EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

Exploratory Workshop Scheme

Standing Committee for Physical and Engineering Sciences (PESC)

ESF Exploratory Workshop on

The Almost Gaussian Universe

Gif-sur-Yvette (France), 8-11 June 2010

Convened by:
Francis Bernardeau, Emiliano Sefusatti and Filippo Vernizzi

SCIENTIFIC REPORT

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1. Executive summary

The workshop took place on the *Orme des Merisiers* site in Gif-sur-Yvette (France) of the *Institut de Physique Théorique* (IPhT) of CEA/Saclay, from Wednesday 9th to Friday 11th of June 2010. It involved the participation of 29 researchers from 7 countries presenting a total of 24 talks of about 30 minutes each (including questions and discussions). There were also two introductive presentations, one by F. Bernardeau on the subject of the workshop and one by M. Aizenman on the ESF mission and activities. Finally, the workshop was concluded by a summary talk by S. Matarrese on the results presented and current issues.

An informal atmosphere, favoured by the relatively small number of participants, has characterized the entire workshop. There have been many lively discussions, during the talks, the breaks and at the conclusion of each day. These discussions reflect the rapidly emerging topic of primordial non-Gaussianity as a proper branch of current cosmological research.

The aim of the meeting consisted in bringing together researchers involved in the study of non-Gaussianities in cosmology to review and settle on firm theoretical grounds the non-Gaussian effects of the two most important cosmological probes to constraint primordial non-Gaussianities: the Cosmic Microwave Background (CMB) anisotropies and the Large-Scale Structures (LSS). As non-Gaussian initial conditions are expected to affect – at comparable levels – a wide range of cosmological observables, the workshop has brought together experts in otherwise distant areas, determining a strong interest – in fact the *necessity* – to involve each participant in understanding the subject well beyond her/his specific activity. Indeed, we have assisted to the starting of new collaborations along the points discuss during the three days.

The workshop aimed at assessing the possibility offered by current and future cosmological observations to constrain – or detect – a non-Gaussian component in the initial conditions of the Universe. Indeed, all inflationary models based on a single slow-rolling field predict extremely Gaussian initial conditions. However, other models of inflation predict departure from Gaussian initial conditions. Thus, detection of non-Gaussianity would rule out a plethora of single-field inflationary models and provide a very important tool to discriminate models of the early Universe. Such a primordial non-Gaussian component needs to be distinguished by the one induced by non-linearities in the evolution after inflation. For this reason, the determination of second-order corrections in the perturbative treatment of density fluctuations and cosmological perturbations at early times has been another important subjects of the workshop.

From the observational point of view, the CMB clearly represents the most natural and direct probe of the initial conditions. Indeed, measurements of the CMB temperature and polarization bispectra (i.e. three-point functions) have been recognized for a long time as the best tool to constrain primordial non-Gaussianity. This picture recently changed following the "discovery" of a large effect of non-Gaussianity of the "local" type on the bias of dark matter halos in N-body simulations. This effect implies that we can obtain, from measurements of the clustering properties of galaxies and galaxy clusters *already in current surveys,* limits on the non-Gaussian parameter f_{NL} (the parameter measuring the "amount" of primordial non-Gaussianity) comparable to those obtained from the CMB. In other terms, it is now clear that LSS observations, in principle, should be able to provide a fundamental confirmation of a possible detection of primordial non-Gaussianity in the CMB bispectrum that will be measured by the Planck satellite. On the other hand, large-scale structure observations

suffer from a long series of possible systematic errors and a lot of work is in order to address such issues.

We can summarize here the theoretical questions that have been addressed during the workshop, along with the answers given to these questions and the open problems raised by the participants:

> **Q:** Are we ready for the analysis of the CMB data from the Planck satellite? Is the optimal estimator of f_{NL} , based on the CMB bispectrum, the ultimate probe of non-Gaussianity or can we extract additional information from other CMB observables (trispectrum, Minkowski functional, etc.)? What "form" of primordial non-Gaussianity are we after?
> **A:** Current CMB bispectrum estimators are optimal and should be used for Planck analysis. However, other approaches (such as trispectrum measurements, Minkowski functionals) should not be totally abandoned, as they might be useful to confirm detection or used as simpler exploratory tools. When looking for possible shapes of primordial signals, we should keep in mind theory predictions. However, naturalness can be "matter of taste" and it is not always a good guide.
>
> **Q:** Are second-order effects generated by the non-linear evolution important? Are we able to distinguish a non-Gaussian signal of inflationary origin from the non-Gaussianity due to the subsequent non-linear evolution?
> **A:** Second-order effects generated by the subsequent non-linear evolution will affect the primordial non-Gaussianity, either in the CMB, in weak lensing and LSS. Currently, there is not yet a consensus on their quantitative values and we should strength our effort for a complete determination and agreement
>
> **Q:** What are the systematics affecting LSS observations of non-Gaussianity? In particular, is the scale-dependent bias behaviour a solid and unique signal of non-Gaussianity? Are we ready for the analysis of the Euclid data from weak lensing and LSS? Do we have an optimal estimator for the non-Gaussianity in weak lensing? What can we learn from the effect of non-Gaussianity on the abundance of rare objects?
> **A:** Large-scale structures have become an important tool to constraint non-Gaussianity and a lot of effort should be devoted to assess their systematics, which at the moment is not completely understood. In particular, we should concentrate our effort to: 1) compute what are the theoretical errors on the different available mass functions and bias parameters for various models of primordial non-Gaussianities; 2) assess the validity of current non-Gaussian N-body simulations; 3) have a clearer idea of the Euclid potential to constrain the amplitude of non-Gaussianities, f_{NL} , for the local *and* other relevant models, based on the power spectrum *and* bispectrum observations

2. Scientific content of the event

The full program, with a direct link to each of the talks, can be found at this address:
http://ipht.cea.fr/Meetings/GaussUniverse2010/agenda.php

- ***First day, morning (Early Universe and CMB):***
  - **Francis Bernardeau:** *Welcome address*
    Reminder of the aim of the workshop. Historical remarks and status on the capability of current observations to constrain non-Gaussianities.

- **Leonardo Senatore:** *Inflation, effective field theory and non-Gaussianities*
General presentation on current early universe models generating non-Gaussianities, from an effective field theory point of view. Highlight on the advantages of effective field theory techniques and on the possibility of generating a large trispectrum without a large bispectrum. Disagreement among the participants on the naturalness of this taking place.
- **Benjamin Wandelt:** *The non-Gaussian Universe*
Review on constraints from Planck. Highlight on the difference between using frequentist or Bayesian statistics. Second part of the talk devoted to the use of voids to study dark energy and non-Gaussianities. Discussion on the ambiguity of the definition of voids.
- **Michele Liguori:** *A general mode-expansion for CMB bispectrum estimation*
Discussion on different shape estimators and shape extraction. Discussion on the possibility of having an exhaustive list of shapes. Naturalness from model building is important or, whatever the data, we will always find a shape fitting them.
- **Paul Shellard:** *General CMB bispectrum & trispectrum estimation*
Another talk on CMB bispectrum estimation and shape analysis and expansion of general shapes in terms of separable ones. First attempts to study the trispectrum.
- **Nicola Bartolo:** *Some novel results on non-Gaussianity from single-field inflation and on anisotropic features*
Discussion of single field models of inflation using an effective field theoretical approach. Possibility of generating a flat shape also in single-field inflation. Statistical anisotropy could also be a signal in the CMB. A statistical estimator of statistical anisotropic non-Gaussianity is presented.

- ***First day, afternoon (CMB / Halos & Galaxy Clusters):***
- **Cyril Pitrou:** *Non-Gaussianity in the CMB from nonlinear effects*
A publicly available Boltzmann code for the second-order evolution of CMB anisotropies is presented. Primary terms at recombination yield f_{NL} (local) ~5. Discussion: it has been stressed the importance of validation of the numerical code by checking them in particular physical limits where the result is robust.
- **Paolo Creminelli:** *The CMB bispectrum at large angular scales*
Presented a CMB semi-analytical calculation of the bispectrum on large angular scale, in a well-defined physical limit where a sort of consistency relation exists, which may become important to check numerical codes.
- **Antonio Riotto:** *The dark matter halo mass function with non-Gaussianity from the excursion set approach*
Development of an approach from first principle to compute the halo mass function for a generic filter and non-Gaussian initial conditions. The method deals with non-Markovian dynamics and memory effects. Discussion: generalization to the non-spherical case and on the diffusive collapse threshold.
- **Aseem Paranjape:** *The non-Gaussian mass function for halos and voids*
Improvement of the methods developed by Maggiore-Riotto by combining them with saddle-point approximation techniques. Comparison between different mass functions present in the literature. Estimation of errors on the mass functions. Discussion of the void-in-cloud issue for the computation of the void mass function.
- **Discussion:** see *point 3* for a summary of the content of the Discussion session at the end of the day.

- ***Second day, morning (Halos & Galaxy Clusters):***
  - **Ravi K. Sheth:** *One more step in models of halo abundances, clustering, and the probability distribution function of the mass*

  Presented an overview of the typical assumptions that enter in the derivation of the halo mass function in the context of the excursion-set approach, discussing their relevance with respect to the discrepancies in comparison with simulations. He proposed a different ansatz for the mass function to specifically address the cloud-in-cloud problem and pointed-out the implications for the extension of this formalism to the case, among others, of non-Gaussian initial conditions.
  - **Patrick Valageas:** *On mass functions and bias of halos*

  Presented an exact analytical derivation of the mass function valid in the high-mass limit and based on the steepest-descent approach. He discussed implications for the halo bias parameters, specifically in the context of non-Gaussian initial conditions, providing predictions with no free parameters.
  - **Raul Jimenez:** *Non-Gaussianity with clusters and voids*

  Provided an overview of current and forecasted limits on non-Gaussian parameters from different probes, focusing specifically on the observed abundance of clusters. He discussed the statistical significance of the detection of very rare events in relation to the case of the massive cluster XMMU J2235.3-2557, whose observation would find more probable explanation in the context of non-Gaussian initial conditions. In addition, he introduced the subject of voids as a cosmological observable and as a probe of the initial conditions.
  - **Lauro Moscardini:** *Imprints of primordial non-Gaussianities in future clusters surveys*

  Presented the Fisher matrix forecasts for the constraints on non-Gaussian parameters expected from measurements of the clusters abundance and power spectrum. In the case of the proposed WFXT X-rays cluster survey, the complementarity between the two observables should provides 1-sigma errors on f_{NL} of the order of 10.
  - **Annalisa Pillepich:** *Non-Gaussianity from the eRosita cluster survey*

  A similar Fisher matrix forecast for the eRosita is presented, indicating a $\Delta f_{NL} \sim 6$. In this case, the observation of cluster abundance is combined with angular correlation function and the study is done in terms of photon counts, rather than the cluster mass, to provide a more direct relation with actual observations.
  - **Discussion:** see point 3 for a summary of the content of the Discussion session at the end of the day.

- ***Second day, afternoon (Weak Lensing):***

  At the last moment, the first speaker of the afternoon (Alexandre Refriegier) was forced to cancel his participation because of his heavy engagements in the Euclid mission, of which he is PI.
  - **Camille Bonvin:** *Full-sky lensing shear at second order*

  Presented a semi-analytical calculation of full-sky second-order weak lensing effects on the reduced shear bispectrum. The precise numerical effect is still under computation. A preliminary calculation seems to confirm that it is non-negligible inducing $f_{NL} \sim$ few. Discussion: is it possible to confirm these effects using N-body simulations?
  - **Cosimo Fedeli:** *The effect of primordial non-Gaussianity on cosmic shear statistics*

  Presented a calculation of the non-Gaussian dark matter power spectrum using the halo model with non-Gaussian corrections. This model is used to make forecasts on the future constraints on f_{NL} (local and equilateral) by weak lensing statistics from the Euclid mission. Discussion on the validity of the halo model on scales interpolating between the halo and the linear power spectrum where all the non-Gaussian effects are

concentrated. Need confirmation from N-body simulations. Why not using the bispectrum instead of the power spectrum to constrain/estimate f_{NL}?

- **Matteo Viel:** *Non-Gaussianity with high-redshift large-scale structure probes*

Presented several high redshifts probes used to constrain non-Gaussianities. These are the autocorrelation function of NVSS, the Lyman-alpha flux and the reionization. A scale dependent bias model can better fit the NVSS data, signalling the presence of primordial non-Gaussianities (f_{NL} local ~ 70); however, uncontrolled systematics effects could induce the non-Gaussian signal.

- **Discussion:** see point 3 for a summary of the content of the Discussion session at the end of the day.

- ***Third day, morning (Large-scale Structure):***

- **Licia Verde:** *Large-scale non-Gaussian halo bias: its potential and limitations*

Presented the expected errors on the non-Gaussian parameter f_{NL} from measurements of the galaxy power spectrum in future spectroscopic and photometric redshift surveys. They indicate that the potentiality to constrain non-Gaussianity is in principle comparable, if not superior, to the CMB bispectrum, while pointing-out a weak degeneracy with other cosmological parameters. In addition, recent results from N-body simulations with non-Gaussian initial conditions corresponding to various models were presented, raising some interesting issues on the problem of properly setting-up non-Gaussian initial conditions.

- **Tommaso Giannantonio:** *Structure formation from primordial non-Gaussianity: non-local bias and future constraints*

Presented a comprehensive model for the halo power spectrum with non-Gaussian initial conditions and discussed differences with previous approaches. A Fisher matrix analysis, involving marginalization on cosmological and bias parameters has then been presented for the proposed Euclid mission, including weak lensing as well as 2D (photometric) and 3D (spectroscopic) galaxy clustering observations. The marginalized errors on local f_{NL} are expected to be below the limits expected from the Planck CMB mission.

- **Roman Scoccimarro:** *Understanding large-scale bias*

Discussed the theoretical differences in the derivation of the effect of primordial non-Gaussianity on the biasing of halos. In addition, preliminary results from a new set of N-body simulations implementing generic non-Gaussian initial conditions have been shown with a specific attention to a comparison of the cumulative signal-to-noise expected for the effect of primordial non-Gaussianity on the power spectrum versus the bispectrum, the latter providing in principle additional information at mildly non-linear scales.

- **Vincent Desjacques:** *Halo stochasticity and f_{NL} estimation*

Discussed mass-weighted measurements of the power spectrum of halos in simulations and its implication for the reduction of shot-noise contamination. The direct application to the estimation of non—Gaussian parameters was then presented, pointing-out in addition systematic errors resulting from the choice of the halo finder.

- **Martin Crocce:** *The matter and halo bispectrum for "Almost Gaussian" initial conditions: theory vs. simulations*

Presented a comparison between measurements of the matter bispectrum in N-body simulations with non-Gaussian initial conditions and predictions in standard perturbation theory at one-loop, discussing the possible application of resummation techniques. Preliminary results for the measurements of the matter-matter-halo bispectrum have been shown.

- **Discussion:** see point 3 for a summary of the content of the Discussion session at the end of the day.

- ***Third day, afternoon (Large-scale structure and finale):***
  - **Kazuya Koyama:** *Scale-dependence of halo bispectrum from non-Gaussian initial conditions*
  Presented a model for the galaxy/halo bispectrum for non-Gaussian initial conditions and compared it to measurements in N-body simulations probing the expected shape and scale dependence in addition to the dependence on the initial trispectrum.
  - **Donghui Jeong:** *The pursuit of primordial non-Gaussianity in the bispectrum and galaxy-galaxy, galaxy-CMB weak lensing*
  Presented a model for the halo bispectrum to account for the effect of primordial non-Gaussianity derived in the high-peaks framework, pointing-out its dependence on both the initial bispectrum and trispectrum. Furthermore, he showed Fisher matrix forecasts for the errors on non-Gaussian parameters from measurements of the galaxy bispectrum in future surveys, in principle indicating this as one of the best probes of the initial conditions. Finally, the possibility of constraining primordial non-Gaussianity from measurements of the mean tangential shear is discussed.
  - **Sabino Matarrese:** *Summary talk.*
  An overview of the presented results and provided some directions of future research.
  - **Discussion:** see point 3 for a summary of the content of the Discussion session at the end of the day.

3. Assessment of the results, contribution to the future direction of the field, outcome

The aim of the workshop was to assess the possibility of constraining, or actually measuring, primordial non-Gaussianities that could have been induced during the early stages of the thermal history of the universe. It is now clear that these effects can only be weak. Different routes have been proposed to achieve such detection. The most natural is to look for such effects in the CMB data but other techniques, exploiting large-scale structure data, have been put forward.

- ***Conclusions:***
  - Regarding CMB observations, and in the context of weak primordial non-Gaussianities, there is now a clear consensus that the current estimators, based on poly-spectra measurements, are optimal. However, other approaches based on other types of observables (for instance for shape oriented indicators such as the Minkowski functional, etc) should not be totally abandoned, as they might be useful to confirm detection or used as simpler exploratory tools.
  - Given the expected accuracy of future CMB experiments, second-order effects will affect the primordial non-Gaussianity determination, either in the CMB, in weak lensing and large scale structures. Whereas there is a clear consensus on their importance, there is not yet a consensus on their quantitative values. Progresses are being made.
  - Whereas the theoretical systematics for CMB observations is, at least potentially, under control, this appears not to be the case for large-scale structure observations. In particular there is no consensus on how to theoretically compute the halo – not to mention the actual galaxy – correlation functions. It is not even established on an

unchallengeable ground that the most advocated non-Gaussian feature – the $1 / k^2$ large-scale rise in the halo power spectrum – is a genuine signature of the primordial non-Gaussianities.

The discussions have identified several questions that ought to be addressed in the near future.

- ***Construction of early universe models:***
  - Very large classes of early universe models exhibit significant primordial non-Gaussianities in the form of a bispectrum signature. However, at this stage it cannot be excluded that the first accessible signature of primordial non-Gaussianities could actually be the trispectrum. For instance, symmetry reasons could impose some classes of models to exhibit a relatively larger trispectrum than bispectrum. This has to be investigated in more details.
  - For the trispectrum, the exploration of the expected shape dependence is yet to be done. Templates are needed.

- ***CMB observations:***
  - Although significant progress has been made regarding the impact of nonlinear physics at recombination, these results are still preliminary and their validity needs to be assessed. A full second-order Boltzmann code is now available and public. However, its impact has to be better understood and its validity needs to be confirmed in some physical limit where the result is known. For this reason, analytical calculations and consistency relations are equally important to identify these limits. Furthermore, although this code takes into account the polarization to compute the bispectrum, it needs to be extended to compute three-point correlation functions involving the polarization.
  - From a theoretical point of view, it is difficult to be exhaustive in predicting bispectra shapes. It is not clear yet if it is possible (or even desirable) to define an exhaustive list of different shapes expected from inflation on the base of naturalness.
  - Little is known on the CMB trispectrum. To start with, we should reconsider the currently known forecast on the limit on the trispectrum from Planck.

- ***Large-scale structure tracers (lensing, halos, galaxies and clusters).*** This is a multiplayer game that involves theoretical investigations, numerical simulations and observations. From the theory/simulation perspective:
  - Theoretical models for the non-Gaussian mass functions do not necessarily agree at the required level of precision. Thus, we need to compute what are the theoretical errors on the different available mass functions and bias parameters for various models of primordial non-Gaussianities. Along the same line, we need to know for instance what are the theoretical requirements for an optimal exploitation of a future experiment such as Euclid.
  - We also need to know the impact of primordial non-Gaussianities on the small-scale poly-spectra. Theoretical developments have been made, but they are not yet able to produce robust answers.
  - We have concluded above that we now have an optimal estimator for the CMB bispectrum. We still miss optimal estimators both for cosmic-shear and large-scale structure observations. To a large extent, these would rely on the answers given to the last two points.
  - We currently have several N-body simulations with primordial non-Gaussianities based on different numerical codes and different way of implementing the non-

Gaussian initial conditions. They still do not give the same results; thus, we need to test them and check between different codes and initial conditions. In particular, it is important to assess the redshift dependence of the results and the halo properties that they predict, depending on the prescription used to actually define haloes.

- We currently use N-body simulations covering a large portion of the observable universe, i.e. a non-negligible fraction of the Hubble radius. These scales become potentially sensitive to general relativistic effects that the N-body codes do not incorporate. We thus need to understand how to interpret the N-body results on these very large scales, and how to compare them with observations.
- Finally, one clear goal is to have a clear assessment of Euclid potential to constrain f_{NL} local (or other shapes), based on the power spectrum and bispectrum observations.

The main obstacles for measuring primordial non-Gaussianities from large-scale structure observations are the systematics of theoretical, astrophysical or observational origin. It is not yet clear what are the best strategies and the best tracers to be used. The use of rare event statistics, such as galaxy cluster counts, is potentially a very effective way of tracking primordial non-Gaussianities but it is also extremely sensitive to systematics. Voids have been proposed as an alternative approach. Several questions should be investigated in the future:

- What is the minimal precision requirement for mass/redshift estimation for galaxy clusters?
- How to unambiguously define, simulate and observe voids in large-scale structure observations?
- Do we know enough of galaxy formation to safely “prove” the existence of primordial non-Gaussianities from galaxy-survey analysis or will we eventually have to rely on end-to-end (gravity + hydrodynamics) simulations?

- ***Concrete actions:***

Some of these questions are very specific to the community that was present at the meeting; however, some other questions (in particular those regarding galaxy formation) are of interest for a much broader community presenting implications for a wide range of targets in cosmological research. Within our group we have identified a couple of actions that are well circumscribed and that could be addressed in the short term:

- Set up a work group whose task would be to assess the validity of CMB codes (second order Boltzmann evolution code in particular).
- Set up a work group whose task would be to assess the validity of the N-body codes for specific primordial non-Gaussian initial conditions (test of convergence on the polyspectra, impact of trispectrum, halo properties, redshift dependences, etc.)

The exact compositions of these work groups are still under discussion. Further funding could be needed to support travel expenses. Recently, a specific website where simulations outputs can be shared and compared has been set up by Licia Verde, one of the participants of the workshop.

4. Final programme

	Wednesday 9
9:30 - 9:45	Francis **Bernardeau** ***Welcome address***
9:45 - 10:00	Morris **Aizenman** (ESF delegate) ***Introduction***
	Early Universe / CMB
10:00 - 10:30	Leonardo **Senatore** ***Inflation, effective field theory and non-Gaussianities***
10:30 - 11:00	Benjamin **Wandelt** ***The non-Gaussian Universe***
11:00 - 11:30	*coffee break*
11:30 - 12:00	Michele **Liguori** ***A general mode-expansion for CMB bispectrum estimation***
12:00 - 12:30	Paul **Shellard** ***General CMB bispectrum & trispectrum estimation***
12:30 - 13:00	Nicola **Bartolo** ***Some novel results on non-Gaussianity from single-field inflation and on anisotropic features***
13:00 - 14:30	*lunch*
	CMB / Halos & Galaxy Clusters
14:30 - 15:00	Cyril **Pitrou** ***Non-Gaussianity in the CMB from nonlinear effects***
15:00 - 15:30	Paolo **Creminelli** ***The CMB bispectrum at large angular scales***
15:30 - 16:00	*coffee break*
16:00 - 16:30	Antonio **Riotto** ***The dark matter halo mass function with non-Gaussianity from the excursion set approach***
16:30 - 17:00	Aseem **Paranjape** ***The non-Gaussian mass function for halos and voids***
17:00 - 18:30	*Discussion*
20:30	

	Thursday 10 Halos & Galaxy Clusters
10:00 - 10:30	Ravi K. **Sheth** ***One more step in models of halo abundances, clustering, and the probability distribution function of the mass***
10:30 - 11:00	Patrick **Valageas** ***On mass functions and bias of halos***
11:00 - 11:30	*coffee break*
11:30 - 12:00	Raul **Jimenez** ***Non-Gaussianity with clusters and voids***
12:00 - 12:30	Lauro **Moscardini** ***Imprints of primordial non-Gaussianities on future cluster surveys***
12:30 - 13:00	Annalisa **Pillepich** ***Non-Gaussianity from the eRosita cluster survey***
13:00 - 14:30	*lunch*
	Weak Lensing / High-redshift
14:30 - 15:00	Camille **Bonvin** ***Full-sky lensing shear at second order***
15:00 - 15:30	Cosimo **Fedeli** ***The effect of primordial non-Gaussianity on cosmic shear statistics***
15:30 - 16:00	*coffee break*
16:00 - 16:30	Matteo **Viel** ***Non-Gaussianity with high-redshift large-scale structure probes***
16:30 - 17:00	*Discussion*
17:00 - 18:30	
20:30	*social dinner*

	Friday 11
	Large-Scale Structure
10:00 - 10:30	Licia **Verde**
	Large scale non-Gaussian halo bias: its potential and its limitations
10:30 - 11:00	Tommaso **Giannantonio**
	Structure formation from primordial non-Gaussianity: non-local bias and future constraints
11:00 - 11:30	*coffee break*
11:30 - 12:00	Román **Scoccimarro**
	Understanding large-scale bias
12:00 - 12:30	Vincent **Desjacques**
	Halo stochasticity and f_{NL} estimation
12:30 - 13:00	Martín **Crocce**
	The matter & halo bispectrum
13:00 - 14:30	*lunch*
	Large-Scale Structure & Finale
14:30 - 15:00	Kazuya **Koyama**
	Scale-dependence of halo bispectrum from non-Gaussian initial conditions
15:00 - 15:30	Donghui **Jeong**
	The pursuit of primordial non-Gaussianity in the bispectrum and galaxy-galaxy, galaxy-CMB weak lensing
15:30 - 16:00	*coffee break*
16:00 - 16:30	Sabino **Matarrese**
	Summary talk
16:30 - 17:00	*Discussion on future actions*
17:00 - 18:30	*and follow-up activities*
	(16:30 - 17:30)
20:30	

5. Final list of participants

Aizenman	**Morris**	*National Science Foundation, US*
Bartolo	**Nicola**	*Università di Padova, Italy*
Bernardeau	**Francis**	*IPhT, CEA-Saclay, France*
Bonvin	**Camille**	*IPhT, CEA-Saclay, France*
Corasaniti	**Pierstefano**	*LUTH, Meudon, France*
Crocce	**Martin**	*ICE, Barcelona, Spain*
Creminelli	**Paolo**	*ICTP, Trieste, Italy*
Desjacques	**Vincent**	*Universität Zürich, Switzerland*
Fedeli	**Cosimo**	*Università di Bologna, Italy*
Giannantonio	**Tommaso**	*University of Bonn, Germany*
Jeong	**Donghui**	*TCC, University of Texas at Austin, US*
Koyama	**Kazuya**	*ICG, University of Portsmouth, UK*
Jimenez	**Raul**	*ICC, Barcelona, Spain*
Liguori	**Michele**	*DAMTP, University of Cambridge, UK*
Matarrese	**Sabino**	*Università di Padova, Italy*
Moscardini	**Lauro**	*Università di Bologna, Italy*
Paranjape	**Aseem**	*ICTP, Trieste, Italy*
Pillepich	**Annalisa**	*ETH, Zürich, Switzerland*
Pitrou	**Cyril**	*ICG, University of Portsmouth, UK*
Riotto	**Antonio**	*CERN, Switzerland*
Scoccimarro	**Roman**	*CCPP, New York University, US*
Sefusatti	**Emiliano**	*IPhT, CEA-Saclay, France*
Senatore	**Leonardo**	*IAS, Princeton, US*
Shellard	**Paul**	*DAMTP, University of Cambridge, UK*
Sheth	**Ravi**	*University of Pennsylvania, US*
Valageas	**Patrick**	*IPhT, CEA-Saclay, France*
Verde	**Licia**	*ICC, Barcelona, Spain*
Vernizzi	**Filippo**	*IPhT, CEA-Saclay, France*
Viel	**Matteo**	*Osservatorio di Trieste, Italy*
Wandelt	**Ben**	*IAP, Paris, France*

6. Statistical information on participants

- ***Age bracket:*** less than 29 yrs (5), 30-39 yrs (16), 40-49 yrs (5), more than 50 yrs (3).
- ***Countries of origin:*** France (7), Germany (1), Italy (7), Spain (3), Switzerland (3), United Kingdom (4), United States (5).
- ***Male/Female:*** Female (3), Male (27).