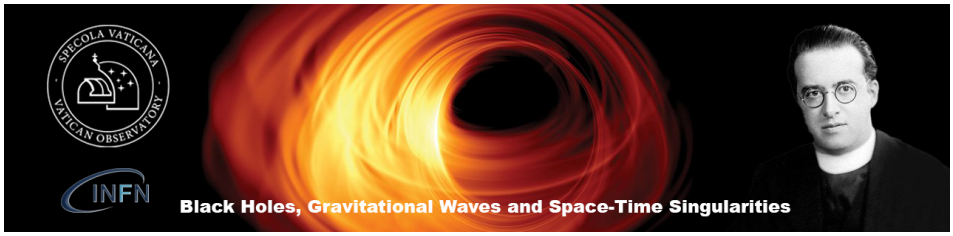
Lemaître Conference 2024



Report of Contributions

https://indico.global/e/13754

Contribution ID: **2** Type: **not specified**

Welcome & introduction

Monday 17 June 2024 09:00 (40 minutes)

Presenter: CONSOLMAGNO, Guy (Specola Vaticana)

Contribution ID: **3** Type: **not specified**

The Origin and Meaning of the Primeval Atom Hypothesis: how quantum physics meets Lemaître's cosmology

Monday 17 June 2024 09:40 (40 minutes)

The aim of the talk is to explain, with some historical details, where the concept of Lemaître's Primeval Atom Hypothesis (1931) came from. We will confront this Hypothesis with his studies (1933-1940) on the initial singularity (and the way to avoid it) and also on the Cosmological Constant, as well as on the Cosmic Rays. We will show how all these intuitions and studies are supported by Quantum Mechanical intuitions and interpretations. In fact, in the Thirties, Lemaître published several papers in connection with Quantum Theory : on Heisenberg Uncertainty Principle and on spinors (what we call now Majorana spinors) in the context of Eddington-Dirac Equation (with the hope to catch a unified fundamental theory). Lemaître was probably one of the very first physicists who suggested to search a link between quantum phenomena and gravitation aiming to understand the deep structure and history of the Universe.

Presenter: LAMBERT, Dominique (University of Namur)

Contribution ID: **4** Type: **not specified**

Quantum theory of the Lemaitre model for gravitational collapse

Monday 17 June 2024 10:20 (40 minutes)

In 1933, Georges Lemaître published a solution of Einstein's equation describing spherically symmetric dust clouds. This is nowadays often called the Lemaître-Tolman-Bondi (LTB) solution and used, in particular, to describing the gravitational collapse of a dust cloud. In my talk, I shall discuss the quantization of this model. A full theory of quantum gravity is not yet available, but insights into the quantum behaviour of dust collapse can come from concrete approaches - here, the direct canonical quantization of Einstein's theory is employed. I shall present the essentials of the formalism and focus on two main applications: Hawking radiation and singularity avoidance. I shall show that Hawking radiation can be recovered from the quantum wave functionals and that the classical singularity can be avoided in certain situations, replacing it by a bounce from collapse to expansion. In this way, Lemaître's old model continues to be fruitful for both fundamental physics and astrophysical applications.

Presenter: KIEFER, Claus (U)

Contribution ID: **5** Type: **not specified**

Again about singularity crossing in gravitation and cosmology

Monday 17 June 2024 11:30 (40 minutes)

We discuss the problem of singularity crossing in isotropic and anisotropic universes. We study the conditions on the disappearance of singularities in quantum cosmology and the behaviour of quantum particles in the vicinity of singularities. Some and attempts to develop general approach to the connection between the field reparametrization and the elimination of singularities will be presented as well.

Presenter: KAMENSHCHIK, Alexander

Contribution ID: **6** Type: **not specified**

Classical Gravity Contains Quantum Mechanics

Monday 17 June 2024 12:10 (40 minutes)

Our search for a quantum theory of gravity is aided by a unique and perplexing feature of the classical theory: General Relativity already "knows"about its own quantum states (the entropy of a black hole), and about those of all matter (via the covariant entropy bound). The results we are able to extract from classical gravity are inherently nonperturbative and increasingly sophisticated. Recent breakthroughs include a derivation of the entropy of Hawking radiation, a computation of the exact integer number of states of some black holes, and the construction of gravitational holograms in our universe using techniques from single-shot quantum communication protocols.

Presenter: BOUSSO, Raphael (University of California, Berkeley)

Contribution ID: **7** Type: **not specified**

The Enigmatic gravitational partition function.

Monday 17 June 2024 15:00 (40 minutes)

Gibbons and Hawking's gravitational partition function remains enigmatic, despite nearly 50 years and much evidence that it indeed counts quantum states. I will discuss steps toward a better understanding of the topology of the paths, the (initially Lorentzian) contour of integration, the counted states, and why a semiclassical treatment can capture that count.

Presenter: JACOBSON, Theodore (University of Maryland)

Contribution ID: **8** Type: **not specified**

Mapping the road from the Planckian end

Monday 17 June 2024 15:40 (40 minutes)

Where may genuinely new insights on the origin of our universe still come from today? Is there an unexplored part of theory space not beset by countless ambiguities, free parameters or ad-hoc assumptions? I will argue that this place is full, nonperturbative quantum gravity based on the gravitational path integral. It requires geometry beyond Riemann, but sticks with the fundamental tenets of quantum field theory. Its key computational tool is lattice quantum gravity, the gravitational analogue of lattice QCD, in its modern formulation of causal dynamical triangulations. It has allowed us to measure diffeomorphism-invariant observables and uncover universal properties of gravity at the Planck scale, which often run counter to semiclassical intuition. Among them is the remarkable dynamical emergence of a quantum universe with de Sitter-like properties from pure 'quantum foam'. Recent progress on nonperturbative two-point functions opens the exciting prospect of deriving predictions for the early quantum universe from first principles.

Presenter: LOLL, Renate (Radboud University Nijmegen)

Contribution ID: **9** Type: **not specified**

Present status of inflationary cosmology

Wednesday 19 June 2024 09:40 (40 minutes)

I will briefly describe the basic principles of inflationary theory, and then I will discuss a set of simple inflationary models, such as Starobinsky model, Higgs inflation and alpha-attractors, which can describe all presently existing inflation-related observational data using no more than one or two parameters. Generalized versions of these models may also describe dark energy and production of primordial black holes.

Presenter: LINDE, Andrei

Contribution ID: **10** Type: **not specified**

Evening discussion

Monday 17 June 2024 17:30 (1 hour)

Contribution ID: **11** Type: **not specified**

Public Lecture (IN ITALIAN)

Seminario di Albano Laziale
Piazza S. Paolo, 5, 00041 Albano Laziale

https://maps.app.goo.gl/bxmSJh7SbSmqgisdA

Contribution ID: **12** Type: **not specified**

Event in the Vatican

Thursday 20 June 2024 06:15 (4 hours)

Contribution ID: **13** Type: **not specified**

Public Lecture (IN ITALIAN)

Friday 21 June 2024 21:00 (1h 30m)

Contribution ID: **14** Type: **not specified**

The scale(s) of quantum gravity and integrable black holes

Monday 17 June 2024 16:50 (40 minutes)

It is often assumed that quantum gravity belongs at the Planck scale, but a possibly much larger size for the ground state emerges in the (non-perturbative) quantisation of the Oppenheimer-Snyder model of dust collapse that naturally hints at Bekenstein's area law. The effective geometry for such quantum black holes can then be obtained which describe integrable singularities without inner horizons.

Presenter: Prof. CASADIO, Roberto (Bologna University)

Contribution ID: **15** Type: **not specified**

LCDM: the road ahead

Tuesday 18 June 2024 09:00 (40 minutes)

LCDM is the most expansive and most successful cosmological paradigm yet. It is supported by a wealth of precision data and observations, with many successes to its credit. However, it is incomplete: what is the nature of dark energy and the identity of the dark matter particle?; absence of a first principles model for inflation with supporting evidence, and firm ideas about the pre-inflationary era. A deluge of precision observations, coming from many directions, e.g., DES and DESI; the CMB; the Hubble tension; the LHC and dark matter searches; JWST and even more to come, are poking at it from many different directions, looking for cracks, hints and surprises. In this talk, I will try to make sense of it all.

Presenter: TURNER, Michael (University of Chicago)

Contribution ID: **16** Type: **not specified**

The Future of Cosmology

Tuesday 18 June 2024 09:40 (40 minutes)

Remarkable progress has been made in precision cosmology since the pioneering choices laid out a century ago by Lemaitre, yet we are currently at a turning point. Experiments have become so large and expensive that we need to prioritize where to go next for compelling and guaranteed science return that is significantly beyond current limits in cosmology. The lunar surface allows a unique way forward. The far side provides a unique radio-quiet environment for exploring the ultimate frontier in observational surveys of the Universe, the dark ages, via 21 cm interferometry and to seek elusive clues on the nature of cosmic inflation. Permanently cold and dark polar craters will provide potential sites for far infrared telescopes that will use the spectrum of the cosmic microwave background radiation to probe our cosmic origins in the first months of cosmic time. Optical and infrared interferometers operating at unprecedented resolution and sensitivity will address profound questions currently being raised about the most distant galaxies and massive black holes, and explore biological tracers in large numbers of exoplanet atmospheres in order to pose the ultimate question of whether we are alone in the Universe.

Presenter: SILK, Joseph (Paris, Inst. Astrophys. and Johns Hopkins U. and Oxford U.)

Contribution ID: **17** Type: **not specified**

Lemaitre: getting Hubble into troubles a century later

Tuesday 18 June 2024 10:50 (40 minutes)

The Hubble-Lemaitre parameter not only relates redshifts to distances in the nearby Universe, it is also a key parameter of the standard cosmological model. H0 affects several physical processes, different cosmic epochs and multiple observables. There are more than a dozen ways to measure H0, which with few exceptions, yield values that gather around two "camps" which do not agree with each other at high statistical significance (this is referred to as "Hubble Tension"). There are three options to "fix" the Hubble Tension. Beside systematics in the data analysis, it's either a modification of the standard cosmological model at early times or a global modification touching the model's fundamental assumptions, which would really imply Hubble troubles! None of there tree options has the consensus of the community.

Presenter: VERDE, Licia

Contribution ID: **18** Type: **not specified**

The Hubble Tension: New Results from JWST

Tuesday 18 June 2024 11:30 (40 minutes)

I will describe new results from a major JWST program to improve measurements of the Hubble constant. The 10 times greater sensitivity and 4 times higher resolution of JWST in the near-infrared provide a powerful means of addressing challenges in previous measurements of the extragalactic distance scale. Distances to a sample of Type Ia supernova hosts have been measured using three independent astrophysical routes: 1) the Cepheid period-luminosity relation, 2) the Tip of the Red Giant Branch (TRGB) and 3) the luminosity function of JAGB/carbon stars. These three measurements provide a constraint on the systematic uncertainties in the distances that set the local calibration for the Hubble constant. As part of our analysis, our JWST photometry was blinded by adding random numbers to each of the photometric catalogs. The analysis was carried out in this blinded state until the relative distances were locked in, at which point the photometry was unblinded simultaneously for all three methods, and a value of Ho for each of the methods was computed. The implications for the Hubble tension will be presented.

Presenter: FREEDMAN, Wendy (University of Chicago)

Contribution ID: **19** Type: **not specified**

Cosmology with gravitational-wave observations

Tuesday 18 June 2024 12:10 (40 minutes)

Brady will describe the current state of ground-based, gravitational-wave astronomy and the prospects for the future. He will present highlights from LIGO-Virgo-KAGRA observations with an emphasis on their cosmological implications. Gravitational waves from black-hole-binary mergers are now being detected about twice per week and astronomers are eagerly awaiting the next multi-messenger event. Over the next decade, a sequence of upgrades will more than double the amplitude sensitivity of the most sensitive gravitational-wave detectors and increase the rate of compact binary detections by about a factor of ten. Brady will discuss the impact of these improvements on cosmological measurements. The talk will end with a discussion of future directions for ground-based gravitational-wave astronomy.

Presenter: BRADY, Patrick

Contribution ID: **20** Type: **not specified**

Postquantum stochastic semiclassical gravity: world without Schrödinger cats

Friday 21 June 2024 15:00 (40 minutes)

Unified theory of space-time with quantized matter and the physics of quantum measurement were considered unrelated for long time, studied by two separate research communities. Quantum cosmologists have always been part of main stream physics, using heavy artillery of mathematics. Quantum measurement problem solvers, with the speaker among them, used light weapons and sometimes whimsical identification of their problems, e.g. in terms of the Schrödinger cat paradox. The bottle-neck of quantum gravity may be this paradox, not cosmologists' failure in finding the ultimate framework of quantization. A solution of quantum gravity problem might be built on the non-relativistic theory of spontaneous wavefunction collapse, eliminating Schrödinger cat states. Such "postquantum" theory is captivating conceptionally, exists formally, but its general - even Lorentzian - covariance could hit a wall.

Presenter: DIOSI, Lajos (Wigner Research Centre for Physics)

Contribution ID: **21** Type: **not specified**

Addressing the so-called quantum/classical "divide" in gravitational contexts, and its implications in cosmology

Tuesday 18 June 2024 15:40 (40 minutes)

We will discuss aspects of the gravity/quantum interphase and the type approaches that can be adopted in its exploration. In so doing we will be forced to consider conceptual difficulties in quantum theory which reveal a fundamental difficulty that must be faced in that pursuit. We will present a path designed to overcome them, and explore some of its implications for cosmology, including the emergence of the seeds of cosmic structure, the expectations about primordial gravity waves, and the concerns about eternal inflation.

Presenter: SUDARSKY, Daniel (Universidad Nacional Autonoma de Mexico)

Contribution ID: **22** Type: **not specified**

The Big Bang and its Dark-Matter Content: Whence, Whither and Wherefore—Part 2

Tuesday 18 June 2024 16:50 (40 minutes)

Presenter: PENROSE, Roger (Mathematical Institute, Oxford)

Contribution ID: **23** Type: **not specified**

Evening discussion

Tuesday 18 June 2024 17:30 (1 hour)

Contribution ID: **24** Type: **not specified**

Evening discussion

Wednesday 19 June 2024 17:30 (1 hour)

Contribution ID: **25** Type: **not specified**

Primordial black holes and gravitational waves from inflation

Wednesday 19 June 2024 09:00 (40 minutes)

Thanks to the rapid progress in gravitational wave astronomy/cosmology, primordial black holes (PBHs) have become one of the hot topics in cosmology. It has made projections of detecting signatures of PBHs feasible. In parallel, it has become clear that there exist a number of ways to produce PBHs from inflation. In this talk, I'll review the PBH formation from inflation and the associated gravitational wave signatures.

Presenter: SASAKI, Misao

Contribution ID: **26** Type: **not specified**

Memory Burden Effect in Black Holes and in de Sitter

Wednesday 19 June 2024 10:50 (40 minutes)

We discuss implications of an universal phenomenon of "memory burden", which implies that information carried by a system tends to stabilize it. The effect is maximally prominent in objects of high microstate degeneracy. We discuss implications of this effect for black holes and for de Sitter cosmology. The memory burden effect leads to a slow-down of black hole decay, the latest by the time it emits about half of the initial mass. This opens up a new window for light primordial black hole dark matter. In de Sitter, the memory burden effect leads to quantum breaking, which has profound implications both for inflation as well as for dark energy. In particular, it excludes the cosmological constant from the energy budget of our Universe.

Presenter: DVALI, Gia

Contribution ID: **27** Type: **not specified**

Sharp Bounds on the Landscape

Wednesday 19 June 2024 11:30 (40 minutes)

Recently, it has become increasingly clear that there are constraints on the low-energy effective theories of quantum gravity that cannot be captured by the standard Wilsonian paradigm. For gravitational theories in asymptotically anti-de Sitter spacetimes, we can formulate such constraints and aim to prove or falsify them using the AdS/CFT correspondence. I will review recent progress in this approach and present my proof with Yifan Wang of a part of the Distance Conjecture that I proposed with Cumrun Vafa in 2006. In three spacetime dimensions, we proved that the emergence of an infinite tower of exponentially light particles is inevitable when a moduli field rolls beyond the Planck scale.

Presenter: OGURI, Hiroshi

Contribution ID: **28** Type: **not specified**

On the Fate of Our Universe

Wednesday 19 June 2024 12:10 (40 minutes)

Motivated by principles of quantum gravity learned from string theory, we contemplate on the fate of our universe. In particular we explain why the dark energy is expected to decay and with it the Universe will undergo a transition to a new state, which is expected to take place not too far in the future.

Presenter: VAFA, Cumrun (Harvard University)

Contribution ID: **29** Type: **not specified**

Primeval Atom 2.0

Wednesday 19 June 2024 15:00 (40 minutes)

Georges Lemaître saw in the quantum birth of the universe also an epistemic horizon, a notion he somewhat poetically expressed in his primeval atom hypothesis. In this he differed from both Einstein and Eddington, and from present-day proponents of the multiverse. I present a novel holographic version of the Hartle-Hawking no-boundary proposal for the origin of the universe and I argue that this is in fact in line with Lemaître's intuition. This new no-boundary proposal is much like a Primeval Atom 2.0 and I briefly discuss its theoretical, phenomenological and philosophical implications.

Presenter: HERTOG, Thomas (KULeuven)

Contribution ID: **30** Type: **not specified**

LIGO is Quantum

Wednesday 19 June 2024 15:40 (40 minutes)

Is there a quantum to classical transition in physics somewhere between the microscopic to macroscopic? What is microscopic and macroscopic? Assuming we model macroscopid as the mass of size of the system, and using techniques I suggested in the early 80's, it is now known that the Ligo mirrors (40Kg, .5 m in size) center of mass motion is quantum. This talks will take us through simple model system for Ligo to pinpoint how the recent work has shown this.

Presenter: UNRUH, William (University of British Columbia)

Contribution ID: **31** Type: **not specified**

Gravitational Waves: the Theorist's Swiss knife

Wednesday 19 June 2024 16:50 (40 minutes)

I will first review how gravitational waves (transients or searches for a gravitational-wave background) are used to constrain particle physics models beyond the Standard Model, early Universe cosmological scenario, or dark matter candidates. I will then discuss the angular power spectrum of gravitational-wave transient sources as a probe of the large-scale structure.

Presenter: SAKELLARIADOU, Maria

Contribution ID: **32** Type: **not specified**

A Background Independent Algebra for Gravity

Friday 21 June 2024 09:00 (40 minutes)

I consider the algebra of observables along the worldline of an observer as a background independent algebra in the context of quantum gravity or cosmology.

Presenter: WITTEN, Edward (Department of Physics-Princeton University-Unknown)

Contribution ID: **33** Type: **not specified**

Recent progress in classical string cosmology

Friday 21 June 2024 09:40 (40 minutes)

The equations of classical (i.e. tree-level) string cosmology in $(d+1)$-dimensional spacetimes with d abelian isometries are well known to be invariant under an O(d,d;R) group of transformations acting on the metric, dilaton and antisymmetric-tensor fields. This symmetry has recently allowed for an all-order classification of higher-derivative (α') corrections by Hohm and Zwiebach. Using a hamiltonian reformulation of their work, I will specify generic conditions under which the solutions provide a regular bouncing cosmology (in contrast to the singular solutions of the lowest order equations) and discuss some of their most interesting properties. Time permitting, I will also mention an ongoing attempt to extend this framework to the collision of plane-symmetric gravi-dilatonic waves whose lowest-order equations are known, since the 70's, to lead inevitably to focussing singularities of the big-crunch type.

Presenter: VENEZIANO, Gabriele

Contribution ID: **34** Type: **not specified**

Recent progress on inflation and dark energy from string theory

Friday 21 June 2024 10:50 (40 minutes)

I will discuss recent progress in constructing models of inflation and dark energy from string theory which are theoretically robust, can fit current data and can lead to observable predictions. I will mention 3 possibilities for the inflaton field: a Kaehler modulus, an axion and a brane modulus. I will also argue that axions are the best candidates to drive dark energy.

Presenter: CICOLI, Michele (Università di Bologna)

Contribution ID: **35** Type: **not specified**

Black Hole Binary Dynamics and Radiation from Classical and Quantum Gravitational Scattering

Friday 21 June 2024 11:30 (40 minutes)

Gravitational wave signals from coalescing binary black holes are detected, and analyzed, by using large banks of template waveforms. The construction of these templates makes an essential use of the analytical knowledge of the motion and radiation of gravitationally interacting binary systems. A new angle of attack on gravitational dynamics consists of considering (classical or quantum) scattering states. Modern quantum amplitude techniques have recently given interesting novel results concerning both the dynamics and the gravitational wave emission of scattering black holes. These results are reaching a level where subtle conceptual issues arise (quantum-classical transition, radiative effects versus conservative dynamics, zero-frequency gravitons, epsilon/epsilon effects,⋯).

Presenter: DAMOUR, Thibault (nstitut des Hautes Etudes Scientifiques)

Contribution ID: **36** Type: **not specified**

Tidal interactions in binary inspirals

Friday 21 June 2024 12:10 (40 minutes)

One of the most exciting prospects of gravitational-wave astronomy is to measure the tidal deformability of neutron stars and convert these measurements into constraints on the equation of state of nuclear matter at very high densities. I describe the ongoing effort by many researchers to model the tidal interactions between compact bodies in binary inspirals, which involves the strong self-gravity of each body and the weak mutual gravity of the binary system. The interaction includes the regime of dynamical tides, in which the external, orbital timescale becomes comparable to each body's internal, hydrodynamical timescale. I conclude with a discussion of black holes and their vanishing Love numbers.

Presenter: POISSON, Eric (University of Guelph)

Contribution ID: **37** Type: **not specified**

JWST Weighs in on the Hubble Tension

Tuesday 18 June 2024 15:00 (40 minutes)

We present high-definition observations with the James Webb Space Telescope of Cepheid variables used to calibrate the luminosity of Type Ia Supernovae and the Hubble constant. The superior resolution of JWST negates crowding noise, the largest source of variance in the NIR Cepheid Period-Luminosity relations (Leavitt laws) measured with HST. Together with the use of two-epochs to constrain Cepheid phases and three filters to remove reddening, we reduce the dispersion in the Cepheid PL relations by a factor of 2.5. We find no significant difference in the mean distance measurements determined from HST and JWST, with a formal difference of -0.01 +/- 0.03 mag. This result is independent of zeropoints and analysis variants including metallicity dependence, local crowding, choice of filters, and slope of the relations. We can reject the hypothesis of unrecognized crowding of Cepheid photometry from HST that grows with distance as the cause of the "Hubble Tension" at 8.2 sigma, i.e., greater confidence than that of the Hubble Tension itself. We conclude that errors in Cepheid measurements across the distance ladder are not the source of the decade-long Hubble Tension.

Presenter: RIESS, Adam (John Hopkins University)

Contribution ID: **38** Type: **not specified**

Evening discussion

Friday 21 June 2024 15:40 (40 minutes)

Presenter: CICOLI, Michele (Università di Bologna)