Planar Structures in ΛCDM universes

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Abstract Planar structures, known as Cosmic Walls, are major components in the cosmic web. Despite numerous surveys proving the existence of such structures, we are now confronting a novel type of planar structure: walls composed of very large galaxies. In our research, we managed to search such planar structures in LCDM universes and conclude that as for large scale simulations, the overall probability of such planar structures robustly emerging in the Local Group is quite small, strongly contradicting present observations which may indicate substantial problems with the LCDM model.

Introduction

Previous observations and calculations have indicated a strong signal of wall structures of pretty large galaxy clusters.(Peebles, "Flat Patterns in Cosmic Structure.") In the survey, Peebles has found significant extended flat structures for large galaxies only. Although planar structures have been analyzed for an extended period of time, we do not set scale thresholds for these component galaxies, which is responsible for the long-term dynamical evolution and physics properties. Hence, we followed the authors' steps to duplicate these findings in prevailing large-scale N-body simulations.

Methods

We adopted the same 'probe-searching' method used by Peebles to reserve consistency, shown in Fig1. For dark matter only simulations, setting absolute magnitude wasn't applicable. We applied assumptions: for most galaxies, their mass and their luminosity can be described to be a monotonic function. We separately used Uchuu(Ishiyama et al., "The Uchuu Simulations.") and MDPL2(Knebe et al., "MultiDark-Galaxies.") as datasets. In our research, we emphasize the role of 'observer' to simulate a proper position in the LCDM universe so that the results come out of a similar observer as we are, situated at Local Group. We set mass thresholds for halos according to the density of galaxies within a redshift sphere near our Milky Way. We also set standards to define good slabs and good observers: according to the redshift sphere, we separately require slabs with 600/13 or more halos within, which are called '600/13 slab'; we require that observers possess more than 2 '600 slabs' and 1 '13 slabs' simultaneously to be called 'a good observer'. 2 and 1 are based on rigorous estimations of observation sets.

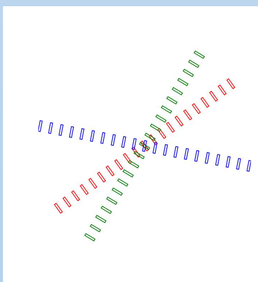

Fig1.
The probe-searching machine reaches out for the all-round sky and set flat slabs to detect high density of galaxy counts.

Results

For 2 different simulations, we reached different outcomes, which may be an effect of box size. However, they both show a significance that the probability that one random observer sees our observation sets is insignificant, shown in Fig2 and Fig3, among which the grey dots demonstrated the '13 slab' observers, and red dots showed observers satisfying '600 slab' conditions. We find that '13 slab' is common among all observers, occupying 15% to 30% of all the observers. However, '600 slab' is the major limit, with the probability respectively at 0.006% and 0.

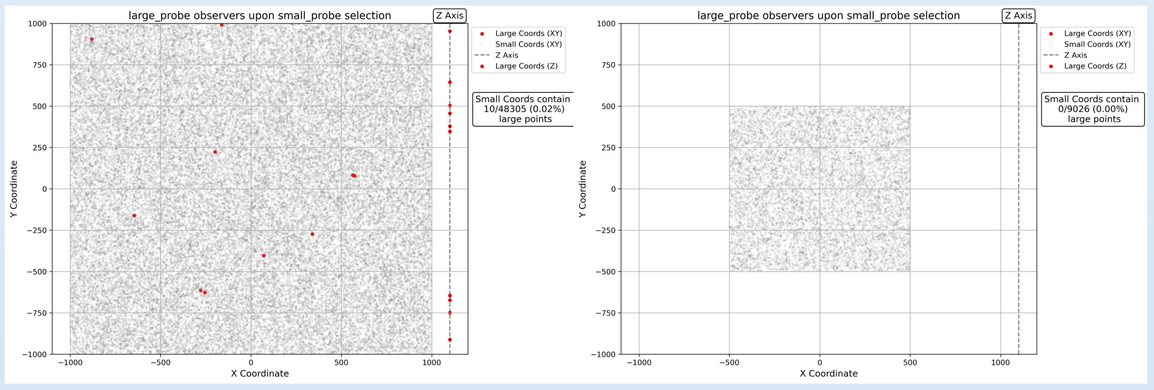

Fig2-3.
Uchuu reflects 10 'good observers' out of 48305 observers selected from '13 slabs' while MDPL2 shows 0 out of 9026.

We also calculated the CDF of 600_slabs, finding extreme values for MDPL2, shown in Fig4-5. In a sense, 600_slab is rare in the LCDM universes, but it robustly appears twice at our location, which is why a discrepancy arises.

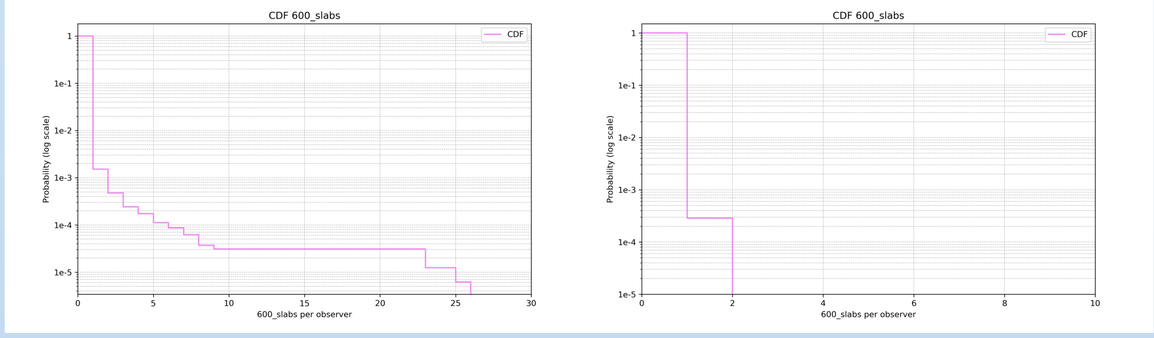

Fig4-5.
Left panel demonstrates the CDF probability of the number of 600 slabs appear in the sky for Uchuu, right panel for MDPL2

Conclusions

We calculated the planar structures respectively in Uchuu and MDPL2, finding the probability of seeing a similar planar structure respectively being 0.006% and 0, too low for the LCDM model to be correct. Also, we found that there are significant differences in two simulations. Size may be a factor causing the results to vary, but we may conduct further experiments to confirm or rule out such conjectures. In any cases, the probability still lies in an unlikely range. Hence, this confirmation identifies a robust discrepancy between our local universe and LCDM model, which urges people to recheck the model from a special point of view.

References

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