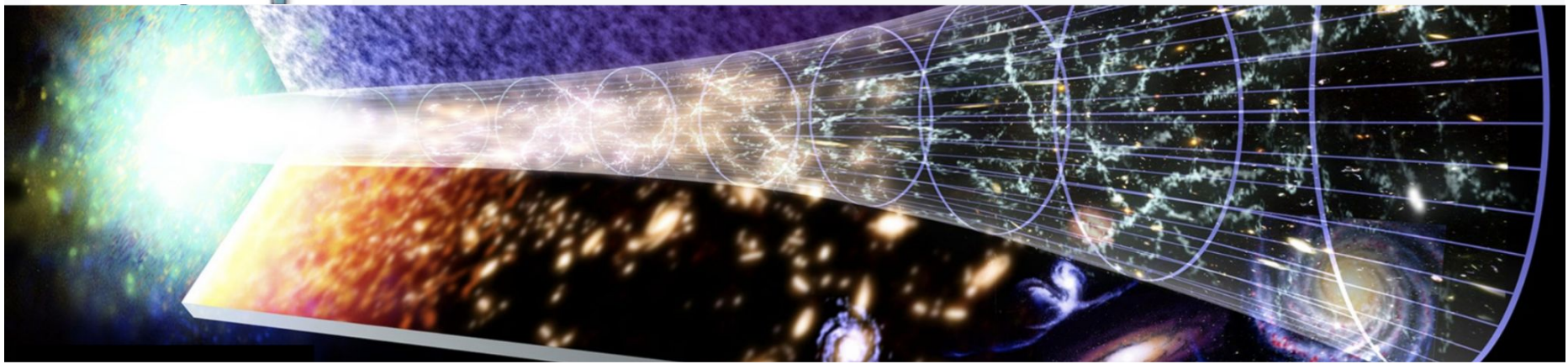




Cosmological Physics GDR



(* GDR="Groupement De Recherche"

ABOUT THE COPHY GDR

What is it ?

The Groupement De Recherche (GDR) CoPhy aims to bring together all actors working in the field of Cosmology in France, experimentalists, phenomenologists and theorists, and to provide opportunities for meetings and joint discussions. It will contribute to promote and give visibility to young researchers in the field.

CoPhy Science Drivers

Initial conditions and primordial Universe

Fundamental laws of the Universe

Matter and energy content of the Universe

Science Drivers



Initial conditions and primordial Universe

The Inflation paradigm has been introduced as a possible solution to the hot Big Bang model problems. The last results from the Planck collaboration show that there is no evidence for dynamics beyond slow roll, while slow-roll inflationary models for large fields are already ruled out. The remaining single-field models (including the simplest and well-motivated R+R² Starobinsky model) predict a tensor-to-scalar ratio of a few 10⁻³. That corresponds to the sensitivity target of the future CMB projects. But the quest for a better understanding of the early phases of the Universe requires to go far beyond this result.



Fundamental laws of the Universe

One of the key discoveries, at the turn of the century, has been the acceleration of the expansion of the Universe. Still, today, the underlying physical processes are yet to be understood. To go beyond the standard parameterisation through a cosmological constant or a fluid with a distinctive equation of state, one of the current hypotheses is the modification of General Relativity (GR) on cosmological scales. Such a modification could also solve the problem of the singularities inherent to GR as well as our inability to formulate a quantum version of GR.



Matter and energy content of the Universe

Cosmology gives insights on Dark Energy, but also on Dark Matter and neutrinos as different types of particles with different masses, interaction and decay properties do affect the power spectrum (or correlation function) at characteristic scales. This represents a unique opportunity to test the robustness of the Λ CDM model and look for new particles or fields beyond the high-energy (particle) physics standard model.

Science Drivers



Initial conditions and primordial Universe

The Inflation paradigm has been introduced as a possible solution to the hot Big Bang model problems. The last results from the Planck collaboration show that there is no evidence for dynamics beyond slow roll, while slow-roll inflationary models for large fields are already ruled out. The remaining single-field models (including the simple Starobinsky model) are still viable. The ratio of tensor to scalar perturbations is sensitive to the question of whether there were phases of inflation before this result.



Fundamental laws of the Universe

One of the key discoveries, at the turn of the 21st century, has been the acceleration of the expansion of the Universe. This discovery underlies...



Content of the Universe

...on Dark Energy, but neutrinos as different neutrino masses, neutrino oscillations do affect the evolution of the universe (through the neutrino energy density) at the present epoch. This presents a unique opportunity to test the nature of the Λ CDM model. The nature of dark matter or fields (including axions) presents a unique opportunity to test (particle) physics.



What physical conditions prevailed in the very early universe?

Can we test for the quantum origin of cosmological perturbations? What does it tell us about the nature of quantum mechanics in a gravitational context? Did the universe undergo a phase of contraction before expanding?

Science Drivers



Can General Relativity be extended to more general, internally consistent theories?

Could modified gravity account for the dark sector of cosmology (dark matter / dark energy)? Can it incorporate quantum gravity effects?



What physical conditions prevailed?

Can we test for the quantum origin of cosmological expansion? Can quantum mechanics in a gravitational context? Did the universe start expanding?



Initial conditions

The Inflationary paradigm has solved the horizon and flatness problems, but it has introduced new problems. Collaborative efforts are needed to understand the dynamical evolution of inflationary models. Many models have been ruled out. The remaining single-field models (including the simple Starobinsky model) are being tested. The ratio of tensor to scalar perturbations is a sensitive probe of the quantum origin of cosmological expansion. This is the question addressed in this result.

Structure of the Universe



Content of the Universe

Observations on Dark Energy, but also on neutrinos as different particles with different masses, and how these properties do affect the evolution of the universe. The Λ CDM model is the standard model of cosmology.

Science Drivers



Initial conditions

The Inflationary model solves the horizon and flatness problems. However, it leaves open questions about the initial conditions and the nature of the inflaton field. Collaborative efforts are needed to constrain the dynamics of inflationary models. The remaining single-field models (including the simple Starobinsky model) are being tested with increasing sensitivity. The question of the phases of inflation remains an open issue. This result...



Can General Relativity be extended to incorporate quantum gravity effects?

Could modified gravity account for the dark sector? Can we incorporate quantum gravity effects?



What physics drives the accelerated expansion of the universe?



What is the origin of the accelerated expansion of the universe?

Is it a cosmological constant, a dark fluid such as dark energy or another component? How does the nature of dark energy and dark matter affect the formation and evolution of cosmological structures?

Theories?

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The Universe

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CDM

Science Drivers



Initial conditions

The Inflationary paradigm solves the horizon and flatness problems, but it leaves open the question of the initial conditions. Collaborative efforts are needed to constrain the dynamical system of the inflaton field. Inflationary models are being tested by CMB observations. The remaining single-field models (including the simple Starobinsky model) are being tested by the ratio of tensor to scalar perturbations. The question of the phases of the inflaton field is being addressed by this result.



What physics?



What is the origin of the acceleration?

Is it a cosmological constant, a dark fluid, or a modification of gravity? Do energy and dark matter affect the formation of structure?



What is the nature of dark matter?

Does dark matter point towards the existence of new degrees of freedom beyond the standard model? Do they resort to supersymmetry, grand-unified theories, sterile neutrinos, axions, extra dimensions, compositeness etc? Are there interactions within the dark sector? Could primordial black holes account for (part of) the dark matter?

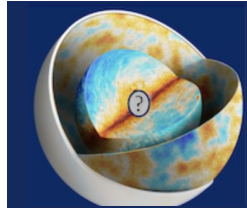
Dark matter in the universe?

How does the nature of dark matter affect the formation of structure? How does the nature of dark matter affect the evolution of the universe?

Theories?

Can it be tested?

Working Groups



Colloque national
CMB-France

TUG

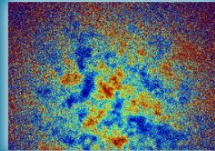
Main principles:

- * build on existing initiative
- * not reinvent the wheel
- * Enlarge the topics of the ADE Tools WG => a GDR WG



Dark Energy

The Dark Energy Working Group



CMB

The Cosmic Microwave Background Working Group



TUG

The Theory, Universe and Gravitation Working Group



Tools

The Tools and Methodology Working Group

+ add **Transverse Task Forces** based on the needs - to be discussed at the first meeting

GDR Coordination Team

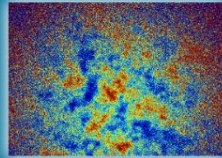
For a period of 4 years (starting Jan. 2023), the GDR is coordinated by Sophie Henrot-Versillé as director,
and Samuel Boissier and Vincent Vennin acting as deputy directors,
together with a steering committee composed of Working Groups coordinators



Dark Energy

The Dark Energy Working Group

Alain Blanchard
Philippe Brax
Pauline Zarrouk



CMB

The Cosmic Microwave Background Working Group

François Bouchet
Matthieu Tristram



TUG

The Theory, Universe and Gravitation Working Group

Vivian Poulin
Pasquale Serpico



Tools

The Tools and Methodology Working Group

Guilhem Lavaux
Yann Rasera

GDR Coordination Team

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**ENSURE AND STRENGTHEN
THE SCIENTIFIC
ANIMATION IN
COSMOLOGY IN FRANCE**

Alain Blanchard
Philippe Brax
Pauline Zarrouk



**IDENTIFY AREAS IN
WHICH NEW TASK FORCES
AND WGS SHOULD BE
CREATED**

François Bouchet
Matthieu Tristram



**PARTICIPATE IN ROADMAP
EXERCISES IF AND WHEN
REQUIRED**

Vivian Poulin
Pasquale Serpico



**COORDINATE WITH OTHER
RELATED GDR AND IRN**

Guilhem Lavaux
Yann Rasera

General Meetings

Coming *soon !!*

We are currently organising the first CoPhy GDR meeting..

It will take place in the Paris area

on the 17th, 18th and 19th of January 2023 !

You can find the agenda there:

[HTTPS://INDICO.IJCLAB.IN2P3.FR/EVENT/8881/](https://indico.ijclab.in2p3.fr/event/8881/)

*the agenda will be regularly updated
do not hesitate to visit it some time to time*

