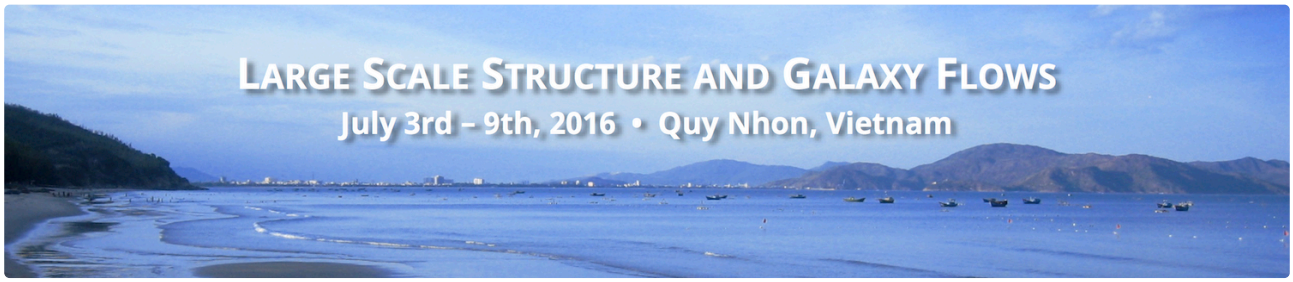



# Large Scale Structure and Galaxy Flows

## July 3rd – 9th, 2016, Quy Nhon, Vietnam

**(Updated on July 7, 2016)**

This international conference is held at ICISE as part of the Rencontres du Vietnam.

Our aims are to discuss and review recent developments on:
— Distances, $H_0$, and peculiar velocities
— Redshift surveys and implied velocity fields
— Linear and non-linear velocity field reconstructions
— Comparison/Reconciliation: velocities ⇔ densities ⇔ observed galaxies
— Bulk flows
— Cosmological parameters
— Initial conditions and constrained simulations
— Baryon Acoustic Oscillations
— Redshift space distortions
— Kinematic Sunyaev-Zel'dovich effect

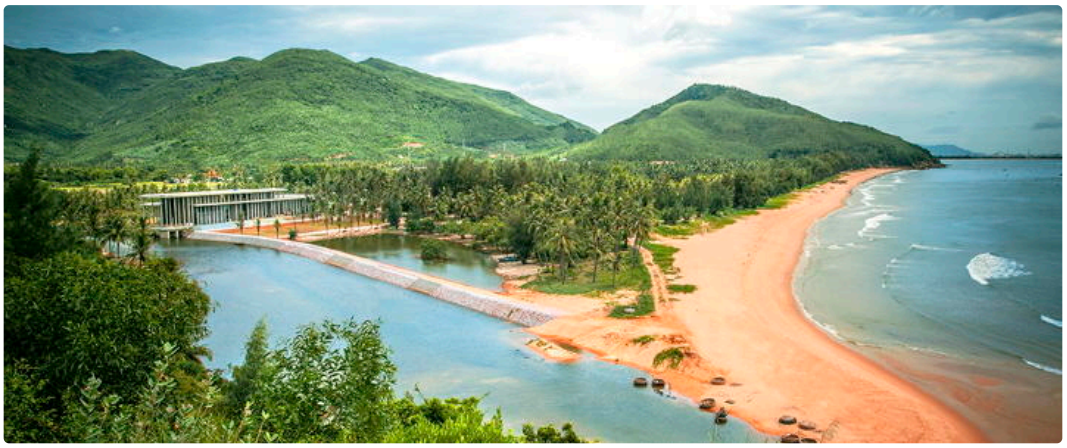
The International Centre for Interdisciplinary Science Education (ICISE) is located in a pleasant place at the seaside of the city of Quy Nhon (Central Vietnam) where conferences to the international standard can be organized. It contributes to the development of research and education in Vietnam and in this region of Asia. With this motivation in mind, Asian scientists are encouraged to meet for events (conferences, schools and workshops) and to share knowledge / expertise with their foreign counterparts.

Since 1993, the institution "Rencontres du Vietnam", which is an official partner of UNESCO, has organized international meetings (conferences and schools) to high scientific level with the motivation of foster exchanges between Vietnamese researchers or from Asia-Pacific and their colleagues coming from other parts of the world.

www.cpt.univ-mrs.fr/~cosmo/CosFlo16/

# Content





# Committee

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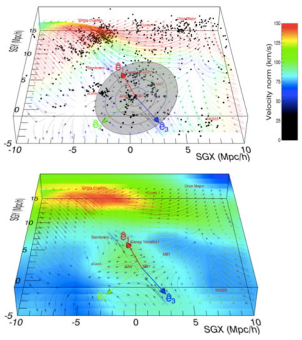
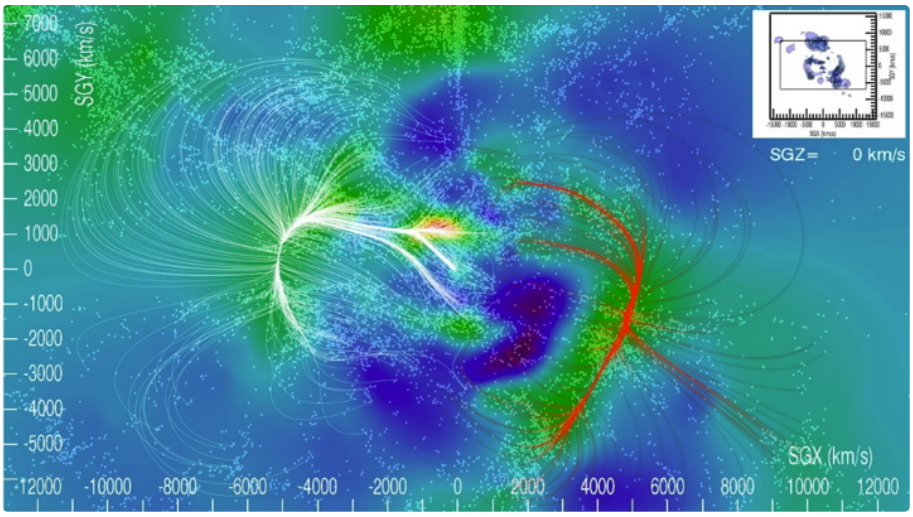
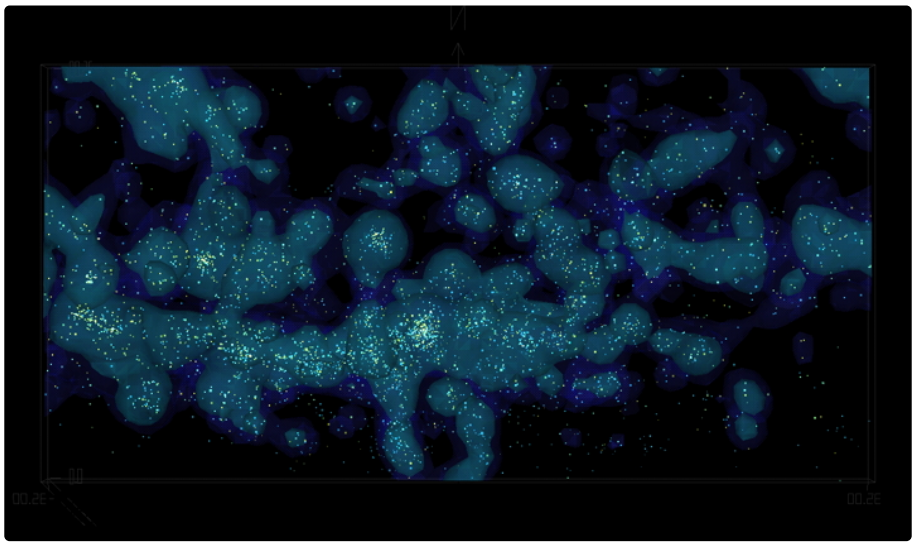
# Scope

According to the paradigm of hierarchical clustering, deviant motions from cosmic expansion arise as matter segregates into high and low regimes. It is possible to determine, alternatively, the motions that should arise from the observed distribution of galaxies or the distribution of matter from the observed motions of galaxies. It is a fundamental success of the paradigm that the two methodologies are in general agreement.




In recent years there has been significant improvement in our knowledge of both the distribution of galaxies through comprehensive redshift surveys and the deviant motions of galaxies through measurements of distances. These observational advances have stimulated interest in methods of interpretation. The constraints on the distribution of matter and cosmological parameters are becoming increasingly precise. Yet major questions remain.



# Schedule

## **Sunday, July 3, 2016** — Arrival of participants at Seagull Hotel

**12:00 – 14:00** Lunch
**14:00 – 19:00** Registration
**19:00 – 19:30** Welcome cocktail
**19:30 – 21:00** Dinner

## Monday, July 4, 2016 — ICISE

**07:30 – 08:30** Shuttle from Hotel to ICISE (last bus at 08:00)

**08:30 – 09:00** **Opening**

Conference Hall — Opening

**08:30 – 08:40** Jean **Trân Thanh Vân** (ICISE)
**Welcome at ICISE**

**08:40 – 08:50** Welcome address of the President of the Bình Định Province

**08:50 – 09:00** Roland **Triay** (AMU)
**Presenting the conference**

**09:00 – 09:10** Group photo

**09:10 – 09:30** Coffee Break

**09:30 – 11:30** **Scientific Activities**

Conference Hall — Distance measurements

**Chairperson:** Renee **Kraan-Korteweg** (UCT)

**09:30 – 10:00** Brent **Tully** (IfA, Hawaii)
**Cosmicflows-3**

**10:00 – 10:30** Lister **Staveley-Smith** (ICRAR/UWA)
**The 2MASS Tully-Fisher Survey and Future TF surveys**

**10:30 – 11:00** Tao **Hong** (NAOC)
**The peculiar velocity field measured by 2MASS Tully-Fisher survey**

**11:00 – 11:30** Ulrich **Feindt** (OKC)
**Peculiar velocities with type Ia supernovae from the Nearby Supernova Factory**

**11:30 – 13:30** Lunch Break

**13:30 – 15:00** **Scientific Activities**

Conference Hall — Distances and velocities

**Chairperson:** Brent **Tully** (IfA, Hawaii)

**13:30 – 14:00** John **Lucey** (CEA)
**Cosmic Flows via an all-sky sample of NIR FP Cluster Distances**

**14:00 – 14:30** Jeremy **Mould** (CAS)
**The 6dF Galaxy Survey and its successor, Taipan**

**14:30 – 15:00** Christina **Magoulas** (UCT)
**Measuring the cosmic bulk flow with 6dFGSv**

**15:00 – 15:30** Coffee Break

**15:30 – 16:30** **Scientific Activities**

Conference Hall — Distances and velocities

**Chairperson:** Jeremy **Mould** (CAS)

**15:30 – 16:00** Matthew **Colless** (ANU)
**Hubble flow and peculiar velocities with the Taipan survey**

**16:00 – 16:30** Joseph **Jensen** (UVU)
**The Future of Infrared Surface Brightness Fluctuation Distance Measurements**

**16:30 – 18:30** Leisure time and informal discussions

**18:30 – 19:00** Shuttle from ICISE to Hotel (last bus at 18:45)

**19:00 – 20:30** Dinner

## Tuesday, July 5, 2016 — ICISE

**07:30 – 08:30** Shuttle from Hotel to ICISE (last bus 08:00)

**08:30 – 10:00 Scientific Activities**

Conference Hall — Zone of Avoidance and Velocity models

**Chairperson:** Matthew **Colless** (ANU)

**08:30 – 09:00** Renee **Kraan-Korteweg** (UCT)
**Discovery of a massive supercluster in Vela**

**09:00 – 09:15** Anja **Schroeder** (SAAO)
**An HI Survey of 2MASS Galaxies in the Zone of Avoidance**

**09:15 – 09:30** Khaled **Said** (UCT)
**Peculiar velocity flow field in the Zone of Avoidance**

**09:30 – 10:00** Marc **Davis** (UCB)
**Comparing observed flows to the expected gravity field: Why the problem is solved**

**10:00 – 10:45** Coffee Break

**10:45 – 11:45 Scientific Activities**

Conference Hall — Zone of Avoidance and Velocity models

**Chairperson:** Renee **Kraan-Korteweg** (UCT)

**10:45 – 11:15** Hume **Feldman** (KU)
**Convergence of Cosmic Flows: Problems and Opportunities**

**11:15 – 11:30** Cullan **Howlett** (ICRAR/UWA)
**Cosmological Constraints from Combined Peculiar Velocity Surveys**

**11:30 – 11:45** Nicholas **Kaiser** (IfA, U. Hawaii)
**Luminosity distance perturbations from peculiar motions.**

**11:45 – 13:30** Lunch Break

**13:30 – 14:45 Scientific Activities**

Conference Hall — Velocity models

**Chairperson:** Hume **Feldman** (KU)

**13:30 – 14:00** Mike **Hudson** (U Waterloo)
**Cosmological parameters and cosmography from the comparison of large-scale structures and peculiar velocities in the nearby Universe**

**14:00 – 14:30** Richard **Watkins** (WU)
**Bulk Flows in Theory and Practice**

**14:30 – 14:45** Per **Andersen** (DARK)
**Cosmology with Peculiar Velocities: Observational Effects**

**14:45 – 15:30** Coffee Break

**15:30 – 16:20 Scientific Activities**

Conference Hall — Velocity models

**Chairperson:** Yehuda **Hoffman** (HU)

**15:30 – 16:00** Guilhem **Lavaux** (IAP / CNRS)
**Cosmic flow reconstruction from deepest distance surveys**

**16:00 – 16:20** Xi **Kang** (PMO)
**Galaxy spin and the large scale structure: universality behind the non-universality relation**

**16:20 – 16:40 Scientific Activities**

Conference Hall — Posters Session

**Chairperson:** Roland **Triay** (AMU)

**16:20 – 16:40** Posters Session

**16:40 – 18:30** Leisure time and informal discussions

**18:30 – 19:00** Shuttle from ICISE to Hotel (last bus at 18:45)

**19:00 – 20:30** Dinner

## **Wednesday, July 6, 2016** — ICISE (morning) and Excursion (afternoon)

**07:30 – 08:30** Shuttle from Hotel to ICISE (last bus 08:00 am)

**08:30 – 09:45** **Scientific Activities**

Conference Hall — Peculiar velocities

**Chairperson:** Guilhem **Lavaux** (IAP / CNRS)

**08:30 – 09:00** Yehuda **Hoffman** (HU)
**Cosmicflows, Bayesian inference, constrained simulations and the Local Universe**

**09:00 – 09:15** Romain **Graziani** (IPNL)
**Cosmic flows reconstruction using WF technique**

**09:15 – 09:45** Daniel **Pomarede** (IRFU)
**The Cosmic V-Web as reconstructed from Cosmicflows-2**

**09:45 – 10:30** Coffee Break

**10:30 – 11:30** **Scientific Activities**

Conference Hall — Peculiar velocities

**Chairperson:** Nicholas **Kaiser** (IfA, U. Hawaii)

**10:30 – 10:45** Tobiasz **Górecki** (UJ)
**Can asymmetric halo profiles affect galaxy clustering?**

**10:45 – 11:15** Yong-Seon **Song** (KASI)
**Measuring coherent motions using redshift space distortion**

**11:15 – 11:30** Jiajun **Zhang** (CUHK)
**Percolation analysis for cosmic web with discrete points**

**11:30 – 12:00** Shuttle from ICISE to Hotel (last bus at 11:45)

**12:00 – 13:00** Lunch

**13:00 – 19:00** Excursion

**19:00 – 20:30** Dinner

## Thursday, July 7, 2016 — ICISE

**07:30 – 08:30** Shuttle from Hotel to ICISE (last bus 08:00)

**08:30 – 09:45** **Scientific Activities**

Conference Hall — Kinematic Sunyaev-Zel'dovich effect and Concurrent

**Chairperson:** Mike **Hudson** (U Waterloo)

**08:30 – 09:00** Carlos **Hernandez-Monteagudo** (CEFCA)
**Constraints on bulk flows and missing baryons in the Universe from the kinetic Sunyaev-Zeldovich effect**

**09:00 – 09:30** Yin-Zhe **Ma** (UKZN)
**Detection of Missing baryons through thermal and kinetic Sunyaev-Zeldovich effect**

**09:30 – 09:45** Elena **Pierpaoli** (USC)
**Cosmological information from the polarized kinetic SZ signal**

**09:45 – 10:30** Coffee Break

**10:30 – 12:00** **International Workshop on "Fundamental Science and Society"**

Auditorium — Opening of "Fundamental Science and Society"

**Chairperson:** Jean **Trân Thanh Vân** (ICISE)

**10:30 – 12:00** Formal speeches : The High level representative of the government of Vietnam, David Gross (Nobel Laureate in Physics, 2004), Koji Omi (Founder and Chairman, Science and Technology in Society Forum, Kyoto), Jean-Marie Solvay (President of the International Solvay Institutes and Administrator of Solvay Group, Brussels), Irina Bokova (UNESCO), Frederik Bordry (Director, Accelerators and Technology of CERN, Geneva).

**12:00 – 13:30** Lunch

**13:30 – 14:45** **Scientific Activities**

Conference Hall — Voids

**Chairperson:** Jorge **Penarrubia** (ROE)

**13:30 – 14:00** Yan-Chuan **Cai** (IfA)
**Structure growth and redshift-space distortions around voids**

**14:00 – 14:30** Laura **Ceccarelli** (IATE)
**The motion of emptiness: Dynamics of cosmic voids**

**14:30 – 14:45** Mousumi **Das** (IIA)
**Low Frequency Radio Observations of the Gas Around Void Galaxies**

**14:45 – 15:30** Coffee Break

**15:30 – 16:15** **Scientific Activities**

Conference Hall — Voids

**Chairperson:** Edward **Shaya** (UMD)

**15:30 – 16:00** Elmo **Tempel** (TO)
**Cosmic web and underlying velocity field in the local universe**

**16:00 – 16:15** Roland **Triay** (AMU)
**Voids as cosmological structures**

**16:15 – 17:00** Leisure time and informal discussions

**17:00 – 17:45** Shuttle from ICISE to Hotel (last bus 17:30)

**17:45 – 18:15** break cloakroom

**18:15 – 19:00** Shuttle from Hotel to ICISE (last bus 18:30)

**19:00 – 22:30** Conference Dinner

**22:30 – 23:00** Shuttle from ICISE to Hotel

## Friday, July 8, 2016 — ICISE

**07:30 – 08:30** Shuttle from Hotel to ICISE (last bus 08:00)

**08:30 – 09:45 Scientific Activities**

Conference Hall — Simulations and Local

**Chairperson:** Elmo **Tempel** (TO)

**08:30 – 08:50** Stefan **Gottloeber** (AIP)
**Constrained simulations of the Local Universe - The CLUES project**

**08:50 – 09:10** Jenny **Sorce** (AIP)
**Simulating our Cosmic Home using Galaxy Flows**

**09:10 – 09:30** Edoardo **Carlesi** (HU)
**The Local Group Factory**

**09:30 – 09:45** Benjamin **L'Huillier** (KASI)
**Alignment of halo pairs in the Horizon Run 4 Simulation**

**09:45 – 10:30** Coffee Break

**10:30 – 11:45 Scientific Activities**

Conference Hall — Simulations and Local

**Chairperson:** Stefan **Gottloeber** (AIP)

**10:30 – 11:00** Edward **Shaya** (UMD)
**Cosmological Parameters from Flow in the Local Supercluster**

**11:00 – 11:15** Jorge **Penarrubia** (ROE)
**Galactic perturbations of the (local) Hubble flow**

**11:15 – 11:30** Caroline **Caldwell** (ARI, Liverpool JMU)
**Velocity dispersions of Groups: An alternative method of estimating cosmological parameters**

**11:30 – 11:45** Michael **McLeod** (UCL)
**Refining Estimates of the Local Group Mass using Local Velocity Shear and ANN**

**11:45 – 13:45** Lunch Break

**13:45 – 15:00 Scientific Activities**

Conference Hall — Physics, Winding up

**Chairperson:** Roland **Triay** (AMU)

**13:45 – 14:00** Caitlin **Adams** (CAS)
**Testing modified gravity beyond the cosmic variance limit**

**14:00 – 14:15** David **Fonseca Mota** (UiO)
**Non-Linear Structure Formation in Gravity beyond General Relativity**

**14:15 – 14:30** Charlotte **Welker** (ICRAR)
**Mergers and gas accretion onto galaxies: the imprint of the cosmic web**

**14:30 – 14:45** Fabien **Nugier** (LeCosPA)
**Adapted coordinates for light signals in cosmology**

**14:45 – 15:00** Yashar **Hezaveh** (Stanford)
**Detection of lensing substructure with ALMA observations of strongly lensed galaxies**

**15:00 – 15:45** Coffee Break

**15:45 – 16:30 Scientific Activities**

Conference Hall — Concluding

**Chairperson:** Brent **Tully** (IfA, Hawaii)

**15:45 – 16:15** Nicholas **Kaiser** (IfA, U. Hawaii)
**Summary**

**16:15 – 16:30** Discussion and Closing

**16:30 – 18:30** Leisure time and informal discussions

**18:30 – 19:00** Shuttle from ICISE to Hotel (last bus at 18:45)

**19:00 – 20:30** Dinner

## **Saturday, July 9, 2016** — Departure of participants from Seagull Hotel

**11:45 – 13:15** Lunch

**Departure for the Post-Conference Tour**

# Speakers

Caitlin **Adams** *(CAS)*, Hawthorn, Australia

**Testing modified gravity beyond the cosmic variance limit**

July, 8, 13:45 – 14:00, Conference Hall

Observations at low-redshift can be used to distinguish between two promising explanations of the Universe's accelerating expansion: dark energy and modified gravity. Specifically, modified gravity theories introduce scale-dependence in the growth rate of structure, which is encoded in the distribution of galaxies and their peculiar velocities. The small sample size associated with these observations makes them limited by cosmic variance, preventing precision tests of cosmological models. To overcome this issue, we have developed a new maximum-likelihood approach for simultaneously fitting the observed density and peculiar velocity fields including the effects of correlated sample variance, marginalizing over key model systematics with full error propagation. Our methodology naturally allows the measurement of the growth rate as a function of scale, and we present first results from the 6-degree Field Galaxy Survey. Finally, we discuss prospects for how these constraints will be improved by the Taipan Galaxy Survey starting later this year, which will increase the available density and velocity samples by an order of magnitude.

Per **Andersen** *(DARK)*, Copenhagen, Denmark

**Cosmology with Peculiar Velocities: Observational Effects**

July, 5, 14:30 – 14:45, Conference Hall

We use the Horizon Run 2 (HR2) simulation to perform an analysis of how well we can measure the cosmological bulk flow using observations of type Ia SNe, and investigate whether observational effects bias the already published results. We review linear theory[1], and expand it to hold for arbitrary geometries. Using results from this expanded theory and the HR2 simulation as a baseline, we test if the Maximum Likelihood (ML) and Minimum Variance (MV)[2] bulk flow estimators reproduce the actual underlying bulk flow for a number of survey geometries. We find that sampling and geometry effects can strongly bias both the ML and MV estimators, with increasingly adverse bias for poorer sampling and less spherical survey geometries. We finally propose a method to best avoid this bias from sampling and geometry.

*References:*

[1] P. Lucchin and F. Lucchin, *Cosmology: The Origin and Evolution of Cosmic Structure*, Wiley, 2nd Editon, 2002.

[2] R. Watkins and H. A. Feldman, *Consistently Large Cosmic Flows on Scales of* $100h^{-1}$ Mpc*: A Challenge for the Standard* $\Lambda$*CDM Cosmology*, MNRAS, 392, 743

Yan-Chuan **Cai** *(IfA)*, Edinburgh, United Kingdom

**Structure growth and redshift-space distortions around voids**

July, 7, 13:30 – 14:00, Conference Hall

Voids are underdense regions in the cosmic web which occupy most volume of the Universe.The growth of structure around voids is sensitive to dark energy and theories of non-standard gravity. The shape of voids can be used to constraint cosmology via the Alcock-Paczynski effect. I will demonstrate the complexity of the distortion patterns around voids in redshift space, and how it may complicates measurements of the Alcock-Paczynski effect. I will show how the linear growth can be recovered using redshift-space distortions around voids [1].

*References:*

[1] Cai, Y.-C., Taylor, A., Peacock, J.A., & Padilla, N. 2016, arXiv:1603.05184

Caroline **Caldwell** *(ARI, Liverpool JMU)*, Liverpool, United Kingdom

**Velocity dispersions of Groups: An alternative method of estimating cosmological parameters**

July, 8, 11:15 – 11:30, Conference Hall

Velocity dispersions of galaxy groups can be used instead of mass to estimate cosmological parameters. One advantage to this approach is that velocity dispersions are directly observable and do not suffer from the same systematic biases as masses. As new large spectroscopic surveys come online, this method will become even more powerful. I present the application of the velocity dispersion method, and an analysis of sources of scatter in the mass-velocity dispersion relation, by comparing a large cosmological hydrodynamical simulation, BAHAMAS, to the GAMA survey to determine an estimate of sigma 8.

Edoardo **Carlesi** *(HU)*, Jerusalem, Israel

**The Local Group Factory**

July, 8, 09:10 – 09:30, Conference Hall

The Local Group Factory is a pipeline designed to produce and simulate isolated halo pairs, with properties broadly compatible with those of MW and M31, within the same kind of large scale environment. The method is based on the Cosmic Flows 2 dataset and the Constrained Simulations technique. I will describe how these simulations can be used to constrain the dynamics of the actual LG, with a particular focus on its total mass and its mass accretion history, and shed more light on the relation between the LG and its large scale environment.

Laura **Ceccarelli** *(IATE)*, Córdoba, Argentina

**The motion of emptiness: Dynamics of cosmic voids**

July, 7, 14:00 – 14:30, Conference Hall

The distribution of galaxies at large scales reveals a complex structure where the almost empty and nearly spherical regions, dubbed as cosmic voids, arise as matter flows away from primordial underdense perturbations toward filaments and walls. Thus, cosmic voids encode relevant information of the growth and evolution of structure through their dynamics. We perform a statistical study of the global motion of cosmic voids using both a numerical simulation and observational data. We analyse their relation to large–scale mass flows and the physical effects that drive those motions. We analyse the bulk motions of voids and find mean velocities in the range 300-400 km/s, not far from the expected mean peculiar velocities of groups and galaxy clusters, depending on void size and the large–scale environment. Statistically, small voids move faster than large ones, and voids in relatively higher density environments have higher bulk velocities than those placed in large underdense regions. The mean mass density around voids suggests that their motions respond to a pull–push mechanism. We analyse the distribution of the pairwise relative velocities of voids and find a remarkable bimodal behaviour consistent with an excess of both systematically approaching and receding voids. The magnitude of these systematic relative velocities account for more than 100 km/s, reaching large coherence lengths of up to 200 Mpc/h. We determine that the origin of this bimodality resides in the large–scale density fluctuations. The relative motion of cosmic voids suggests a scenario of a sparkling Universe, with approaching and receding voids according to their local environment. In order to compare the theoretical results and the observations we have used samples of voids from the Sloan Digital Sky Survey and the peculiar velocity field inferred from linear theory finding consistent results with the simulation predictions. Regarding large–scale flows, our results suggest a scenario of galaxies and galaxy systems flowing away from void centres with the additional, and more relevant, contribution of the void bulk motion to the total velocity.

Matthew **Colless** *(ANU)*, Weston Creek, Australia

**Hubble flow and peculiar velocities with the Taipan survey**

July, 4, 15:30 – 16:00, Conference Hall

The Taipan survey will measure redshifts for about $10^6$ galaxies and peculiar velocities for about $10^5$ galaxies in the nearby universe. Starting in 2016, the survey will yield a direct measurement of the Hubble constant with 1% precision, the largest maps of the density and velocity fields of local structures, and new and stringent tests of large-scale gravitational physics using galaxy motions, probing Einstein's theory of gravity and alternatives. The size and depth of the Taipan survey makes it ideally suited to identifying the key mass concentrations influencing the Local Group motion, resolving the current controversy and testing the predictions of the $\Lambda$CDM model.

Mousumi **Das** *(IIA)*, Bengaluru, India

**Low Frequency Radio Observations of the Gas Around Void Galaxies**

July, 7, 14:30 – 14:45, Conference Hall

Voids contain a sparse but significant population of galaxies that represent the remnants of the hierarchical galaxy formation process and their distribution may delineate a void substructure. A significant fraction of them show signatures of ongoing star formation and nuclear activity which is similar to that found in normal galaxies in denser environments. It is not clear what triggers this star formation and nuclear activity; close interactions with comapnion galaxies or gas accretion along filaments are possible explanations. To understand what drives their evolution and whether it relates to an underlying substructure within the voids, we are investigating the large scale radio continuum emission around a sample of Bootes void galaxies using low frequency (610/150 MHz) GMRT observations. We present some early results of our radio study and discuss its implications for understanding galaxy evolution in voids.

*References:*

[1] M. Das, T. Saito, D. Iono, M.Honey, S. Ramya, *Detection of Molecular Gas in Void Galaxies : Implications for Star Formation in Isolated Environments*, ApJ, 815, 40 (2015).

## Speakers

Marc **Davis** *(UCB)*, Berkeley, United States

**Comparing observed flows to the expected gravity field: Why the problem is solved**

July, 5, 09:30 – 10:00, Conference Hall

Comparison of galaxy flows with those predicted from the local galaxy distribution ended as an active field after two analyses came to vastly different conclusions 30 years ago, but that was due to faulty data. All the old results are therefore suspect. With new data collected in the last several years, the problem deserves another look. For this we analyze the gravity field inferred from the enormous data set derived from the 2MASS collection of galaxies (Huchra et al. 2005), and compare it to the velocity field derived from the well calibrated SFI++ Tully- Fisher catalog (Springob et al. 2007). Using the "Inverse Method" to minimize Malmquist biases, within 10,000 km/s the gravity field is seen to predict the velocity field (Davis et al. 2011) to remarkable consistency. This is a beautiful demonstration of linear perturbation theory and is fully consistent with standard values of the cosmological variables. I show that the problem is greatly simplified by expanding the flow into 20 orthogonal basis functions and comparing the amplitudes of this expansion between the observed velocity field with the gravity field, finding an excellent match, as opposed to the poor match obtained 30 years ago. THUS THE PROBLEM IS SOLVED.

Ulrich **Feindt** *(OKC)*, Stockholm, Sweden

**Peculiar velocities with type Ia supernovae from the Nearby Supernova Factory**

July, 4, 11:00 – 11:30, Conference Hall

In a previous study of 117 SNe from the Nearby Supernova Factory combined with the world literature supernova data out to $z = 0.1$, we found that the Shapley supercluster does not fully explain the inferred velocities and that an additional attractor is required [1]. Since then we have more than doubled the size of our supernova dataset and are currently preparing an update of this study. In this talk I will additionally discuss the prospects of the next generation of transient surveys, e.g. the Zwicky Transient Facility. These surveys will benefit greatly from the improved distance measurements made possible using "twin" type Ia supernovae with matching spectral data, which reduce the luminosity dispersion to $0.072 \pm 0.010$ mag [2].

*References:*

[1] Feindt, U., Kerschhaggl, M., Kowalski, M., et al., *Measuring cosmic bulk flows with Type Ia supernovae from the Nearby Supernova Factory*, 2015, A&A 560, A90 [Erratum, 2015, A&A 578, C1] [astro-ph/1310.4184].

[2] Fakhouri, H. K., Boone, K., Aldering, G., et al., *Improving Cosmological Distance Measurements Using Twin Type Ia Supernovae*, 2015, ApJ 815, 58 [astro-ph/1511.01102]

Hume **Feldman** *(KU)*, Lawrence, United States

**Convergence of Cosmic Flows: Problems and Opportunities**

July, 5, 10:45 – 11:15, Conference Hall

Modeling the cosmic velocity field, and especially estimating its lowest order moment, the bulk flow, has been a popular pursuit among aficionados in the cosmological community for three decades now. Other than estimating the magnitude and direction of the flow, one of the main difficulties has been defining the scale of flow detected. There is a nearly universal agreement as to the direction of the flow, however, there is some disagreements regarding the magnitude and scale of the flow. We developed and applied the Minimal Variance (MV) formalism to optimize and clearly define the scale of a particular analysis, using the width of the survey window function as a proxy for scale. Comparing the MV ideal window function to any analysis window function gives an unbiased estimate to the survey width (or scale) and thus provides a method to directly compare various results. Further, I will introduce a new estimator of the peculiar velocity from redshift and distance estimates. This estimator results in peculiar velocity estimates that are statistically unbiased and have Gaussian distributed errors. The adoption of the new estimator significantly improves the accuracy and validity of studies of the large-scale peculiar velocity field and eliminates potential systematic biases, thus helping to bring peculiar velocity analysis into the era of precision cosmology. I will discuss the method, compare various recent analyses and show that the disagreements are not as significant as they appear.

David **Fonseca Mota** *(UiO)*, Oslo, Norway

**Non-Linear Structure Formation in Gravity beyond General Relativity**

July, 8, 14:00 – 14:15, Conference Hall

We use cosmological hydrodynamical simulations to study the effect of screened modified gravity models on the mass estimates of galaxy clusters. We compare the mass of clusters inferred via lensing versus the mass inferred via kinematical measurements as a probe of violations of the equivalence principle at Mpc scales. We find that estimates of cluster masses via X-ray observations is mainly sensitive to the coupling between the scalar degree of freedom and baryons – while the kinematical mass is mainly sensitive to the coupling to dark matter. Therefore the relation between the two mass estimates is a probe of a possible non-universal coupling between the scalar field, the standard model fields, and dark matter. Finally, we use observational data of kinetic, thermal and lensing masses to place constraints on deviations from general relativity on cluster scales for a general parametrization of screened modified gravity theories which also contains $f(R)$ and Symmetron theories.

Tobiasz **Górecki** *(UJ)*, Kraków, Poland

**Can asymmetric halo profiles affect galaxy clustering?**

July, 6, 10:30 – 10:45, Conference Hall

In the framework of the ΛCDM cosmology galaxies are formed inside the dark matter haloes. Links between the distribution of galaxies and underlying dark matter field are studied through the analysis of galaxy clustering. One of the simplest and most common statistical tools used to quantify the galaxy clustering is a two-point correlation function. In the ”traditional” approach, backed by measurement in local surveys, it was fitted by a power law. More recently, galaxy clustering is more often interpreted in terms of the Halo Occupation Distribution Model (HOD) - more complex, but taking into account different mechanisms of clustering of galaxies located inside the same dark matter halo and in different haloes.

Commonly used HOD models are based, however, on a number of simplifying assumptions. One of these assumptions is the spherical symmetry of the dark matter halo. However, the theoretical predictions, numerical simulations and some observations clearly indicate that the real halos usually are not symmetrical.

In my presentation, I am going to present the first HOD model which takes into account the asymmetry of the of dark matter halo profile. I will present how the halo asymmetry may affect the shape of the galaxy correlation function. I will use the local SDSS and $z \sim 1$ VIPERS data to demonstrate how the assumption of halo asymmetry affects the interpretation of the correlation function measurements. I discuss possible implications for our understanding of the evolution of the large-scale structure of the Universe.

Stefan **Gottloeber** *(AIP)*, Potsdam, Germany

**Constrained simulations of the Local Universe - The CLUES project**

July, 8, 08:30 – 08:50, Conference Hall

Numerical simulations are the driving force behind much of the theoretical progress in our understanding of the formation of structure in the universe. Cosmological simulations must cover a large dynamical and mass range. A representative volume of the universe should be large, but this comes at the expense of the resolution. To overcome this problem during the last decade we have developed a new approach which consists of using observations of the nearby universe as constraints imposed on the initial conditions of the simulations. The resulting constrained simulations successfully reproduce the observed structure within a few tens of megaparsecs around the Milky Way including the nearby well known clusters of galaxies and voids. Zoomed high resolution dark matter only as well as gasdynamical simulations allow to study in great detail the formation of objects in the nearby universe like the Local Group, the Local Void or Virgo, the most nearby cluster. We have performed such simulations within the CLUES project (Constrained Local UniversE simulations - http://www.clues-project.org). I am going to review the recent progress and will discuss ongoing projects.

## Speakers

Romain **Graziani** *(IPNL)*, Villeurbanne, France

**Cosmic flows reconstruction using WF technique**

July, 6, 09:00 – 09:15, Conference Hall

The Wiener Filter is a known technique to provide a faithful reconstruction of the local Universe's linear peculiar velocity field from observed distances and redshifts [1]. However, with larger catalogs - as the new CosmicFlows3 [2] - come larger observational biases. Reconstructing the redshift space velocity field avoid some of these biases.

This reconstruction is a great tool for the identification of the local universe's large scale structures. Using the linear velocity field as a direct probe of the clustering of structures, one can identify knots, sheets and filaments to characterize the distribution of matter.

*References:*

[1] Zaroubi, S. and Hoffman, Y. and Dekel, A., *Wiener Reconstruction of Large-Scale Structure from Peculiar Velocities*, ApJ (Aug 1999).

[2] R. Brent Tully, Helene M. Courtois, Jenny G. Sorce, *CosmicFlows-3*, ApJ (2016) [astro-ph/1605.01765].

Carlos **Hernandez-Monteagudo** *(CEFCA)*, Teruel, Spain

**Constraints on bulk flows and missing baryons in the Universe from the kinetic Sunyaev-Zeldovich effect**

July, 7, 08:30 – 09:00, Conference Hall

The kinetic Sunyaev-Zeldovich effect (kSZ) describes the intensity fluctuations in the Cosmic Microwave Background radiation (CMB) caused by the Doppler kick experienced by CMB photons as they encounter moving free electrons. The kSZ effect is completely determined by the peculiar momentum of the electrons, thus constituting an ideal tool to search for bulk flows and hidden baryonic matter in the universe. The latest CMB experiments have yielded the very first kSZ detections [1,2,3] which have not only revealed galaxy and matter coherent motions extending up to $\sim$ 100 Mpc at different redshifts, but have also solved the problem of the so-called hidden or missing baryons in the late universe.

*References:*

1 Hand, N., Addison, G.E., Aubourg, E., et al. 2012, Physical Review Letters, 109, 041101

2 Planck Collaboration, Ade, P.A.R., Aghanim, N., et al. 2016, Astronomy & Astrophysics, 586, A140

3 Hernández-Monteagudo, C., Ma, Y.-Z., Kitaura, F.S., et al. 2015, Physical Review Letters, 115, 191301

Yashar **Hezaveh** *(Stanford)*, Stanford, United States

**Detection of lensing substructure with ALMA observations of strongly lensed galaxies**

July, 8, 14:45 – 15:00, Conference Hall

The number of observed dwarf satellites of the Milky Way is about three orders of magnitude lower than what cold dark matter (CDM) simulations predict, an issue that is referred to as the "Missing Satellite Problem". In this talk, I will discuss how in strong lensing systems we can detect low-mass dark matter subhalos in the lens galaxies by measuring the gravitationally-induced distortions that subhalos induce in the lensed images of background sources. Measuring the abundance of dark matter subhalos with strong lensing allows us to determine their mass function and to compare it with the predictions of CDM and other dark matter models. I will present our first detection of a subhalo using ALMA data and show how we can place constraints on the abundance of subhalos down to $\sim 2 \times 10^7 M_\odot$ with these observations. I will also give a brief overview of our ongoing observational campaign to place stronger constraints at lower masses.

Yehuda **Hoffman** *(HU)*, Jerusalem, Israel

**Cosmicflows, Bayesian inference, constrained simulations and the Local Universe**

July, 6, 08:30 – 09:00, Conference Hall

The association of Near Field and Cosmology rests on the implicit Copernican assumption that the near field constitutes a typical patch of the universe. A key question that needs to be addressed is how typical the near field is, and thereby how relevant it is to cosmology at large. Constrained simulations embody the concept of Near Field Cosmology in the realm of cosmological simulations and are used here to shed light on the problem. Recent advances in the setting of constrained initial conditions and the availability of the Cosmicflows-2 database of galaxy velocities have paved the way to the mass production of constrained simulations of the Local Universe. Of particular interest is the ability to produce in abundance Local Group (LG) like objects by our Local Group Factory. This opens a new era in which the Copernican nature of the LG and the near field can be studied statistically. We present a Bayesian framework for assessing the question of how typical is the LG. This needs to be addressed within a context - a prior knowledge of the standard cosmological model ($\Lambda$CDM) and a LG model that defines what a LG is. The Cosmicflows-2 data adds new information on the local universe and it should be used to update our knowledge of the LG. Constrained simulations are the optimal mean for sampling the posterior probability of the properties of the LG and the Local Universe.

Tao **Hong** *(NAOC)*, Chaoyang District, Beijing, China

**The peculiar velocity field measured by 2MASS Tully-Fisher survey**

July, 4, 10:30 – 11:00, Conference Hall

The 2MASS Tully-Fisher Survey (2MTF) aims to measure Tully-Fisher (TF) distances for all bright inclined spirals in the 2MASS Redshift Survey (2MRS) using high-quality HI widths and 2MASS photometry. By combining the HI spectra from new GBT [1] and Parkes [2] observations with ALFALFA data and archival data, 2MTF provides a very uniform sky coverage with a Zone of Avoidance of $|b| = 5^\circ$, which makes the 2MTF catalog a good sample for peculiar velocity analysis. With the full ALFALFA data imported, the 2MTF catalog was fully completed in early 2016. By using the early version of 2MTF sample, Hong et al. [3] measured the bulk flow in the depth of $R_I = 20, 30$ and $40\ h^{-1}$Mpc, respectively, the measuring results are consistent with the $\Lambda$CDM predictions. In this talk, I will introduce the bulk flow results of 2MTF, and repeat the peculiar velocity field analysis using the full 2MTF sample.

*References:*

[1] Masters, K. L., Crook, A., Hong, T., et al. 2014, MNRAS 443, 1044.

[2] Hong, T., Staveley-Smith, L., Masters, K. L., et al. 2013, MNRAS, 432, 1178.

[3] Hong, T., Springob, C. M., Staveley-Smith, L., et al. 2014, MNRAS, 445, 402.[1] Masters, K. L., Crook, A., Hong, T., et al. 2014, MNRAS 443, 1044.

[2] Hong, T., Staveley-Smith, L., Masters, K.L., et al. 2013, MNRAS, 432, 1178.

[3] Hong, T., Springob, C.M., Staveley-Smith, L., et al. 2014, MNRAS, 445, 402.

Cullan **Howlett** *(ICRAR/UWA)*, Crawley, Australia

**Cosmological Constraints from Combined Peculiar Velocity Surveys**

July, 5, 11:15 – 11:30, Conference Hall

Peculiar velocity surveys present a very promising route to measuring the growth rate of structure and its potential scale dependence. However, individual peculiar velocity surveys suffer from large statistical errors due to the intrinsic scatter in the astrophysical relation used to infer each galaxy's true distance, and from potential systematics due to incorrect calibration of the zero-point of this relation, scale-dependent/velocity bias and non-linear motions. In this talk I advocate the use of combining multiple peculiar velocity and redshift surveys to reduce these effects.

In particular I will present forecasts and preliminary measurements of the growth rate of structure from the combination of the 2-Mass Tully Fisher survey (2MTF) and 6-degree Field Galaxy Survey velocity subsample (6dFGSv). I will then demonstrate that a full combination of all the data from the two next generation surveys, WALLABY and TAIPAN, has the potential to provide a $\sim 3\%$ measurement of the growth rate of structure at $z \approx 0$, placing extremely tight limits on possible extensions to General Relativity, but that such a measurement will require careful consideration of modelling systematics.

## Speakers

Mike **Hudson** *(U Waterloo)*, Waterloo, CANADA

**Cosmological parameters and cosmography from the comparison of large-scale structures and peculiar velocities in the nearby Universe**

July, 5, 13:30 – 14:00, Conference Hall

Maps of the mass density field can be used to predict peculiar velocities point-by-point. The comparison of these predictions to peculiar velocity data can be used to determine the cosmological parameter combination $f(\Omega_m)\sigma_8$, and to infer the contributions to the flow on very large scales. This talk is based primarily on [1]. Using redshifts from the 2M++ redshift compilation [2], we reconstruct the density of galaxies within 200 $h^{-1}$ Mpc, allowing for the first time good sampling of important superclusters such as the Shapley Concentration.

We compare the predicted peculiar velocities from 2M++ to Tully-Fisher and SNe peculiar velocities. We find a value of $\beta^* \equiv \Omega_m^{0.55}/b^* = 0.431 \pm 0.021$, suggesting $\Omega_m^{0.55}\sigma_{8,\rm lin} = 0.401 \pm 0.024$, in good agreement with other probes. The predicted peculiar velocity of the Local Group arising from the 2M++ volume alone is $540 \pm 40$ km/s, towards $l = 268^\circ \pm 4^\circ, b = 38^\circ \pm 6^\circ$, only 10° out of alignment with the cosmic microwave background dipole. To account for velocity contributions arising from sources outside the 2M++ volume, we fit simultaneously for $\beta^*$ and an external bulk flow. We find that an external bulk flow is preferred at the $5.1\sigma$ level, and the best fit has a velocity of $159 \pm 23$ km/s towards $l = 304^\circ \pm 11^\circ, b = 6^\circ \pm 13^\circ$. Thus there is evidence for contributions to the large-scale flow, likely arising from beyond 200 $h^{-1}$ Mpc. Finally, the predicted bulk flow of a 50 $h^{-1}$ M Mpc Gaussian-weighted volume centred on the Local Group is in agreement with predictions from $\Lambda$ cold dark matter.

*References:*

[1] J. Carrick, S. J. Turnbull, G. Lavaux and M. J. Hudson, *Cosmological parameters from the comparison of peculiar velocities with predictions from the 2M++ density field*, MNRAS, 450, 317, (2015).

[2] G. Lavaux and M. J. Hudson, *The 2M++ galaxy redshift catalogue*, MNRAS, 416, 2840, (2011).

Joseph **Jensen** *(UVU)*, Orem, UNITED STATES

**The Future of Infrared Surface Brightness Fluctuation Distance Measurements**

July, 4, 16:00 – 16:30, Conference Hall

Surface brightness fluctuations (SBF) are a means for measuring precise distances to early-type galaxies. We have calibrated the SBF method for the Wide Field Camera 3 IR channel (WFC3/IR) on the HST, making it possible to measure accurate distances out to 100 Mpc in a single orbit. We have an ongoing program to measure SBF distances for galaxies from the MASSIVE Galaxy Survey, a project to study the internal structure and dynamics of the most massive galaxies in the local universe, including meaningful constraints on their central black hole masses. To extend the technique to greater distances, we have demonstrated the IR SBF technique using the GeMS multi-conjugate adaptive optics system on Gemini. From the ground, near-IR observations using adaptive optics on large telescopes achieve much higher spatial resolution, enhancing the SBF signal. The HST and Gemini measurements show how JWST and the next generation of ground-based telescopes may be used to extend the IR SBF distance technique to 500 Mpc.

Nicholas **Kaiser** *(IfA, U. Hawaii)*, Honolulu, UNITED STATES

**Luminosity distance perturbations from peculiar motions.**

July, 5, 11:30 – 11:45, Conference Hall

This talk is based on [1] and [2] in which we consider some aspects of the perturbation to the luminosity distance d(z) that are of relevance for SN1a cosmology and for future peculiar velocity surveys at non-negligible redshifts

*References:*

[1] N. Kaiser and M.J. Hudson, *On the perturbation of the luminosity distance by peculiar motions*, MNRAS 450, p883 (2015)

[2] N. Kaiser and M.J. Hudson, *Kinematic bias in cosmological distance measurement*, MNRAS 454, p280 (2015)

Nicholas **Kaiser** *(IfA, U. Hawaii)*, Honolulu, UNITED STATES

**Summary**

July, 8, 15:45 – 16:15, Conference Hall

Xi **Kang** *(PMO)*, Nanjing, China

**Galaxy spin and the large scale structure: universality behind the non-universality relation**

July, 5, 16:00 – 16:20, Conference Hall

It is observationally found that the correlation between galaxy spin and large scale structure depends on galaxy type/mass. For massive galaxies, their spin is perpendicular to the filament, but for low-mass galaxies their spin is parallel to the filament direction. N-body simulation also predicts such a mass dependence between halo spin and large scale structure. We found that such a dependence is due to the mass accretion at early universe. For low mass haloes, their subhaloes are accreted perpendicular to the filament, and for high-mass haloes, most subhaloes are accreted along the filament. Such a manner well explains the observed correlation. We further identify the physical origin of such a correlation, and found that the anisotropy collapse of dark matter halo is universal, which can explain the non-universalty between galaxy/halo spin with the large scale structure.

Renee **Kraan-Korteweg** *(UCT)*, Rondebosch, South Africa

**Discovery of a massive supercluster in Vela**

July, 5, 08:30 – 09:00, Conference Hall

Recent redshifts observations of over 4500 galaxies at low Galactic latitudes obtained with MOS on SALT and AAOmega on the AT led to the discovery of a very extended massive galaxy overdensity at 18000 km $s^{-1}$. This prospective supercluster straddles the Galactic Plane in the constellation of Vela and lies just beyond the boundaries and volumes of current systematic ‚Äúwhole-sky‚Äù redshift and peculiar velocity surveys. Its position in redshift space coincides with the approximate direction and distance range at which recent peculiar velocity studies find evidence for *residual* bulk flows. It hence may well constitute an additional missing piece of the puzzle in solving the various contradictory (residual) bulk flow results.

Benjamin **L'Huillier** *(KASI)*, Daejeon, Korea, Republic of

**Alignment of halo pairs in the Horizon Run 4 Simulation**

July, 8, 09:30 – 09:45, Conference Hall

Using the Horizon Run 4 simulation [1], with $L = 3.5h^{-1}$Gpc and $N = 6300^3$ particles, we study the effects of close and distant interactions on the alignment of the spins, shapes, and orbits of target haloes with their closest neighbour. Interactions are defined as targets located within the virial radius of their closest neighbour with a mass ratio $q = M_{\rm N}/M_{\rm T} > 0.4$.

We found that interactions occur preferentially in the plane of rotation of the target halo, and in the direction of the major axis of the target. Moreover, interacting pairs initially have their spins anti-parallel at $z \simeq 4$, but they become aligned by $z = 0$. The alignments become stronger with time, and weakly depend on the mass of the target.

*References:*

[1] J. Kim, C. Park, B. L'Huillier and S.E. Hong, *Horizon Run 4 Horizon Run 4 Simulation: Coupled Evolution of Galaxies and Large-Scale Structures of the Universe* JKAS 48, 213 (2015)

[2] B. L'Huillier, C. Park and J. Kim, , submitted to MNRAS

Guilhem **Lavaux** *(IAP / CNRS)*, Paris, France

**Cosmic flow reconstruction from deepest distance surveys**

July, 5, 15:30 – 16:00, Conference Hall

I will review the algorithmic state of the VIRBIUS [1] inference machine. Then I will present the first applications of this machine on recent distant surveys such as CosmicFlows-2 [2] and 6dFv [3]. VIRBIUS is attempting to build a full linear model of the velocity field, including the possibility for the different sub-catalog to have different zero-point calibration, different subpopulation of tracers, possibly with catastrophic errors and unknown distance distributions. I will show some results obtained by this method using these catalogs, assessing at the same time the error rate in observational data.

*References:*

[1] Lavaux G., *Bayesian 3D velocity field reconstruction with VIRBIUS*, 2016, MNRAS, **457**, 1, p.172-197

[2] Tully R.B., Courtois H.M., Dolphin A.E., Fisher J.R., etal. 2013, AJ, **146**, 86

[3] Campbell L.A., Lucey J.R., Colless M., Jones D.H., etal. 2014, MNRAS, **443**, 1231

## Speakers

John **Lucey** *(CEA)*, Durham, United Kingdom

**Cosmic Flows via an all-sky sample of NIR FP Cluster Distances**

July, 4, 13:30 – 14:00, Conference Hall

Fundamental plane (FP) distances and peculiar velocities have been determined for an all-sky set of 88 nearby clusters ($0.020 < z < 0.055$). This dataset was constructed by adopting velocity dispersion measurements from the published surveys and deriving photometric parameters (effective radii and surface brightnesses) from 2MASS J-band image tiles. Cluster distances were determined using the inverse FP relation which resulted in a distance error per galaxy of 19 per cent. The FP galaxies used per cluster range from 15 to 100 which resulted in a mean cluster distance error of $\sim 4$ per cent. In the CMB frame the cluster sample has a small bulk flow amplitude, i.e. less than $170 km\,s^{-1}$ with an uncertainty of $120 km\,s^{-1}$. We recover the expected Local Group motion with respect to the CMB.

Yin-Zhe **Ma** *(UKZN)*, Durban, South Africa

**Detection of Missing baryons through thermal and kinetic Sunyaev-Zeldovich effect**

July, 7, 09:00 – 09:30, Conference Hall

Previous studies of galaxy formation have shown that only 10 per cent of the baryons are in compact objects, while 90 per cent of them are missing. Numerical simulation shows that the missing baryons are in a state of diffuse plasma with temperature $10^5$ to $10^7$ Kelvin, which is hard to be detected by X-ray observations. We will present three studies that coherently detect the missing baryons. The first is the cross-correlation between the kinetic Sunyaev-Zeldovich maps from Planck with the linear reconstructed velocity field. We find significance ($4.6\sigma$) detection of the peculiar motion of gas on Mpc scales. Further studies show that this bulk motion indicates that the concentration of gas constitutes a fraction of $f_b = 0.8$, which indicates that all baryons are detected with the Planck kSZ maps. Second, we cross-correlate the thermal Sunyaev- Zeldovich from Planck maps with gravitational lensing from the Canada France Hawaii Lensing Survey (CFHTLenS) and constrain the diffuse baryon component with the various pressure profile. We find that the 1 and 2 halo terms detected at $3.96\sigma$ and $3.67\sigma$ confidence level (CL) respectively. The effective virial temperature of the isothermal gas is found to be in the range $7.10^5$–$3.10^8$ K. In addition, by stacking the pairs of luminous red galaxies, we can place a constraint on the temperature of the filament in between the dark matter halos.

Christina **Magoulas** *(UCT)*, Cape Town, South Africa

**Measuring the cosmic bulk flow with 6dFGSv**

July, 4, 14:30 – 15:00, Conference Hall

While recent years have seen rapid growth in the number of galaxy peculiar velocity measurements, disagreements remain about the extent to which the peculiar velocity field - a tracer of the large-scale distribution of mass - agrees with both $\Lambda$CDM expectations and with velocity field models derived from redshift surveys. The 6dF Galaxy Survey includes peculiar velocities for nearly 9000 early-type galaxies (6dFGSv), making it the largest and most homogeneous galaxy peculiar velocity sample to date. We have used the 6dFGS velocity field to determine the amplitude and scale of large-scale cosmic flows in the local universe and test standard cosmological models. We also compare the galaxy density and peculiar velocity fields to establish the distribution of dark and luminous matter and better constrain key cosmological parameters such as the redshift-space distortion parameter.

Michael **McLeod** *(UCL)*, London, United Kingdom

**Refining Estimates of the Local Group Mass using Local Velocity Shear and ANN**

July, 8, 11:30 – 11:45, Conference Hall

We revisit the estimation of the combined mass of the Milky Way (MW) and Andromeda (M31), which dominate the mass of the Local Group, by analysing an ensemble of 30,190 halo pairs from the Small MultiDark Planck simulation [1] assuming a $\Lambda$CDM cosmology. We utilise artificial neural networks (ANN) to estimate the mass from dynamical parameters and local velocity shear information, and find that the rms scatter in the log-mass is reduced by approximately a factor of two compared to the Timing Argument. We apply this to observations of MW and M31 to make a new estimate of the Local Group mass. We also use the model derived by the ANN to explore the effect of the shear parameters.

*References:*

[1] Riebe et al., *The MultiDark Database: Release of the Bolshoi and MultiDark cosmological simulations*, Astronomische Nachrichten, 334, 691

Jeremy **Mould** *(CAS)*, Hawthorn, Australia

**The 6dF Galaxy Survey and its successor, Taipan**

July, 4, 14:00 – 14:30, Conference Hall

The recent 6dF Galaxy Survey presented scale-dependent measurements of large scale flows and the normalized growth rate of structure $f\sigma_8(k, z = 0)$ using only the peculiar motions of galaxies based on the Fundamental Plane (FP) for early type galaxies. These galaxies form the basis of 6dFGSv, the largest and most uniform galaxy peculiar-velocity sample to date. Johnson et al. [1] constrained the growth rate in a series of $\Delta k \sim 0.02$ Mpc$^{-1}$ bins to ∼35% precision, including a measurement on scales >400 Mpc, which represents one of the largest scale growth rate measurement to date. No evidence was found for a scale-dependence in the growth rate, or any statistically significant variation from the growth rate or bulk flow predicted by CMB cosmology. Magoulas et al. [2,3] developed a robust Bayesian model to derive peculiar velocities and FP distances for a subsample of 9,000 galaxies from 6dFGSv. A Bayesian analysis of the data set as a whole was performed, determining cosmological parameters from the peculiar-velocity field (*e.g.*, fitting $\beta$ and the bulk flow), by comparing to the field predicted from the redshift survey and assuming that the galaxy distribution traces the matter distribution. A bulk flow was measured of 366 km/s in the direction $(l, b) = (308, 20°)$ and over the volume referred to above, in reasonable agreement with the results of other recent studies. The AAO's new Taipan survey commenced this year with an FP sample ten times larger. It will allow us to understand in detail the growth of structure in the low redshift universe, providing strong constraints on the nature of dark energy and a measurement of the Hubble constant from baryon acoustic oscillations to 1% accuracy.

*References:*

[1] A. Johnson et al. (2014), MNRAS, 444, 3926

[2] C. Magoulas et al. IAU Symposium 289, Cambridge University Press, Cambridge U.K. (2013), pg. 402

[3] C. Magoulas et al. (2015), in preparation.

Fabien **Nugier** *(LeCosPA)*, Taipei City, Taiwan, Province of China

**Adapted coordinates for light signals in cosmology**

July, 8, 14:30 – 14:45, Conference Hall

I will explain the long-standing motivation of doing cosmology with coordinates directly adapted to physical observables. I will present one of these systems of coordinates, the geodesic light-cone coordinates [1], which has been extensively used for cosmology in the last few years. Its applications go from theoretical inhomogeneous/anisotropic models to concrete examples like: the exact computation of the luminosity distance-redshift relation at second order in perturbations around FLRW (including peculiar velocities, (integrated) Sachs-Wolf effect, redshift perturbations and other 2nd order terms [2]), the effect of the large-scale structure on the Hubble diagram [3], number counts of galaxies, weak lensing [4] and ultra-relativistic particles propagation.

*References:*

[1] M. Gasperini, G. Marozzi, F. Nugier, and G. Veneziano, *Light-cone averaging in cosmology: Formalism and applications*, JCAP 1107 (2011) 008, [astro- ph 1104.1167].

[2] I. Ben-Dayan, G. Marozzi, F. Nugier, and G. Veneziano, *The second-order luminosity-redshift relation in a generic inhomogeneous cosmology*, JCAP 1211 (2012) 045, [astro- ph 1209.4326].

[3] I. Ben-Dayan, M. Gasperini, G. Marozzi, F. Nugier, and G. Veneziano, *Average and dispersion of the luminosity-redshift relation in the concordance model*, JCAP 1306 (2013) 002, [astro- ph 1302.0740].

[4] G. Fanizza and F. Nugier, *Lensing in the geodesic light-cone coordinates and its (exact) illustration to an off-center observer in Lemaître-Tolman-Bondi models*, JCAP 1502 (2015), no. 02 002, [astro- ph 1408.1604].

Jorge **Penarrubia** *(ROE)*, Edinburgh, United Kingdom

**Galactic perturbations of the (local) Hubble flow**

July, 8, 11:00 – 11:15, Conference Hall

The rather intuitive concept of 'galaxy mass' is an ill-defined quantity in cosmology. First, because in an expanding, close-to-homogeneous Universe collapsed structures do not show well-defined boundaries, and second because the availability of dynamical tracers becomes very scarce in the outskirts of dark matter haloes. In this talk I will discuss the possibility (and challenges) of measuring galaxy mass by inspecting the perturbation that collapsed structures introduce on the local expansion of the Universe. As an application, I will summarize recent attempts to measure simultaneously the masses of our Galaxy, the Large Magellanic Cloud and M31. The results may have important implications for dynamical techniques devised to model the potential of the Milky Way with Gaia data.

## Speakers

Elena **Pierpaoli** *(USC)*, Los Angeles, United States

**Cosmological information from the polarized kinetic SZ signal**

July, 7, 09:30 – 09:45, Conference Hall

Moving clusters leave a distinct signature in the Cosmic Microwave Background (CMB) through the well known kinetic Sunyaev-Zeldovich (SZ) effect. In the presence of CMB anisotropies, the polarized SZ effect for non-moving clusters conveys information regarding the primordial quadrupole moment at the location of the cluster, therefore allowing, in principle, to reduce cosmic variance for this mode. We generalize this result to moving clusters. We show that if the cluster has a peculiar velocity, more large scale modes influence the expected signal in temperature and polarization, producing frequency distortions that can be exploited to recover the amplitude and orientation of the primordial dipole and octupole.

*References:*

[1] "Kinetic Sunyaev Zeldovich effect in an anisotropic CMB model: measuring low multipoles of the CMB at higher redshifts using intensity and polarization spectral distortions"; S. Yasini and E. Pierpaoli *Ph. Rev. D. submitted (2016)*, [arXiv:1605/02111].

Daniel **Pomarede** *(IRFU)*, Gif sur Yvette, France

**The Cosmic V-Web as reconstructed from Cosmicflows-2**

July, 6, 09:15 – 09:45, Conference Hall

The Cosmicflows-2 Catalog of galaxy peculiar velocities is used as input to a Wiener Filter and Constrained Realizations to reconstruct the velocity field. The structure of the Cosmic Web is revealed by the analysis of the eigenvalues of the shear tensor. We present a cartography of the web. Three-dimensional visualizations show an elegant structure of knots interconnected by filaments. The mapping of local cosmic flows running inside the filaments towards the knots is presented, showing how the web is structured in terms of adjacent basins of attraction. These reconstructions include the Zone of Avoidance.

Khaled **Said** *(UCT)*, Cape Town, South Africa

**Peculiar velocity flow field in the Zone of Avoidance**

July, 5, 09:15 – 09:30, Conference Hall

I will present the first peculiar velocity flow field derived from galaxies in the Zone of Avoidance (ZoA) using a for obscuration optimized NIR Tully-Fisher relation [1]. Systematic deep NIR follow-up observations for all galaxies detected in HIZOA, the Parkes HI ZoA survey have been obtained with the IRSF telescope in addition to narrow-band HI survey for all inclined spirals using Parkes radio telescope [2]. The presented flow fields cover dynamically important large-scale structures such as Puppis, the Great Attractor, and the Local Void which are bisected by the Milky Way. To extend the flow field analysis to the north, follow-up HI observations of all inclined 2MASX bright low-latitude galaxies are being obtained with the Nancay radio Telescope and provide further insight into the hidden part of the Perseus-Pisces Supercluster. Merging these samples with the 2MTF sample should substantially reduce its excluded ZoA.

*References:*

[1] Said K., Kraan-Korteweg R. C., Jarrett T. H., 2015, MNRAS , 447, 1618
[2] Said K., Kraan-Korteweg R. C., Staveley-Smith L., et al. 2016, MNRAS , 457, 2366

Anja **Schroeder** *(SAAO)*, Cape Town, South Africa

**An HI Survey of 2MASS Galaxies in the Zone of Avoidance**

July, 5, 09:00 – 09:15, Conference Hall

We have used a magnitude-limited, complete sample of 2MASS galaxies in the Zone of Avoidance ($|b| < 10$ deg) for a comprehensive HI survey with the Nançay radio telescope. The aim is to complement the 2MASS Redshift Survey and thus to have a complete all-sky sample of galaxies as input to bulk-flow studies. I will present the results and discuss better defined as well as new large scale structures crossing the Galactic Plane, including a follow-up study of a massive cluster in the Perseus-Pisces filament.

Edward **Shaya** *(UMD)*, College Park, United States

**Cosmological Parameters from Flow in the Local Supercluster**

July, 8, 10:30 – 11:00, Conference Hall

After many years of accumulating precise TRGB distances with HST of several hundred galaxies in the Local Supercluster (LSC), it is time to re-examine the peculiar velocity flow of the LSC and the flow toward the Virgo Cluster. Using Numerical Action code, we can do a non-linear reconstruction of the mass distributions from the velocity field. We address the mass-to-light of local galaxies, the masses of the Local Group and the Virgo Cluster, the fraction of matter between groups of galaxies, the Virgo turnaround radius and whether the mass of the Virgo Cluster extends significantly beyond the extent of its galaxies.

Yong-Seon **Song** *(KASI)*, Daejeon, Korea, Republic of

**Measuring coherent motions using redshift space distortion**

July, 6, 10:45 – 11:15, Conference Hall

We analyze the clustering of large scale structure in the Universe in a model independent method, accounting for anisotropic effects along and transverse to the line of sight. The Baryon Oscillation Spectroscopy Survey Data Release 11 provides a large sample of 690,000 galaxies, allowing determination of the Hubble expansion H, angular distance $D_A$, and growth rate $G_T$ at an effective redshift of $z = 0.57$. After careful bias and convergence studies of the effects from small scale clustering, we find that cutting transverse separations below $40$ Mpc/h delivers robust results while smaller scale data leads to a bias due to unmodelled nonlinear and velocity effects. The converged results are in agreement with concordance LCDM cosmology, general relativity, and minimal neutrino mass, all within the 68% confidence level. We also present results separately for the northern and southern hemisphere sky, finding a slight tension in the growth rate – potentially a signature of anisotropic stress, or just covariance with small scale velocities – but within 68% CL. The measured coherent motion through the redshift space distortions is consistent with the prediction of LCDM universe.

Jenny **Sorce** *(AIP)*, Potsdam, Germany

**Simulating our Cosmic Home using Galaxy Flows**

July, 8, 08:50 – 09:10, Conference Hall

Our Local Universe, the best-observed volume of the Universe, provides an excellent sample with which we can attempt to understand the formation and evolution of our cosmological neighborhood. Using data - positions and peculiar velocities of more than 8,000 galaxies from the second catalog of the Cosmicflows project - and a newly developed technique - the reverse Zel'dovich approximation and a bias correction, we produce simulations which resemble the Local Universe. The resulting Constrained Local UniversE Simulations reproduce the Large-Scale Structure down to a few megaparsecs (typically 3-4 $h^{-1}$ Mpc). Local observations, in particular nearby objects like the Virgo cluster, and constrained simulations can therefore be efficiently compared and studied in great details.

Lister **Staveley-Smith** *(ICRAR/UWA)*, Nedlands, Australia

**The 2MASS Tully-Fisher Survey and Future TF surveys**

July, 4, 10:00 – 10:30, Conference Hall

The 2MASS Tully-Fisher (2MTF) survey aims to be a well-defined, comprehensive survey of galaxy flows in the local Universe. It consists of a subset of inclined 2MRS spirals with K-band magnitudes brighter than 11.25 and recession velocities less than 10,000 km $s^{-1}$. New Parkes [1] and GBT [2] HI observations have been combined with archival data and equatorial data from the entire ALFALFA survey. Analysis of the WISE TF relationship [3], maps of the peculiar velocity field [4], and measurements of the bulk flow [5] have been published for the almost-complete version of 2MTF. New analyses of the bulk flow and velocity power spectrum are now under way, as is an updated analysis of cosmological implications. Over the next decade, ASKAP and WSRT/APERTIF will provide surveys which will probe deeper into the nearby Universe.

*References:*

[1] Hong, T., Staveley-Smith, L., Masters, K. L., Springob, C. M., Macri, L. M., Koribalski, B. S., Jones, D. H., Jarrett, T. H., Crook, A. C., 2013, MNRAS, 432, 1178.

[2] Masters, K. L., Crook, A., Hong, T., Jarrett, T. H., Koribalski, B. S., Macri, L., Springob, C. M., Staveley-Smith, L., 2014, MNRAS, 443, 1044.

[3] Lagattuta, D. J., Mould, J. R., Staveley-Smith, L., Hong, T., Springob, C. M., Masters, K. L., Koribalski, B. S., Jones, D. H., 2013, ApJ, 771, 88.

[4] Springob, C. M., Hong, T., Staveley-Smith, L., Masters, K. L., Macri, L. M., Koribalski, B. S., Jones, D. H., Jarrett, T. H., Magoulas, C., Erdofüdu, P., 2016, MNRAS, 456, 1886.

[5] Hong, T., Springob, C. M., Staveley-Smith, L., Scrimgeour, M. I., Masters, K. L., Macri, L. M., Koribalski, B. S., Jones, D. H., Jarrett, T. H., 2014, MNRAS, 445, 402.

## Speakers

Elmo **Tempel** *(TO)*, Tõravere, Estonia

**Cosmic web and underlying velocity field in the local universe**

July, 7, 15:30 – 16:00, Conference Hall

We present an analysis of the cosmic web in the local Universe. First, we use the improved FoF group finder [1] to detect galaxy groups and to suppress the fingers-of-God redshift distortions in 2MRS survey. The corrected distribution of galaxies is thereafter used to extract galaxy filaments using the Bisous model [2]. We compare the filaments detected in galaxy distribution with the underlying velocity field reconstructed from the peculiar velocities of galaxies [3]. We find a good agreement between the two methods.

*References:*

[1] E. Tempel, R. Kipper, A. Tamm and et al. *Friends-of-friends galaxy group finder with membership refinement. Application to the local Universe*, (2016) A&A accepted [arXiv:1601.01117].

[2] E. Tempel, R.S. Stoica, V.J. Martinez and et al. *Detecting filamentary pattern in the cosmic web: a catalogue of filaments for the SDSS*, (2014) MNRAS, 438, 3465 [arXiv:1308.2533].

[3] N. Libeskind, E. Tempel, Y. Hoffman, R.B. Tully and H. Courtois, *Filaments from the galaxy distribution and from the velocity field in the local universe*, (2015) MNRAS, 453, L108 [arXiv:1505.07454].

Jean **Trân Thanh Vân** *(ICISE)*, Quy Nhon, Viet Nam

**Welcome at ICISE**

July, 4, 08:30 – 08:40, Conference Hall

Roland **Triay** *(AMU)*, Marseille, France

**Presenting the conference**

July, 4, 08:50 – 09:00, Conference Hall

Roland **Triay** *(AMU)*, Marseille, France

**Voids as cosmological structures**

July, 7, 16:00 – 16:15, Conference Hall

The behavior of single voids evolving in a uniform and pressureless distribution of matter can be used to characterize the expansion of the universe. The expansion of such a structure, which is modeled in the case of spherical voids within a covariant Newtonian formalism, as well as in GR, bursts up, without encountering any linear regime, to reach asymptotically the Hubble flow, and shows a feature that characterizes the cosmological constant effect and enables one to estimate the scalar curvature of the comoving space.

*References:*

[1] HH. Fliche, R. Triay, *Lambda effect in the cosmological expansion of voids.*, JCAP 11:022 (2010)

[2] K. Maeda, N. Sakai, R. Triay, *Dynamics of Void and its Shape in Redshift Space.*, 08:026 (2011)

[3] N.D. Nguyen, R.Triay, *Isotropization of voids.*, in preparation

Brent **Tully** *(IfA, Hawaii)*, Honolulu, United States

**Cosmicflows-3**

July, 4, 09:30 – 10:00, Conference Hall

Cosmicflows-3 is a database of 17,669 galaxy distances, more than double the number in the previous edition. The new catalog adds 2,257 distances based on the correlation between galaxy rotation and luminosity using Spitzer 3.6 micron photometry, 8,885 Fundamental Plane distances provided by the 6dFGS collaboration, and 25-30% augmentations of the samples provided by the Tip of the Red Giant Branch and Type Ia supernova techniques. The zero point calibration is consistent with $H_0 = 75$ km/s/Mpc and the ensemble seriously challenges claims of $H_0$ below 70.

Richard **Watkins** *(WU)*, Salem, United States

**Bulk Flows in Theory and Practice**

July, 5, 14:00 – 14:30, Conference Hall

While the Bulk Flow is easy to define in theory, the problem of estimating Bulk Flows from actual peculiar velocity data is fraught with complications, both because we measure only the radial components of peculiar velocities and because these measurements are very noisy. I will discuss alternate estimation methods and argue that the best approach to this problem is to abandon physically intuitive definitions and instead focus on determining linear combinations, or moments, of peculiar velocity measurements that are most useful for constraining Cosmological parameters. I will show how the minimum variance method [1] can be used to generate moments that probe the local universe in a well defined way, and contrast it with other formulations. In particular, I will show how to construct moments that probe space in a uniform way and are comparable between surveys, even those that have very nonuniform galaxy and error distributions. Finally, I will discuss the results obtained from applying these methods to the *CosmicFlows-2* catalog [2] .

*References:*

[1] R. Watkins, H.A. Feldman, and M. J. Hudson, *Consistently Large Cosmic Flows on Scales of* $100h^{-1}$Mpc: *A Challenge for the Standard* ΛCDM *Cosmology*, *MNRAS* 392 (2009) 743.

[2] R. Watkins and H.A. Feldman, *Large-scale Bulk Flows from the Cosmicflows-2 Catalog*, *MNRAS* 447 (2015) 132.

Charlotte **Welker** *(ICRAR)*, Crawley, Australia

**Mergers and gas accretion onto galaxies: the imprint of the cosmic web**

July, 8, 14:15 – 14:30, Conference Hall

In this talk I will present the major features that govern the geometry and dynamics of cosmic flows on Mpc scales, and further develop the consequences for mergers and gas inflows on galactic scales. In particular, I will explain how the dynamical and anisotropic nature of the cosmic web imprints the cold gas streams and their later accretion onto galaxies, and how it affects the satellite distribution, spin, morphology and scaling relations of galaxies over a wide range of redshifts. To perform this analysis, I will rely on both insights from lagrangian theory and recent results drawn from zoom simulations of clusters and the analysis of the $100Mpc \cdot h^{-1}$ box "full-physics" hydrodynamical cosmological simulation Horizon-AGN.

*References:*

[1] c. Welker, Y. Dubois, C. Pichon, J. Devriendt, E. Chisari, *Caught in the rhythm: how satellites settle in a plane around their central galaxy*, Submitted to Astronomy and Astrophysics (2016).[astro-ph/arXiv:1512.00400].

[2] C. Welker, Y. Dubois, J. Devriendt, C. Pichon, S. Kaviraj *The rise and fall of stellar discs across the peak of cosmic star formation hisory: mergers versus smooth aqcuisition.* (2015), submitted to MNRAS, [astro-ph/arXiv:1502.050539].

Jiajun **Zhang** *(CUHK)*, Hong Kong, Hong Kong

**Percolation analysis for cosmic web with discrete points**

July, 6, 11:15 – 11:30, Conference Hall

Percolation analysis has long been used to quantify the connectivity of the cosmic web. Unlike most of the previous works using density fields on grids, we have studied percolation analysis based on discrete points. Using a Friends-of-Friends (FoF) algorithm, we generate the S-bb relation, between the fractional mass of the largest connected group (S) and the FoF linking length (bb). We propose a new model, the Probability Cloud Cluster Expansion Theory (PCCET) to relate the S-bb relation with correlation functions. We show that the S-bb relation reflects a combination of all orders of correlation functions. We have studied the S-bb relation with N-body simulation and find that the S-bb relation is robust against redshift distortion and incompleteness in observation. From the Bolshoi simulation, with Halo Abundance Matching (HAM), we have generated a mock galaxy catalogue. Good matching of the projected two-point correlation function with observation is confirmed. However, comparing the mock catalogue with the latest galaxy catalogue from SDSS DR12, we have found significant differences in their S-bb relations. This indicates that the mock galaxy catalogue cannot accurately recover higher order correlation functions than the two-point correlation function, which reveals the limit of HAM method.

# Posters

Jianxiong **Chen** *(CUHK)*, Shatin, Hong Kong

### Halo mass function in Decaying Dark Matter Model

To tackle the small scale crisis of the cold dark matter model [1], a decaying dark matter model has been proposed, $DDM \rightarrow DM + l$, where $DDM$ is the unstable mother dark matter particle, $DM$ is the stable daughter dark matter particle, and $l$ stands for a light or massless particle. Suppressions on sub-galactic structure formation have been observed in $N$-body investigations on this scenario [2]. Here we apply the Extended Press-Schechter method to calculate the halo mass function subject to particle decay effect and compare it with that measured from $N$-body simulations. This work will help us to better understand the suppression mechanism induced by dark matter decay.

*References:*

[1] D. H. Weinberg, J. S. Bullock, F. Governato, R. K. de Naray and A. H. G. Peter, *Cold dark matter: controversies on small scales*, arXiv:1306.0913 [astro-ph.CO]

[2] D. Cheng, M.-C. Chu and J. Tang, *Cosmological structure formation in Decaying Dark Matter models*, J. Cosmology Astropart. Phys. 07 (2015) 009, arXiv:1503.05682 [astro-ph.CO]

Rain **Kipper** *(TO)*, Tõravere, Estonia

### Galaxy groups in the local Universe

It is common to use Friends-of-friends (FoF) method to find the groups in the galaxy sample. This method has the disadvantage of connecting nearby structures, thus making groups larger. In this work we combine the FoF method with multimodality analysis to refine the membership of the FoF groups. As a result, we found the FoF groups richer than 10 members, contained in half of cases more than one refined group, indicating the importance of more precise modelling. Comparison with [1] catalogue showed this method to give similar results, despite the different methodology.

*References:*

[1] B. Tully, *Galaxy Groups: A 2MASS Catalog*, A&A. 149 (2015) 171.

Lan **Nguyen Quynh** *(HNUE)*, Hanoi, Viet Nam

### Gravitational Waves from Binary Neutron Stars

The relativistic evolution of neutron stars, either in a head on collision or in binary orbit is of current interest as such systems are expected to emit detectable gravitational radiation. In this work, numerical simulations of colliding neutron stars, having either a realistic or a $\Gamma = 2$ polytropic equation of state (EOS) confirm the rise in central density for the softer EOS. For the binary calculation, our results show that the neutron stars can collapse to black holes before colliding when the EOS is realistic, the central density as the stars approach, when a stiff equation of state is used. Illustrate templates for the gravitational radiation emitted from the binary are calculated and we show that the frequency of the emitted gravitational waves changes more slowly for a realistic EOS. This may result in a stronger signal in the 50-100 Hz band.

Junsup **Shim** *(SNU)*, Seoul, Korea, Republic of

### Superclusters : To be straight, or not to be

This presentation is based on our previous works about investigating supercluster shape, specifically the straightness of superclusters, in various cosmologies.[1][2][3] We measure the specific size $\tilde{S}$ of the supercluster which represents the degree of supercluster straightness and compare $\tilde{S}$ in different cosmologies, on the ground that the shape of filamentary structure of the supercluster will change either if $1)$ the nature of dark energy differs from the Cosmological constant $\Lambda$ or $2)$ the governing law of gravitation deviates from the general theory of relativity at large scale. We identify superclusters by applying FoF algorithm on halo catalogs of N-body simulations for different cosmologies, for example coupled dark energy (cDE) and $f(R)$ gravity models. It is found that both the cDE and $f(R)$ gravity have the effect of significantly bending the superclusters resulting in smaller values of $\tilde{S}$ compared to that of $\Lambda$CDM, whereas the massive neutrinos contribute to straightnening the superclusters. Interestingly, the deviation of the supercluster straightness in cDE ($f(R)$ gravity) from $\Lambda$CDM increases (decreases) with redshift. A physical interpretation of our findings is discussed.

*References:*

[1] Junsup Shim, Jounghun Lee, *Dark Sector Coupling Bends the Superclusters*, Astrophys.J. 777 (2013) 74, [arXiv:1306:1642].

[2] Junsup Shim, Jounghun Lee, Baojiu Li, *Massive Gravity wrapped in the Cosmic Web*, Astrophys.J. 784 (2014) 84, [arXiv:1311:7187].

[3] Junsup Shim, Jounghun Lee, Marco Baldi, *Breaking the Cosmic Degeneracy between Modified Gravity and Massive Neutrinos with the Cosmic Web*, [arXiv:1404:3639].

# Participants

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