-scale distribution of galaxies. In this study, we used the 2- & 3-point correlation functions using 0 < x,y,z < 256[Mpc/h]. We measure the 3pcf with a maximum side length of 25Mpc/h in 120 triangular configuration bins, and the 2pcf is measured up to 40Mpc/h in 10 linearly spaced bins. We estimate cosmological parameters with a simple machine learning regression method known as a Decision Tree (DT). The trained DT is then applied to the 2pcf and 3pcf measured from the 500 single cosmology simulations, giving us parameter constraints on Ω_m and σ_8.

N-PCF



Cosmological Information from Higher Order Clustering Statistics

Sumi Kim[1], Seyeon Hwang[1], Cristiano Sabiu[1,2], Inkyu. C. Park[1,2]

[1]Department of Physics, University of Seoul, Seoul 02504, KOREA. [2]Natural Science Research Institute, University of Seoul, Seoul 02504, KOREA.

Abstract

In this work, we analyze mock large scale structure data to estimate the cosmological information using higher order statistics. The mock data is generated via the Lagrangian perturbation theory-based code, PINOCCHIO.

From a suite of dark matter halo light-cone catalogues with various cosmological parameters we measured various N-point correlation functions and trained a decision tree to predict cosmological parameters. In this work we probe up to the 4-point correlation function using the . GRAMSCI (GRAph Made Statistics for Cosmological Information, (Sabiu, C.G. 2019, ApJS, 242, 2)) code. We compare the cosmological information content of the 2-, 3-, and 4-point correlation functions and finally combine all the results to obtain the tightest constraints on the cosmological parameters.

Data

For training data, in PINOCCHIO we changed 6 cosmological parameters, Ω_m, σ_8, w_0, w_a, n_s, and h for 1000 simulations, parameters varying with the chart below. All simulations are produced in a light cone in the redshift range $0.1 < z < 0.3$. The ratio of training and testing data is 90% and 10%, respectively. Each simulation has different cosmological parameters and a different random seed. For testing the model, we used 100 fixed cosmology simulations. The parameters range of the different cosmology and the specific parameters of the single cosmology are listed in the table below.

	Different cosmology		Single cosmology
Ω_m	0.25 ~ 0.40	Ω_m	0.3133
σ_8	0.75 ~ 0.85	σ_8	0.8079
w_0	-1.30 ~ -0.70	w_0	-1
w_a	-0.30 ~ 0.30	w_a	0
n_s	0.90 ~ 1.10	n_s	0.9649
h	0.60 ~ 0.80	h	0.6730

Method

The n – point correlation function is commonly used method of compressing the spatial information of large-scale structure of the galaxy distribution. It can be calculated with the formula

$$\zeta^N(\vec{r}_1, \vec{r}_2, \dots, \vec{r}_{N-1}) = \langle \delta(\vec{x})\delta(\vec{x}+\vec{r}_1)\delta(\vec{x}+\vec{r}_2)\dots\delta(\vec{x}+\vec{r}_{N-1})\rangle_x$$

$$= \langle \delta(\vec{x}) \textstyle\prod_{i=1}^{N-1} \delta(\vec{x}+\vec{r}_i)\rangle_x .$$

Delta is over density field, r is the displacement between points and brackets mean spatial averaging. This formula is related to estimate higher order statistics with GRAMSCI.

In this work we used this code to calculate 4– point correlation function, which the four points are distributed with all possible binned configurations up to a maximum single side length. We measured from 0 to 30Mpc/h, with 6 bins in each 'arm' resulting in 126 configurations. We also measured the 2 and 3pcf whose measurement details are in the chart below. With these results as training data, we run a simple machine learning code which is well known as decision tree/random forest.

	r_{max}	config.
2pcf	50	20
3pcf	50	220
4pcf	30	126

Output

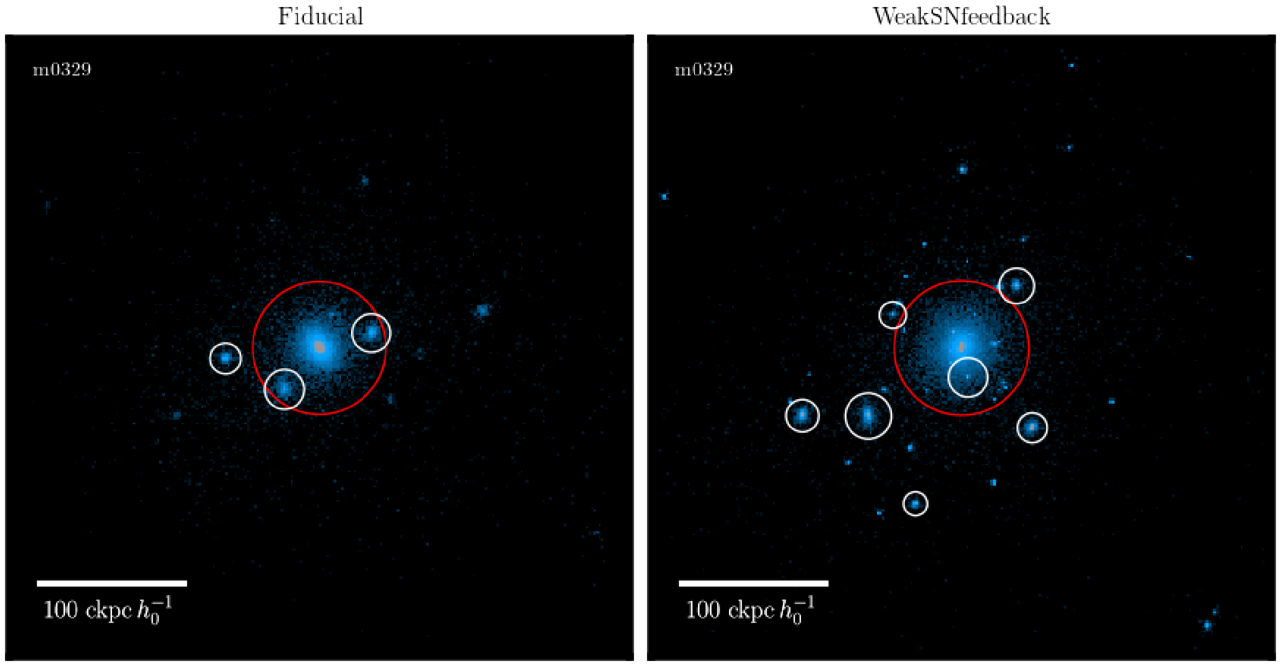
These are the six models showing each parameters of Ω_m, σ_8, w_0, w_a, n_s, and h for test size 10% of 1000 simulations. As we can see below, only the Ω_m and σ_8 parameters are learned. The other parameters did not train well at all and display a flat distribution. We concluded from this that only Ω_m and σ_8 parameters can be used for prediction using this mock survey design and the N-point correlation functions.

Result

We find that only Ω_m and σ_8 are constrained using the mock observations we consider, i.e. a 400 sq degree survey out to z=0.3. Other cosmological parameters are not constrained by the 2, 3 or 4pcf.

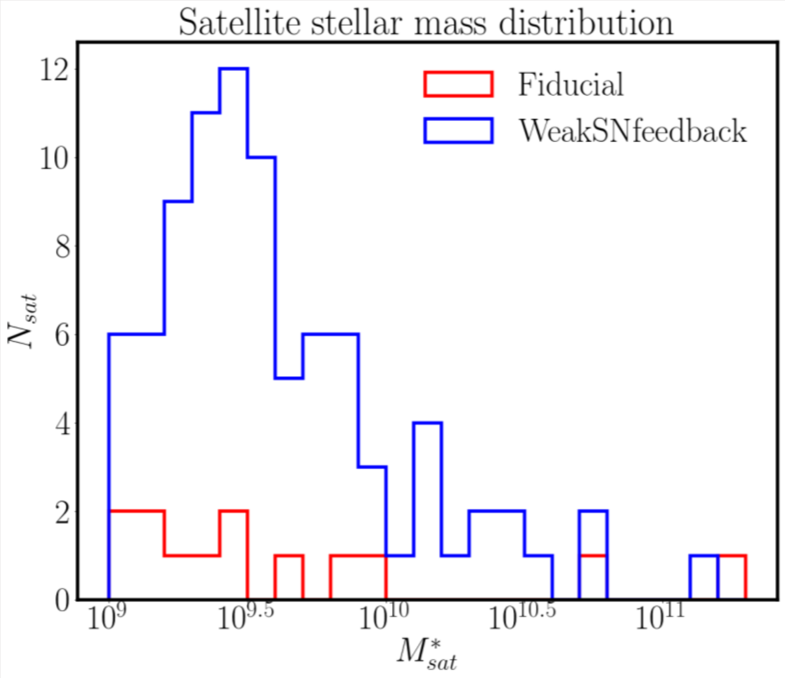
To conclude how much information did higher order clustering statistics get from galaxy distribution, we compared the contours from output with 2 and 3pcf estimation results. In the below comparison plot the 2pcf has the largest contour. This means that the 2pcf, which is relatively low order statistics, contains less information than the others. We plot the contours for the combined 3pcf and 4pcf and find that the contour is tighter than that for the 2pcf, suggesting that higher order correlation functions provide more information about certain cosmological parameters. Finally, we draw combined results of 2pcf, 3pcf, and 4pcf in parameter space to get most constrained contour and compare it with 2pcf to see how much higher statistics affected. **Overall, we find that Ω_m is 35% more constrained when using higher order clustering statistics.** Through this work and result, we found that how higher order clustering statistics can extract more cosmological information from the same data using standard methods. In the future we will consider larger surveys with a view to applying this methodology to real observations such as DESI.

Satellite galaxy distribution



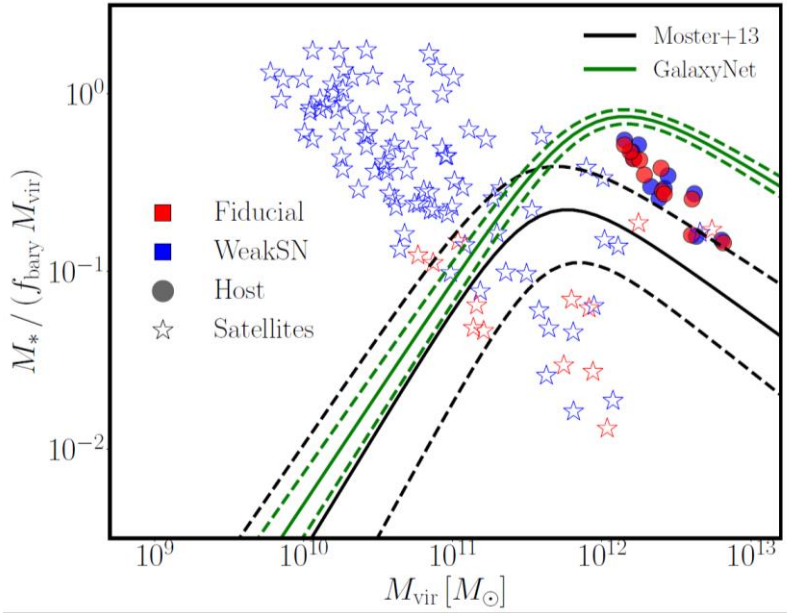
두 가지 시뮬레이션 모델을 비교하여 타원형 중심 은하 주변의 위성 은하의 분포에 Supernova wind의 세기가 어떤 영향을 미치는지 조사

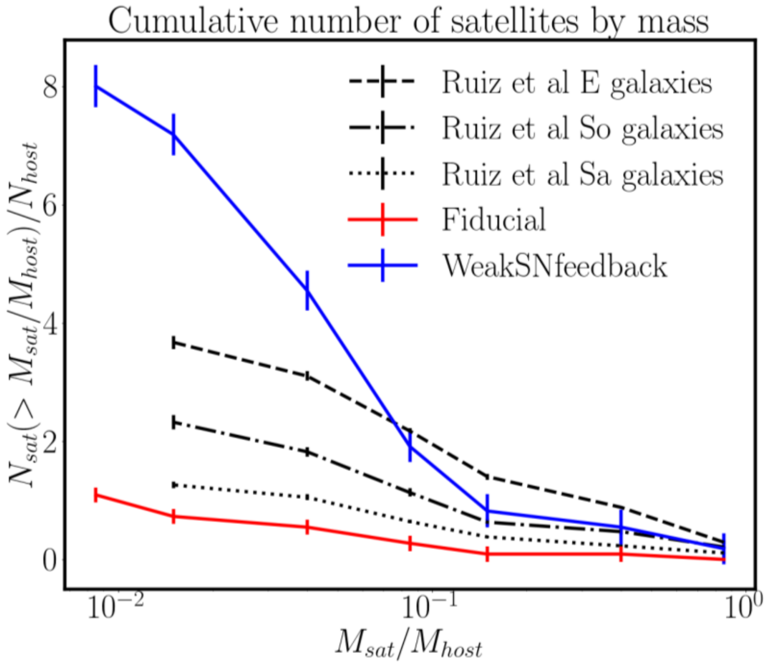
Supernova wind 세기를 약하게 만든 모델에서 대조군보다 위성은하의 개수와 질량이 증가

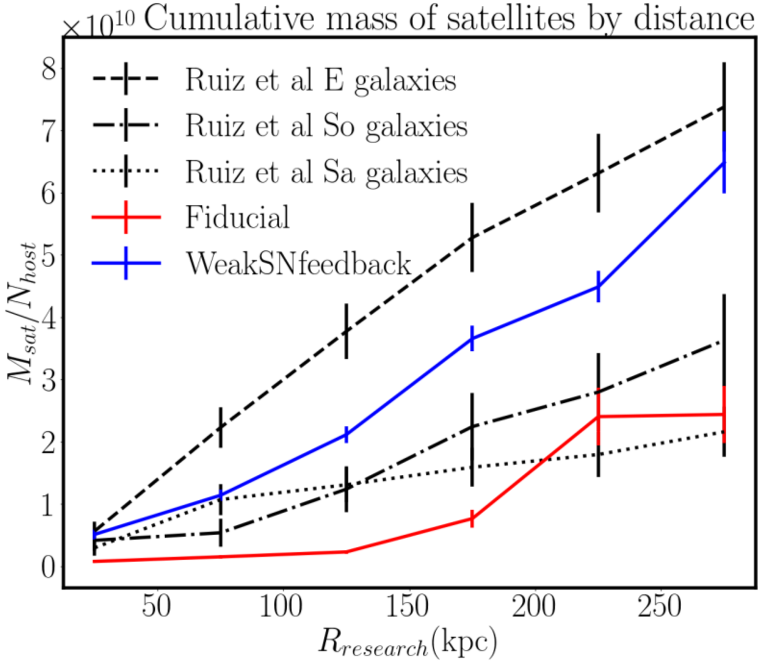


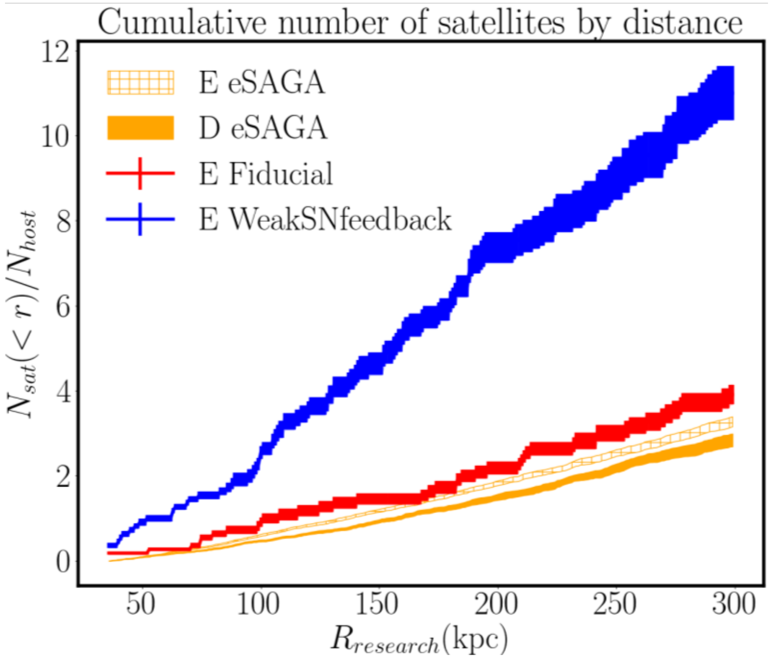
Satellite galaxy distribution

중심 은하에서는 모델에 따라
큰 변화가 없지만 위성 은하에서는
질량에 따른 개수 변화,
거리에 따른 질량 변화,
거리에 따른 개수 변화 등
모델에 따라 큰 변화가 있음을 확인함

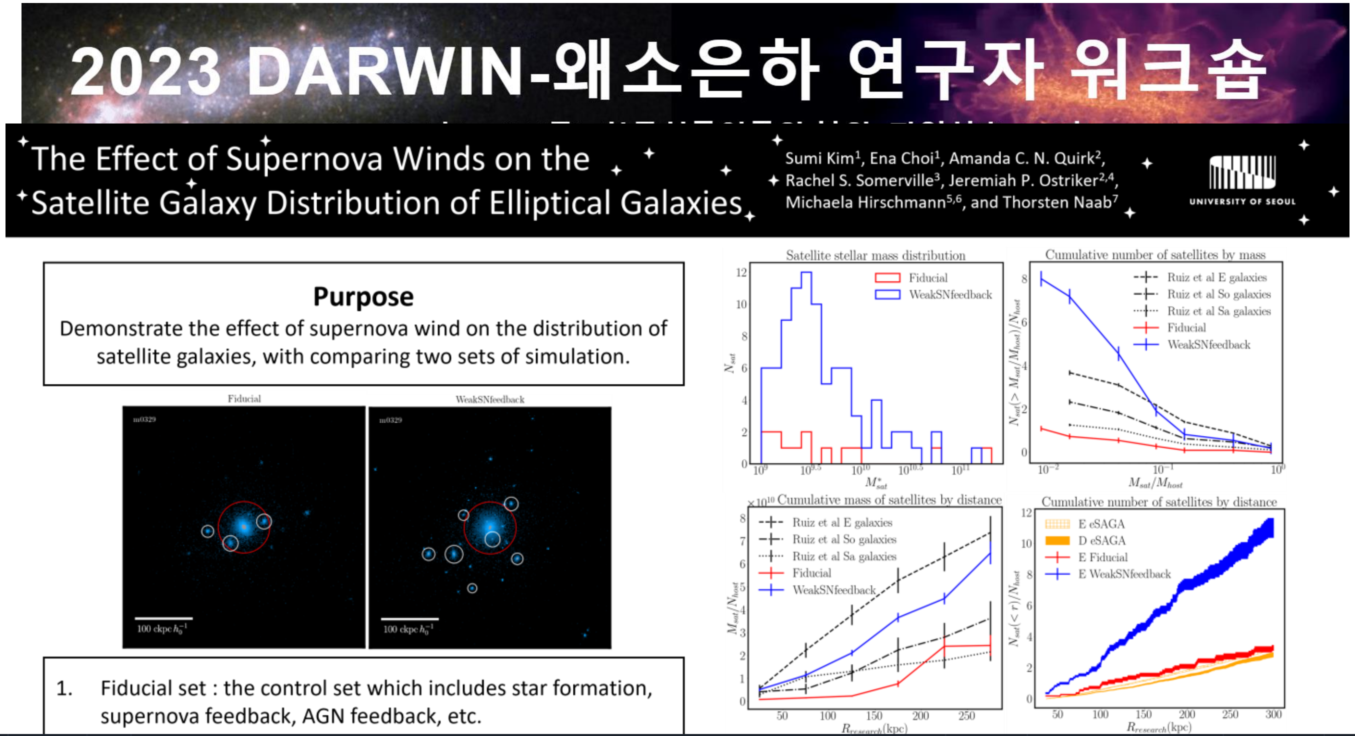








Satellite galaxy distribution



2023 DARWIN-왜소은하 연구자 워크숍

The Effect of Supernova Winds on the Satellite Galaxy Distribution of Elliptical Galaxies

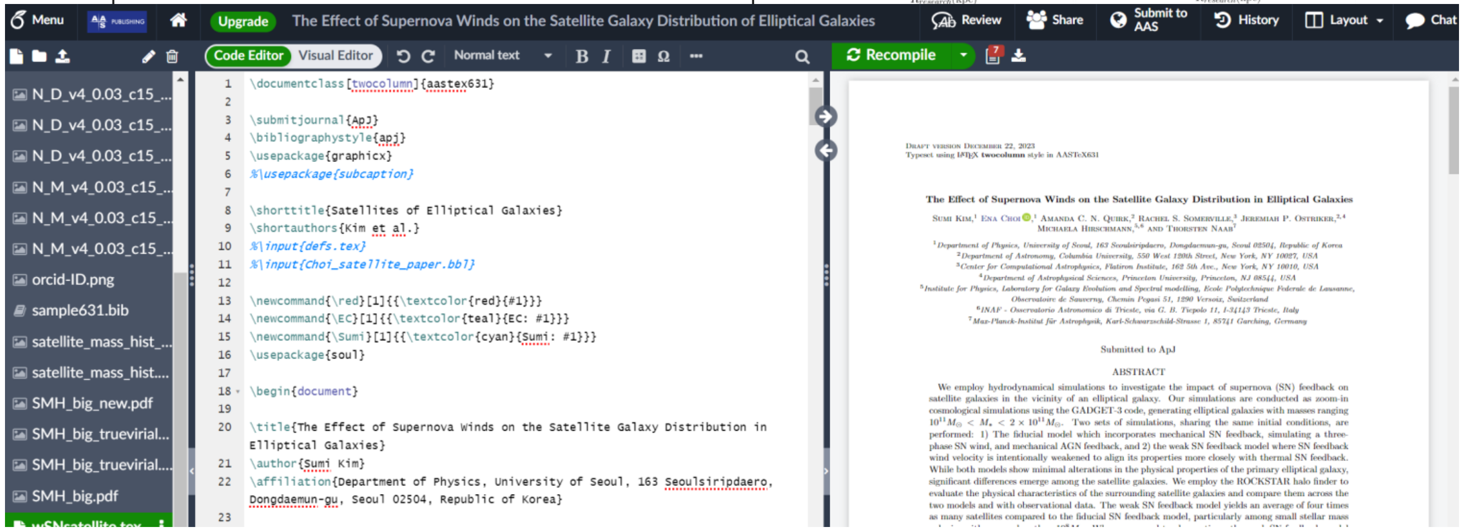
Sumi Kim[1], Ena Choi[1], Amanda C. N. Quirk[2], Rachel S. Somerville[3], Jeremiah P. Ostriker[2,4], Michaela Hirschmann[5,6], and Thorsten Naab[7]

UNIVERSITY OF SEOUL

Purpose

Demonstrate the effect of supernova wind on the distribution of satellite galaxies, with comparing two sets of simulation.

1. Fiducial set : the control set which includes star formation, supernova feedback, AGN feedback, etc.



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\author{Sumi Kim}
\affiliation{Department of Physics, University of Seoul, 163 Seoulsiripdaero, Dongdaemun-gu, Seoul 02504, Republic of Korea}

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[1] *Department of Physics, University of Seoul, 163 Seoulsiripdaero, Dongdaemun-gu, Seoul 02504, Republic of Korea*
[2] *Department of Astronomy, Columbia University, 550 West 120th Street, New York, NY 10027, USA*
[3] *Center for Computational Astrophysics, Flatiron Institute, 162 5th Ave., New York, NY 10010, USA*
[4] *Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544, USA*
[5] *Institute for Physics, Laboratory for Galaxy Evolution and Spectral modelling, Ecole Polytechnique Federale de Lausanne, Observatoire de Sauverny, Chemin Pegasi 51, 1290 Versoix, Switzerland*
[6] *INAF - Osservatorio Astronomico di Trieste, via G. B. Tiepolo 11, I-34143 Trieste, Italy*
[7] *Max-Planck-Institut für Astrophysik, Karl-Schwarzschild-Strasse 1, 85741 Garching, Germany*

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ABSTRACT

We employ hydrodynamical simulations to investigate the impact of supernova (SN) feedback on satellite galaxies in the vicinity of an elliptical galaxy. Our simulations are conducted as zoom-in cosmological simulations using the GADGET-3 code, generating elliptical galaxies with masses ranging $10^{11} M_\odot < M_* < 2 \times 10^{11} M_\odot$. Two sets of simulations, sharing the same initial conditions, are performed: 1) The fiducial model which incorporates mechanical SN feedback, simulating a three-phase SN wind, and mechanical AGN feedback, and 2) the weak SN feedback model where SN feedback wind velocity is intentionally weakened to align its properties more closely with thermal SN feedback. While both models show minimal alterations in the physical properties of the primary elliptical galaxy, significant differences emerge among the satellite galaxies. We employ the ROCKSTAR halo finder to evaluate the physical characteristics of the surrounding satellite galaxies and compare them across the two models and with observational data. The weak SN feedback model yields an average of four times as many satellites compared to the fiducial SN feedback model, particularly among small stellar mass