New Horizons in Primordial Black Hole physics (NEHOP)

Report of Contributions

Contribution ID: **1** Type: **Talk**

Primordial Extremal Black Holes

Wednesday, June 21, 2023 4:40 PM (20 minutes)

We show that primordial near-extremal charged black holes with a wide range of masses from the Planck scale to around 10^9 grams could be cosmologically stable and provide a viable explanation for dark matter. The near-extremal charged black holes can carry either the Standard Model magnetic charges or other dark gauge charges. Several observational methods including the merger events of binary systems are proposed to observe these black holes. A theoretic calculation for the charged black hole late-time evolution using Ads_2/CFT_1 will also presented.

Primary author: BAI, Yang (University of Wisconsin-Madison)

Presenter: BAI, Yang (University of Wisconsin-Madison)

Session Classification: Session 12

Contribution ID: **2** Type: **Talk**

Lattice simulations of axion inflation

Monday, June 19, 2023 3:20 PM (20 minutes)

If gauge fields are coupled to an axion field during inflation they can lead to unique observational signatures, such as primordial black holes and chiral gravitational waves. However, this system often shows strong backreaction effects, invalidating the standard perturbation theory approach. In this talk, I present the first nonlinear lattice simulation of an axion-U(1) system during inflation. We find that non-Gaussianity is large in the linear regime, whereas it is suppressed when the dynamics becomes nonlinear. This relaxes previous bounds from overproduction of primordial black holes, allowing for an observable gravitational waves signal at interferometer scales. Our work establishes lattice simulations as a crucial tool to study the inflationary epoch and its predictions.

Primary author: CARAVANO, Angelo (LMU Munich)

Presenter: CARAVANO, Angelo (LMU Munich)

Session Classification: Session 3

Contribution ID: **5** Type: **Talk**

Primordial black holes and particle dark matter are intimately intertwined

Tuesday, June 20, 2023 10:00 AM (20 minutes)

We explore the possibility to detect dark matter (DM) in the form of a new weakly interacting massive particle (WIMP) from its interaction in the dense environment around a primordial black hole (PBH). We constrain the abundance of PBHs from the gamma-ray flux expected by the annihilation of WIMPs gravitationally bound to PBHs. We derive analytically the DM profile around the PBH, forming a characteristic power-law profile. Based on 2011.01930; 2008.08077

Primary author: VISINELLI, Luca (Shanghai Jiao Tong University)

Co-authors: Prof. CARR, Bernard (Queen Mary University of London); Dr KÜHNEL, Florian

Presenter: VISINELLI, Luca (Shanghai Jiao Tong University)

Session Classification: Session 5

Contribution ID: **6** Type: **Talk**

Gravitational wave signatures from magnetised supermassive primordial black holes

Wednesday, June 21, 2023 3:20 PM (20 minutes)

Primordial black holes (PBH) can account for a wide variety of cosmic conundra, among which the origin of primordial magnetic fields. In this talk, we consider supermassive PBHs furnished with a disk due to the vortexlike motion of the primordial plasma around them at the epoch of their formation, proposing at the end a novel natural ab initio mechanism for the generation of a battery induced seed magnetic field (MF) which can be later amplified by various dynamo/instability processes and provide the seed for the present day MF on intergalactic scales. Then, we derive the gravitational-wave (GW) signal induced by the magnetic anisotropic stress of such a population of magnetised PBHs, checking its detectability by future GW detectors. Finally, by avoiding GW overproduction we set upper bound constraints on the abundances of supermassive PBHs $\Omega_{\rm PBH}$ as a function of their mass, which are comparable with constraints on $\Omega_{\rm PBH}$ from large-scale structure probes; hence promoting the portal of GWs incuded by magnetised PBHs as a new probe to explore the enigmatic nature of supermassive PBHs.

Primary author: Dr PAPANIKOLAOU, Theodoros (National Observatory of Athens)

Presenter: Dr PAPANIKOLAOU, Theodoros (National Observatory of Athens)

Session Classification: Session 11

Contribution ID: **8** Type: **Talk**

PBH-infused seesaw origin of matter and unique gravitational waves

Wednesday, June 21, 2023 2:40 PM (20 minutes)

The Standard Model, extended with three right-handed (RH) neutrinos, is the simplest model that can explain light neutrino masses, the baryon asymmetry of the Universe, and dark matter (DM). Models in which RH neutrinos are light are generally easier to test in experiments. In this work, we show that even if the RH neutrinos are super-heavy (Mi=1,2,3 > 10^9 GeV)—close to the Grand Unification scale—the model can be tested thanks to its distinct features on the stochastic Gravitational Wave (GW) background. We consider an early Universe filled with ultralight primordial black holes (PBH) that produce a super-heavy RH neutrino DM via Hawking radiation. The other pair of RH neutrinos generates the baryon asymmetry via thermal leptogenesis, much before the PBHs evaporate. GW interferometers can test this novel spectrum of masses thanks to the GWs induced by the PBH density fluctuations. In a more refined version, wherein a U(1) gauge symmetry breaking dynamically generates the seesaw scale, the PBHs also cause observable spectral distortions on the GWs from the U(1)-breaking cosmic strings. Thence, a low-frequency GW feature related to DM genesis and detectable with a pulsar-timing array must correspond to a mid- or high-frequency GW signature related to baryogenesis at interferometer scales. I will also briefly discuss possible extensions of this setup to QCD-axion physics and the study of cosmic X-ray background in the presence of cosmic magnetic field.

Primary author: SAMANTA, Rome (CEICO, Institute of Physics, Prague)

Presenter: SAMANTA, Rome (CEICO, Institute of Physics, Prague)

Session Classification: Session 11

Contribution ID: **11** Type: **Highlight talk**

PBH formation during preheating

Tuesday, June 20, 2023 3:50 PM (10 minutes)

We examined the production of large curvature perturbations that may lead to PBH formation in the early universe, in particular during preheating. At this stage, large non-linear dynamics lead to the exponential amplification of field perturbations that can ultimately collapse into a black hole or form semi-stable configurations such as oscillons (DM candiate). The details of this phenomenon are directly linked to the features of the inflaton potential and type of inflation. We aim at easing the apparent confusion in the community regarding this issue and provide a consistent view of the conditions that actually lead to PBH formation. Many promising avenues follow from the previous approach, for instance the fate of single oscillons, the evolution of clusters of oscillons or the formation of PBHs in multi-field inflation scenarios to name a few, all of them reserch directions that might be important for the PBH community. This is a work in collaboration with Guillermo Ballesteros (IFT), Marco Taoso (INFN) and Pasquale Serpico (LAPTh/CNRS).

Primary author: IGUAZ JUAN, Joaquim (LAPTh/CNRS)

Co-authors: Mr BALLESTEROS, Guillermo (IFT); Dr TAOSO, Marco (INFN); Dr SERPICO, Pasquale (LAPTh/CNRS)

Presenter: IGUAZ JUAN, Joaquim (LAPTh/CNRS)

Session Classification: Session 7

Contribution ID: **12** Type: **Talk**

Leptogenesis looking into the abyss: The effects of Primordial Black Hole evaporation

Tuesday, June 20, 2023 12:20 PM (20 minutes)

Black Hole evaporation offers a unique particle production method unlike any other interaction process. In the Early Universe, such evaporation can affect the baryon asymmetry produced via leptogenesis since heavy right-handed neutrinos can be emitted independently of the properties of the primordial plasma. However, there is also a large amount of entropy injected, which could dilute the generated asymmetry. We will explore in detail this interplay between Primordial Black Holes and Leptogenesis, determining the regions of the parameter space where the evaporation increases or erases the asymmetry.

Primary author: PEREZ, Yuber

Presenter: PEREZ, Yuber

Session Classification: Session 6

Contribution ID: **13** Type: **Highlight talk**

Primordial black holes and gravitational waves induced by exponential-tailed perturbations

Wednesday, June 21, 2023 3:40 PM (10 minutes)

PBHs whose masses are in $\sim [10^{-15}M_\odot, 10^{-11}M_\odot]$ have been extensively studied as a candidate for the whole DM. One of the promising probes to test such a PBH-DM scenario is scalar-induced stochastic GWs accompanied by enhanced primordial fluctuations to form the PBHs with frequency peaked in the mHz band being targeted by the LISA mission.
In order to utilize the stochastic GWs for checking the PBH-DM scenario, it is necessary to exactly relate the PBH abundance and the amplitude of the GWs spectrum.
Recently in Kitajima et al, the impact of the non-Gaussianity of the enhanced primordial curvature perturbations on the PBH abundance has been investigated based on the peak theory, and they found that a specific non-Gaussian feature called the exponential tail significantly increases the PBH abundance compared with the Gaussian case. This means that the amplitude of the GWs spectrum would be reduced.
Then, in this work, we investigate the spectrum of the induced stochastic GWs associated with the PBH-DM scenario in the exponential-tail case.
In order to take into account the non-Gaussianity properly, we employ the diagrammatic approach for the calculation of the spectrum.
We find that the amplitude of the stochastic GW spectrum is slightly lower than the one for the Gaussian case, but it can still be detectable with the LISA sensitivity.
We also find that the non-Gaussian contribution can appear on the high-frequency side through their complicated momentum configurations.
Although this feature emerges under the LISA sensitivity, obtaining information about the non-Gaussianity from GW observation with a deeper sensitivity such as the DECIGO mission might be possible.

Primary authors: Dr ABE, Katsuya (Nagoya University); INUI, Ryoto (Nagoya University); Mr YOKOYAMA, Shuichiro (Nagoya University (KMI)); Mr TADA, Yuichiro (Nagoya University (IAR))

Presenter: INUI, Ryoto (Nagoya University)

Session Classification: Session 11

Contribution ID: **15** Type: **Talk**

Statistics of coarse-grained cosmological fields in stochastic inflation

Monday, June 19, 2023 12:00 PM (20 minutes)

We present a generic framework to compute the one-point statistics of cosmological perturbations, when coarse-grained at an arbitrary scale R, in the presence of quantum diffusion. Making use of the stochastic-δN formalism, we show how it can be related to the statistics of the amount of expansion realised until the scale R crosses out the Hubble radius. This leads us to explicit formulae for the probability density function (PDF) of the curvature perturbation, the comoving density contrast, and the compaction function. We then apply our formalism to the calculation of the mass distribution of primordial black holes produced in a single-field model containing a "quantum well" (i.e. an exactly flat region in the potential). We confirm that the PDFs feature heavy, exponential tails, with an additional cubic suppression in the case of the curvature perturbation. The large-mass end of the mass distribution is shown to be mostly driven by stochastic-contamination effects, which produce black holes more massive than those naively expected. This work bridges the final gap between the stochastic-inflation formalism and the calculation of the mass distribution of astrophysical objects such as primordial black holes and opens up various prospects that we finally discuss.

Primary authors: Dr VENNIN, Vincent (LPENS Paris); TADA, Yuichiro (Nagoya University)

Presenter: TADA, Yuichiro (Nagoya University)

Session Classification: Session 2

Contribution ID: **16** Type: **Talk**

Dark Matter production from evaporating black holes

Tuesday, June 20, 2023 12:00 PM (20 minutes)

Hawking evaporation of black holes is expected to copiously produce all kinds of particles, regardless of their charges. In this talk, I will discuss how Hawking evaporation provides an efficient way of creating dark matter by way of gravity only. I will then explore the interplay between Primordial Black Hole production and interacting dark matter and their potential incompatibilities. Particularly I will focus on Freeze-in dark matter models. I will discuss the public code I co-developed called FRISBHEE, which solves the system of coupled Friedmann-Boltzmann equations. This talk will be based on Phys.Rev.D 105 (2022) 1, 015022, Phys.Rev.D 105 (2022) 1, 015023, Phys.Rev.D 106 (2022) 10, 103012 and arXiv:2212.0387.

Primary author: Dr CHEEK, Andrew (Astrocent, NCAC)

Presenter: Dr CHEEK, Andrew (Astrocent, NCAC)

Session Classification: Session 6

Contribution ID: **17** Type: **Talk**

Primordial black holes from confinement

Tuesday, June 20, 2023 3:20 PM (20 minutes)

In this talk I will present a novel mechanism for the formation of primordial black holes. Here, heavy quarks of a confining gauge theory produced by de Sitter fluctuations are diluted by inflation and get confined after horizon re-entry. The large amount of energy stored in the color flux tubes connecting the quark pair leads to black-hole formation. After discussing the confinement dynamics, I will focus on the phenomenological features of the new mechanism and show it can account for both the entirety of dark matter and the supermassive black holes in the galactic centers. Under proper conditions, the scenario can be realized in a generic confining theory, including ordinary QCD. Moreover, highly-spinning sub-solar black holes can be easily produced.

Primary author: ZANTEDESCHI, Michael

Presenter: ZANTEDESCHI, Michael

Session Classification: Session 7

Contribution ID: **18** Type: **Talk**

Signatures of primordial black hole dark matter at DUNE and THEIA

Wednesday, June 21, 2023 10:00 AM (20 minutes)

Primordial black holes (PBHs) are a potential dark matter candidate whose masses can span over many orders of magnitude. If they have masses in the 10^15 – 10^17 g range, they can emit sizeable fluxes of MeV neutrinos through evaporation via Hawking radiation. We explore the possibility of detecting light (non-)rotating PBHs with future neutrino experiments DUNE and THEIA. We will show that they will be able to set competitive constraints on PBH dark matter, thus providing complementary probes in a part of the PBH parameter space currently constrained mainly by photon data.

Primary author: DE ROMERI, Valentina

Presenter: DE ROMERI, Valentina

Session Classification: Session 9

Contribution ID: **19** Type: **Talk**

Lyman-α constraints on the primordial black hole dark matter

Wednesday, June 21, 2023 12:20 PM (20 minutes)

Primordial black holes are one of the most well-motivated dark matter candidates and it is important to devise new search strategies for them. Low-mass PBHs (masses between ~ 10^{15} g to 10^{18} g) can be detected via their Hawking radiation. Evaporating PBHs inject energy into the intergalactic medium (IGM), which can significantly alter the thermal and ionization history of the Universe. At the low redshifts, measurements of the Lyman-α forest informs us about the temperature of IGM. In this work, we use these measurements to derive new constraints on the PBH abundance as the dark matter for both the non-spinning and spinning black holes.

Primary author: PARASHARI, Priyank (Indian Institute of Science, Bengaluru)

Presenter: PARASHARI, Priyank (Indian Institute of Science, Bengaluru)

Session Classification: Session 10

Contribution ID: **20** Type: **Talk**

Primordial black holes and how to (not over-) produce them

Monday, June 19, 2023 11:40 AM (20 minutes)

The simplest way to produce primordial black holes is via the collapse of large overdense regions in the early universe. However, a boost of the primordial perturbations requires very specific dynamics in single-field inflation, and both the amplitude of perturbations and the resulting abundance of primordial black holes are extremely sensitive to the parameters of the inflationary model. I will show how this can be seen as an opportunity for learning about the early universe, as well as a drawback for the motivation of primordial black holes from single-field inflation.

Primary author: COLE, Pippa

Presenter: COLE, Pippa

Session Classification: Session 2

Contribution ID: **21** Type: **Highlight talk**

Lattice simulation of stochastic inflation

Monday, June 19, 2023 4:40 PM (10 minutes)

The primordial black hole (PBH), a hypothetical rare object, is one of the candidates for dark matter. This is made by the gravitational collapse of the region of large curvature perturbation. Though one often adopts the perturbation theory for the growth of the fluctuation, it may fail in the case of large perturbation associated with PBHs. This problem is resolved by the non-perturbative approach called stochastic formalism. We focus on the accurate growth of initial density fluctuation with numerical lattice simulation in this formalism. We reduce the number of runs and efficiently focus on large perturbations by the technique of importance sampling. We successfully got the real-space map of large curvature perturbation, which is helpful to accurately discuss the PBH formation.

Primary authors: TADA, Yuichiro (Nagoya University (IAR)); Ms MIZUGUCHI, Yurino (Nagoya University)

Presenter: Ms MIZUGUCHI, Yurino (Nagoya University)

Session Classification: Session 4

Contribution ID: **25** Type: **Highlight talk**

Impact of non gaussianities on the primordial black hole abundance

Monday, June 19, 2023 5:00 PM (10 minutes)

Primordial Black Holes (PBHs) have recently attracted ample attention as they may explain some of the LIGO/Virgo/KAGRA observations and significantly contribute to the dark matter in our universe. The standard formation scenario assumes PBHs form out of the collapse of large radiation over-densities in the early universe.
We present the computation of PBHs mass fraction in the presence of local non-gaussianity (NG) in the curvature perturbation field ζ by including both NG arising from the non-linear relation between density contrast and curvature perturbations and NG of primordial origin.
We then revise PBHs production in the axion-curvaton model. We show that, thanks to a precise computation of the PBH abundance, this model can explain both the totality of dark matter in the asteroid mass range and the tentative signal reported by the NANOGrav collaboration in the nano-Hz frequency range.

Primary authors: Prof. URBANO, Alfredo Leonardo (Università di Roma "La Sapienza"); IOVINO, Antonio Junior (Università degli studi di Roma "La Sapienza"); Dr FRANCIOLINI, Gabriele (Università di Roma "La Sapienza"); Mr FERRANTE, Giacomo (LUPM, CNRS, Universitè Montpellier)

Presenter: IOVINO, Antonio Junior (Università degli studi di Roma "La Sapienza")

Session Classification: Session 4

Contribution ID: **27** Type: **Highlight talk**

Primordial black holes from dissipative effects during inflation

Monday, June 19, 2023 4:50 PM (10 minutes)

Coupling the inflaton field to light degrees of freedom can lead to the former dissipating its energy into a thermal bath. The temperature fluctuations of this bath act as a source for inflaton perturbations. This can potentially lead to an enhancement of the primordial power spectrum $\mathcal{P}_\mathcal{R}$ and the subsequent increased production of primordial black holes (PBHs). We propose a reliable method to compute the thermally-enhanced $\mathcal{P}_\mathcal{R}$ based on a Fokker-Planck equation, and verify its consistency with a Monte Carlo approach and a fully analytical approximation based on the Green's function method. We observe that a strong, transient dissipative phase during inflation increases the predicted abundance of asteroid-mass PBHs, which could account for the totality of the dark matter in the Universe. The proposed method can also be applied to the calculation of CMB observables (A_s, n_s, tensor-to-scalar ratio), allowing to probe dissipative inflation models both at small and large scales.

Primary authors: PEREZ RODRIGUEZ, Alejandro; Dr BALLESTEROS, Guillermo (IFT UAM-CSIC); Dr REY, Julian (DESY); Dr GARCIA GARCIA, Marcos Alejandro (Instituto de Fisica UNAM); Dr PIERRE, Mathias (DESY)

Presenter: PEREZ RODRIGUEZ, Alejandro

Session Classification: Session 4

Contribution ID: **28** Type: **Talk**

Particle physics models that predict dark matter in the form of primordial black holes.

Tuesday, June 20, 2023 10:20 AM (20 minutes)

Primordial black hole is a dark matter candidate in a variety of models of physics beyond the standard model, including supersymmetry and models with asymmetric dark matter. I will discuss the formation of black holes in such scenarios, as well as the effects of predicted PBHs on astrophysics and cosmology.

Primary author: KUSENKO, Alexander (UCLA and Kavli IPMU)

Presenter: KUSENKO, Alexander (UCLA and Kavli IPMU)

Session Classification: Session 5

Contribution ID: **29** Type: **Highlight talk**

AMPM: Asteroid-Mass Primordial Black Hole Microlensing

Wednesday, June 21, 2023 10:30 AM (10 minutes)

Formed in the earliest second of the universe, a galactic halo population of Primordial black holes (PBH) are a simple solution to the dark matter (DM) problem. A halo population of PBHs in the Milky Way may be detected on Earth using small-scale gravitational lensing, or 'microlensing' .Several decades of microlensing research have gone into constraining the potential range of PBHs and their contribution to halo DM. High cadence galactic imaging allows the last potential mass range, the asteroid-mass PBHs, to be investigated as DM. A new research effort determines whether low-mass Primordial Black Holes (PBHs) contribute to the halo DM by pointed imaging of the LMC with 1 minute cadence DECam observations.

Along with providing additional DM density constraints in the asteroid-mass regime from the LMC observations, a prototype project will also be presented in the talk. By forcing a constant tracking rate with DECam, LMC stars appear as miniature drift scans on every exposure, and each drift may be considered as a series of individual 2 second samples of a star. The initial results for the prototype extraction method to combine stellar drifts into an effective light curve of cadence 2 seconds will be presented, with the aim to detect the shortest possible microlensing signals arising from very low-mass PBHs in the galactic dark halo.

Primary author: KEY, Renee (Swinburne University of Technology)

Co-authors: Prof. DUFFY, Alan (Swinburne University of Technology); Prof. TAYLOR, Edward (Swinburne University of Technology); Prof. FREEMAN, Ken (Australian National University)

Presenter: KEY, Renee (Swinburne University of Technology)

Session Classification: Session 9

Contribution ID: **30** Type: **Talk**

Stochastic constant-roll inflation and primordial black holes

Monday, June 19, 2023 12:20 PM (20 minutes)

Primordial black holes can be seeded by perturbations from cosmic inflation. In the literature, these perturbations are often computed in linear order so that their statistics are Gaussian. However, non-Gaussianities can be important for the rare events of black hole formation. The leading non-Gaussianities can be computed with the non-linear formalism of stochastic inflation, which predicts an exponential tail for the perturbation probability distribution. I talk about recent progress in these stochastic computations, especially during constant-roll inflation, a phase typical for black-hole-producing inflationary models. As a new result, I show how stochastic constant-roll inflation can be solved analytically starting from the curvature power spectrum, and discuss the ensuing corrections to black hole abundance.

Primary author: Dr TOMBERG, Eemeli (NICPB Tallinn)

Presenter: Dr TOMBERG, Eemeli (NICPB Tallinn)

Session Classification: Session 2

Contribution ID: **32** Type: **Talk**

Primordial black holes from stochastic tunnelling

Monday, June 19, 2023 2:40 PM (20 minutes)

If inflation gives rise to large enough curvature perturbations, these will generate large overdensities in the primordial plasma, which may eventually collapse to form primordial black holes when inflation is over.
Therefore, primordial black holes typically arise in inflationary scenarios where the backreaction of large amplitude fluctuations significantly modify the large-scale dynamics of the universe.
Under the program dictated by the stochastic-δN formalism, this quantum backreaction can be properly incorporated, and the impact of quantum diffusion on the properties of collapsed objects, such as primordial black holes, can be assessed.
In this framework, I will discuss the abundance of primordial black holes generated by stochastic tunnelling, which may happen when the inflationary potential displays a false vacuum state that is overshoot thanks to quantum diffusion, as well as the impact of quantum diffusion on clustering properties of primordial black holes at their formation.

Primary authors: ANIMALI, Chiara (LPENS, Paris); VENNIN, Vincent

Presenter: ANIMALI, Chiara (LPENS, Paris)

Session Classification: Session 3

Contribution ID: **33** Type: **Highlight talk**

Planck Constraints and Gravitational Wave Forecasts for Primordial Black Hole Dark Matter Seeded by Multifield Inflation

Wednesday, June 21, 2023 3:50 PM (10 minutes)

In my talk, I will present recent work on the formation of primordial black hole dark matter and the resultant gravitational wave signal, drawing from recent results of (arXiv 2303:xxxxx, MIT-CTP/5525, with co-authors W. Qin, S. Balaji, D.I. Kaiser, and E. McDonough) and building on our previous results as published in (Phys. Rev.D 106, 063535 (2022), arXiv:2205.04471). In our work, we performed a Markov Chain Monte Carlo (MCMC) analysis of a simple yet generic multifield inflation model characterized by two scalar fields coupled to each other and nonminimally coupled to gravity, fit to *Planck* 2018 cosmic microwave background (CMB) data. In particular, model parameters are constrained by data on the amplitude of the primordial power spectrum of scalar curvature perturbations on CMB scales A_s, the spectral index n_s, and the ratio of power in tensor to scalar modes r, with a prior that the primordial power spectrum should also lead to primordial black hole (PBH) production sufficient to account for the observed dark matter (DM) abundance. I will demonstrate that n_s in particular largely controls the constraints on our class of models. Whereas previous studies of PBH formation from an ultra-slow-roll phase of inflation have highlighted the need for at least one model parameter to be highly fine-tuned, I will identify a degeneracy direction in parameter space such that shifts by $\sim 10\%$ of one parameter can be compensated by comparable shifts in other parameters while preserving a close fit between model predictions and observations. Furthermore, I will show how this allowed parameter region produces observable gravitational wave (GW) signals in the frequency ranges to which upcoming experiments are projected to be sensitive, including Advanced LIGO and Virgo, the Einstein Telescope (ET), DECIGO, and LISA.

Primary author: Ms GELLER, Sarah (Massachusetts Institute of Technology)

Co-authors: Prof. KAISER, David (MIT); Prof. MCDONOUGH, Evan (University of Winnipeg); Dr BALAJI, Shyam (Laboratoire de Physique Theorique et Hautes Energies (LPTHE), UMR 7589 CNRS Sorbonne Universte); Ms QIN, Wenzer (MIT)

Presenter: Ms GELLER, Sarah (Massachusetts Institute of Technology)

Session Classification: Session 11

Contribution ID: **34** Type: **Highlight talk**

Supermassive Black Holes Directly from Inflation

Monday, June 19, 2023 5:10 PM (10 minutes)

It is generally thought that the supermassive black holes (SMBH) of mass $M \sim 10^8 - 10^{10} M_\odot$ ubiquitous in galactic nuclei grew from initially low mass seeds through the processes of accretion and mergers. Eddington-limited growth, however, is insufficient to explain the surplus of SMBH observed at high redshift $z \sim 6$, when the age of the universe was less than 1 Gyr. An alternative proposition is that these SMBH are primordial in origin, having been formed from the collapse of matter overdensities in the early universe.

In this talk, I explore the possibility of SMBH from the direct collapse of curvature perturbations generated during inflation. This generically requires a large enhancement of the primordial power spectrum on small scales, which could arise in single-field models with e.g. a transient period of ultra slow roll or local features like bumps or dips, as well as in a variety of multi-field models. SMBH are formed at late cosmological times, however, corresponding to scales where constraints from spectral distortions of the cosmic microwave background are relevant. In particular, the large enhancement of the power spectrum necessary for efficient black hole formation is naively in conflict with measurements of μ-type spectral distortions from COBE/FIRAS. However, this is assuming Gaussian statistics for the curvature perturbation; less amplification of the power spectrum is needed in the event that the statistics are sufficiently non-Gaussian. I quantify the extreme degree of non-Gaussianity needed to make the scenario of SMBH from direct collapse of inflationary perturbations work and explore the sorts of inflationary models that could give rise to such statistics.

Primary author: IRELAND, Aurora (University of Chicago)

Presenter: IRELAND, Aurora (University of Chicago)

Session Classification: Session 4

Contribution ID: **35** Type: **Talk**

Observational Evidence for Primordial Black Holes: A Positivist Perspective

Monday, June 19, 2023 5:20 PM (20 minutes)

I review the observational evidence for primordial black holes (PBHs) from a variety of lensing, dynamical, accretion and gravitational-wave effects. This is a shift from the usual emphasis on PBH constraints. Microlensing observations of stars and quasars suggest that PBHs of around 1 M⊠ could provide most of the dark matter in galactic halos and intergalactic space, especially if they have an extended mass spectrum. In this case, the Poisson fluctuations associated with the PBHs could generate the first bound objects at a much earlier epoch than in the standard cosmological scenario and this could explain the recent detection of high redshift ultra-faint dwarf galaxies. LIGO/Virgo observations of coalescing compact objects may provide evidence for PBHs, since they encompass the mass gaps not usually associated with stellar remants, but those dominating the detection rate have tens of solar masses and could only provide a small fraction of the dark matter. PBHs could explain various other observational conundra and sufficiently large ones could provide seeds for the supermassive black holes in galactic nuclei. even if their density is tiny. The strength of the evidence for PBHs is independent of any specific model for their formation. However, the sound-speed naturally undergoes a series of dips at around the QCD epoch and this motivates a scenario in which the PBH mass function exhibits a number of distinct bumps, allowing PBHs to play many of the roles discussed above.

Primary author: Dr KÜHNEL, Florian (MPP & LMU Munich)

Presenter: Dr KÜHNEL, Florian (MPP & LMU Munich)

Session Classification: Session 4

Contribution ID: **37** Type: **Highlight talk**

Primordial Black Holes as laboratories for Physics beyond the standard scenarios

Tuesday, June 20, 2023 5:50 PM (10 minutes)

We use the evaporation of Primordial Black Holes as a laboratory to investigate Physics beyond the Standard Model of particles and to probe the structure of black holes.
We show that PBHs develop non-negligible spins through Hawking's emission of many axion-like particles yielding a unique probe of the total number of light scalars in the fundamental theory, independent of how weakly they interact with known matter. We propose a distant-independent method to determine the mass and spin of PBHs based on measuring specific features in the photon Hawking emission spectrum. We study a regular rotating black hole, described by the Kerr-black-bounce metric, and evaporating under the Hawking emission of a single scalar field and compare it with a Kerr black hole evaporating under the same conditions. We show that the regularizing parameter affects the evolution of the PBH and comment on the possibility of investigating the beyond-the-horizon structure of a black hole by exploiting its Hawking emission.

Primary authors: ROSA, João (University of Coimbra); CALZA, Marco (University of Coimbra)

Presenter: CALZA, Marco (University of Coimbra)

Session Classification: Session 8

Contribution ID: **38** Type: **Highlight talk**

The Effective Theory of Quantum Black Holes

Tuesday, June 20, 2023 5:40 PM (10 minutes)

We explore the quantum nature of black holes by introducing an effective framework that takes into account deviations from the classical results. The approach is based on introducing quantum corrections to the classical Schwarzschild geometry in a way that is consistent with the physical scales of the black hole and its classical symmetries. This is achieved by organizing the quantum corrections in inverse powers of a physical distance. By solving the system in a self-consistent way we show that the derived physical quantities, such as event horizons, temperature and entropy can be expressed in a well-defined expansion in the inverse powers of the black hole mass. The approach captures the general form of the quantum corrections to black hole physics without requiring to commit to a specific model of quantum gravity.

Primary authors: BINETTI, Emanuele (Università di Napoli Federico II); SANNINO, Francesco (CP3-Origins & DIAS, SDU); PEZZELLA, Franco (INFN sezione di Napoli); DEL PIANO, Manuel (Scuola Superiore Meridionale); HOHENEGGER, Stefan (IP2I, CNRS/IN2P3)

Presenter: DEL PIANO, Manuel (Scuola Superiore Meridionale)

Session Classification: Session 8

Contribution ID: **39** Type: **Talk**

Primordial black hole superradiance

Wednesday, June 21, 2023 9:00 AM (20 minutes)

I will describe superradiant particle production in the context of primordial black holes, discussing its cosmological and astrophysical relevance. In particular, I will focus on the superradiant production of axion-like particles and other exotic bosonic particles that they may account for (a fraction of) dark matter. I will discuss particle production by primordial black holes in the asteroid-mass range, as well as by (much) lighter black holes. In the latter case, there is a significant interplay between Hawking evaporation and superradiance that may lead to interesting dynamical and observational consequences. Finally, I will discuss potential observational signatures of primordial black hole superradiance.

Primary author: ROSA, João (University of Coimbra)

Presenter: ROSA, João (University of Coimbra)

Session Classification: Session 9

Contribution ID: **40** Type: **Talk**

Dark Matter in the Time of Primordial Black Holes

Tuesday, June 20, 2023 11:40 AM (20 minutes)

The evaporation of primordial black holes (PBH) with masses ranging from $\sim 10^{-1}$ to 10^{9} g could have generated the whole observed dark matter (DM) relic density. It is typically assumed that after being produced, its abundance freezes and remains constant. However, thermalization and number-changing processes in the dark sector can have a strong impact, in particular enhancing the DM population by several orders of magnitude. Here we estimate the boost from general arguments such as the conservation of energy and entropy, independently from the underlying particle physics details of the dark sector. Two main consequences can be highlighted: i) As the DM abundance is increased, a smaller initial energy density of PBHs is required. ii) Thermalization in the dark sector decreases the mean DM kinetic energy, relaxing the bound from structure formation and hence, allowing light DM with mass in the keV ballpark.

Furthermore, DM interacting only gravitationally is also unavoidably produced by the irreducible UV gravitational freeze-in. We show that the latter mechanism sets strong bounds, excluding large regions of the parameter space favored by PBH production.

Primary author: BERNAL, Nicolás (NYU Abu Dhabi)

Presenter: BERNAL, Nicolás (NYU Abu Dhabi)

Session Classification: Session 6

Contribution ID: **41** Type: **Talk**

Formation of trapped vacuum bubbles during inflation, and consequences for PBH scenarios

Monday, June 19, 2023 3:00 PM (20 minutes)

A class of inflationary scenarios for primordial black hole (PBH) formation include a small barrier in the slope of the potential. There, the inflaton slows down, generating an enhancement of primordial perturbations. Moreoever, the background solution overcomes the barrier at a very low speed, and large backward quantum fluctuations can prevent certain regions from overshooting the barrier. This leads to localized bubbles where the field remains "trapped" behind the barrier. In such models, therefore, we have two distinct channels for PBH production: the standard adiabatic density perturbation channel and the bubble channel. Here, we perform numerical simulations of bubble formation, addressing the issues of initial conditions, critical amplitude and bubble expansion. Further, we explore the scaling behaviour of the co-moving size of bubbles with the initial amplitude of the field fluctuation. We find that for small to moderate non-Gaussianity $f_{\rm NL} \leq 2.6$, the threshold for the formation of vacuum bubbles agrees with previous analytical estimates arXiv:1908.11357 to 5% accuracy or so. We also show that the mass distribution for the two channels is different, leading to a slightly broader range of PBH masses when both contributions are comparable. The bubble channel is subdominant for small $f_{\rm NL}$, and becomes dominant for $f_{\rm NL} \geq 2.6$. We find that the mass of PBHs in the bubble channel is determined by an adiabatic overdensity surrounding the bubble at the end of inflation. Remarkably, the profile of this overdensity turns out to be of type-II. This represents a first clear example showing that overdensities of type-II can be dominant in comparison with the standard type-I. We also comment on the fact that in models with local type non-Gaussianity (such as the one considered here), the occurrence of alternative channels can easily be inferred from unitarity considerations.

Primary author: ESCRIVÀ, Albert (Nagoya University)

Presenter: ESCRIVÀ, Albert (Nagoya University)

Session Classification: Session 3

Contribution ID: **42** Type: **Talk**

Hot spots around small primordial black holes

Wednesday, June 21, 2023 5:40 PM (20 minutes)

Small PBHs with masses $10^9\,g$ completely evaporate before the big bang nucleosynthesis (BBN). One of the important traces of such small PBHs is that the Hawking radiation emitted from these PBHs heats up the ambient plasma if its temperature is lower than the Hawking temperature. In this talk, we discuss the formation of a locally high-temperature region around a small PBH and see how it results in a non-trivial temperature profile, namely a hot spot surrounding a PBH with a broken power-law tail. We also discuss its possible phenomenological impacts.

Primary author: MUKAIDA, Kyohei (KEK)

Presenter: MUKAIDA, Kyohei (KEK)

Session Classification: Session 12

Contribution ID: **43** Type: **Talk**

Small Primordial Black Holes as Window on Quantum Gravity

Tuesday, June 20, 2023 5:20 PM (20 minutes)

Hawking's calculation of particle production by a black hole is based on the semi-classical limit of a fixed metric. This approximation may break down after a finite time as a black hole evolves due to back-reaction. Therefore, I shall argue that two far-reaching questions remain to be answered:
(1) How long is the semi-classical description valid?
(2) What happens after a potential breakdown?
Primordial black holes (PBHs) offer unique opportunities to address these issues by observations. Since one possible option is a slowdown of evaporation, it is conceivable that PBHs below 10^{15}g can have survived until today. Such long-lived small PBHs could not only act as dark matter, but detecting even a single one of them would also greatly advance our understanding of quantum gravity. Finally, I will attempt to answer the above questions using explicitly solvable analogue models. An non-perturbative computation of real-time evolution reveals indications that (1) the semi-classical description can break down long before half of the mass is lost and that indeed (2) evaporation slows down drastically at this point.

Based on:
M. Michel, S. Zell, *The Timescales of Quantum Breaking*, arXiv:2203.XXXXX, to appear.
G. Dvali, L. Eisemann, M. Michel, S. Zell, *Black hole metamorphosis and stabilization by memory burden*, Phys. Rev. D 102 (2020) 103523, arXiv:2006.00011.

Primary authors: MICHEL, Marco (Ben-Gurion University of the Negev); ZELL, Sebastian (UCLouvain)

Presenter: ZELL, Sebastian (UCLouvain)

Session Classification: Session 8

Contribution ID: **44** Type: **Talk**

1-loop contributions to the inflationary power spectrum

Tuesday, June 20, 2023 3:00 PM (20 minutes)

With the prospect of future detection of gravitational waves in the next decade and the growing interest in the cosmology of primordial black holes, it is high time to study the dynamics of relevant models of inflation in depth. Typically the models of inflation that can lead to large spectrum of induced gravitational waves and abundant primordial black holes required to reach a large amplitude of the scalar perturbations at small scales. Despite reaching such large amplitudes for the scalar perturbations, in general only the tree-level power spectrum is considered to analyse a particular model of inflation while determining the abundance of primordial black holes and the spectrum of induced gravitational waves. However, there can be large loop-level contributions to the primordial power spectrum in such models. In this work, we have studied the 1-loop contributions to the curvature power spectrum using Green's function method for generic forms of the Lagrangian in single-field and multi-field inflation scenarios. We present our results for specific examples of inflation models. We inspect the phenomenological implications in certain cases where the 1-loop power spectrum has a reasonably large contribution to the full inflationary power spectrum.

Primary author: BHATTACHARYA, Sukannya (University of Padova (INFN, Padova))

Presenter: BHATTACHARYA, Sukannya (University of Padova (INFN, Padova))

Session Classification: Session 7

Contribution ID: **45** Type: **Highlight talk**

Primordial black holes from the pre-big bang

Tuesday, June 20, 2023 3:40 PM (10 minutes)

I will discuss the possibility of producing a significant fraction of dark matter in the form of primordial black holes (PBHs) in the context of the pre-big bang scenario. To this purpose, we consider the enhancement of curvature perturbations possibly induced by a variation of the sound-speed parameter c_s that emerges naturally due to higher-order string corrections. We describe the production both in radiation and in matter dominated era.

Primary author: CONZINU, Pietro (University of Pisa & INFN)

Presenter: CONZINU, Pietro (University of Pisa & INFN)

Session Classification: Session 7

Contribution ID: **46** Type: **Talk**

Determining where primordial black holes form

Wednesday, June 21, 2023 11:20 AM (20 minutes)

Primordial black holes (PBHs) are of great interest cosmologically: they a promising dark matter candidate, and provide plausible explanations for a number of observations, perhaps most noticeably the observations of gravitational waves from merging black holes. Even if they are never detected, this fact can be used to place unique constraints on the small-scale primordial power spectrum. With new surveys beginning operation and new observations becoming available, it is becoming increasingly important to make accurate calculations regarding PBHs, in order to determine their viability in cosmological models - how many PBHs are there? What are their masses? How often would they merge?

Underpinning all of these calculations is the criteria used to determine when and where a PBH will form in the early universe. The use of different criteria has a large impact on the calculation of the abundance, mass function, merger rate of binary PBHs, constraints on non-Gaussianity, and many more. In this talk, I will discuss the pros and cons of various parameters which can be used as the formation criterion, and, making use of recent simulation results, make an argument for the optimum criterion, which gives the most accurate calculations for the initial distribution of PBHs.

Primary author: YOUNG, Samuel (Leiden University)

Presenter: YOUNG, Samuel (Leiden University)

Session Classification: Session 10

Contribution ID: **47** Type: **Talk**

Dark matter and dark radiation from evaporating primordial black holes

Tuesday, June 20, 2023 11:20 AM (20 minutes)

Primordial black holes might have existed in the early universe and, via their evaporation mechanism (completed before Big Bang Nucleosynthesis), they might have released stable particles beyond the Standard Model. We review the possibility that such particles might contribute to dark matter or dark radiation.

Primary author: MASINA, Isabella (University of Ferrara, Italy)

Presenter: MASINA, Isabella (University of Ferrara, Italy)

Session Classification: Session 6

Contribution ID: **48** Type: **Talk**

Stellar-born black holes across the cosmic time

Tuesday, June 20, 2023 9:00 AM (20 minutes)

LIGO and Virgo have started unraveling the mass spectrum and merger rate density of binary black holes (BBHs) in the Local Volume, while in the next decade the Einstein Telescope and Cosmic Explorer will probe BBH mergers across the cosmic time. The origin of such systems still makes us scratch our heads. In this talk, I will review the main scenarios for the formation of stellar-born binary black holes via binary-star evolution and dynamics of dense stellar systems, highlighting the main open questions. We expect that BBH mergers from metal-poor and metal-free stars take place out to redshift 20-40. These will be significantly more massive than BBHs born from metal-rich stars in the Local Volume. Understanding the contribution of stellar-born BBHs to the merger rate in the high-redshift Universe will be a key step to reconstruct the reionization epoch and the merger rate density of primordial black holes.

Primary author: MAPELLI, Michela

Presenter: MAPELLI, Michela

Session Classification: Session 5

Contribution ID: **49** Type: **Talk**

Axion-like particles from light primordial black holes

Wednesday, June 21, 2023 5:00 PM (20 minutes)

We consider a cosmological scenario in which the very early Universe experienced a transient epoch of matter domination due to the formation of a large population of primordial black holes (PBHs) with masses $M \leq 10^9$ g, that evaporate before Big Bang nucleosynthesis. In this context, Hawking radiation would be a non-thermal mechanism to produce a cosmic background of axion-like particles (ALPs). We assume the minimal scenario in which these ALPs couple only with photons. In the case of ultralight ALPs ($m_a \leq 10^{-9}$ eV) the cosmic magnetic fields might trigger ALP-photon conversions, while for masses m a ⊠ 10 eV spontaneous ALP decay in photon pairs would be effective. We investigate the impact of these mechanisms on the cosmic X-ray background, on the excess in X-ray luminosity in Galaxy Clusters, and on the process of cosmic reionization. We outline possible developments of this scenario including BH rotation and superradiance.

Primary author: Mr MONTANINO, Daniele (Università del Salento & INFN)

Presenter: Mr MONTANINO, Daniele (Università del Salento & INFN)

Session Classification: Session 12

Contribution ID: **50** Type: **Talk**

Probing PBH DM with high-energy astrophysics

Wednesday, June 21, 2023 9:40 AM (20 minutes)

I will present how we can use high-energy astrophysics at multiple wavelengths to constrain PBH DM. First, I will show how old data from INTEGRAL/SPI in the MeV band can be exploited to set the strongest bounds on evaporating PBH. I will also review how we can use GeV to TeV observation to probe PBHs, even if not providing very competitive results. Finally, I will move towards stellar-mass PBHs and discuss the signatures the accretion of gas can leave in radio and X-ray observations.

Primary author: CALORE, Francesca (CNRS, LAPTh)

Presenter: CALORE, Francesca (CNRS, LAPTh)

Session Classification: Session 9

Contribution ID: **52** Type: **Talk**

Black Holes'Dark Dress - Detecting Particle Dark Matter around Primordial Black Holes with Gravitational Waves

Tuesday, June 20, 2023 9:40 AM (20 minutes)

Primordial Black Holes (PBHs) can form binaries very efficiently in the early Universe, some of which could be observed merging at low redshift. Searching for such mergers, current Gravitational Wave (GW) observations constrain Solar-mass PBHs to make up less than around one thousandth of the Dark Matter (DM) in our Universe. Such a sub-dominant PBH population is therefore likely to be accompanied by a new particle species making up the majority of the DM. I will review the process by which particle DM can form large over-densities around sub-dominant PBHs and present on-going efforts to understand how these 'dark dresses'can affect the merger rates of PBH binaries and therefore affect GW constraints on the PBH abundance. In addition to altering merger rates, the presence of dark dresses can also have a detectable effect on the shape of GW signals we would observe from PBH binaries. I will discuss the prospects for detecting these effects in current and future GW observatories, and consider what we might learn about both Dark Matter and Primordial Black Holes if we do.

Primary author: KAVANAGH, Bradley (IFCA (UC-CSIC), Santander)

Presenter: KAVANAGH, Bradley (IFCA (UC-CSIC), Santander)

Session Classification: Session 5

Contribution ID: **53** Type: **Talk**

Gravitational-wave probes of planetary-mass primordial black holes

Tuesday, June 20, 2023 9:20 AM (20 minutes)

Gravitational waves can probe the existence of planetary-mass primordial black holes. During their inspirals, these systems will emit gravitational-wave radiation that can be simply described as coming from quasi-Newtonian orbits. Considering a mass range of 10-7 to 10-2 solar masses, we show that gravitational-wave signals from these systems could be quasi-monochromatic and quasi-infinite, i.e. continuous gravitational waves, or follow a power-law frequency evolution and last O(hours-months), i.e. transient continuous gravitational waves. We adapt methods originally designed to detect asymmetrically rotating neutron stars to search for primordial black hole inspirals, and present forecasts of the constraints on the fraction of dark matter that primordial black holes could compose for current and future detectors, and place the first upper limits on asteroid-mass primordial black holes using LIGO/Virgo O3 data. Our methods can probe a large portion of the mass parameter space for primordial black holes with relatively good sensitivity, especially in future detectors.

Primary author: MILLER, Andrew (Nikhef /Utrecht University)

Presenter: MILLER, Andrew (Nikhef /Utrecht University)

Session Classification: Session 5

Contribution ID: **54** Type: **Talk**

Questions on calculation of primordial power spectrum with large spikes: the resonance model case

Tuesday, June 20, 2023 2:40 PM (20 minutes)

Inflationary models predicting a scale-dependent large amplification of the density perturbations have recently attracted a lot of attention because the amplified perturbations can seed a sizable amount of primordial black holes (PBHs) and stochastic background of gravitational waves (GWs). While the power spectra in these models are computed based on the linear equation of motion, it is not obvious whether loop corrections are negligible when such a large amplification occurs during inflation.
In this talk, I will discuss our paper, arXiv:2211.02586, in which we use the in-in formalism and calculate the one-loop scalar power spectrum numerically and analytically in an illustrative model where the density perturbations are resonantly amplified due to oscillatory features in the inflaton potential. Our calculation is technically new in that the amplified perturbations are numerically taken into account in the in-in formalism for the first time. With the calculation results, I will show that, for the typical parameter space leading to the O(10^7) amplification of the power spectrum for a sufficient PBH production in the oscillatory feature models, the one-loop power spectrum dominates over the tree-level one, indicating the breakdown of the perturbation theory.

Primary author: INOMATA, Keisuke (University of Chicago, KICP)

Presenter: INOMATA, Keisuke (University of Chicago, KICP)

Session Classification: Session 7

Contribution ID: **55** Type: **Talk**

Should we care about cosmological black holes?

Tuesday, June 20, 2023 5:00 PM (20 minutes)

When primordial black holes (PBHs) form in the early universe, their environment is dominated by the radiation bath and the not-very-distant cosmological horizon. There are a wide number of cosmological black hole' metrics which describe such objects—locally black-hole like objects which are asymptotically FLRW. However, pretty much all of these metrics have various flaws, such as physical singularities or pressure conditions which require matter-dominated backgrounds. I will briefly discuss some of these solutions, and the formalism we use to study them more clearly. I will also argue that the choice of such metric may have large phenomenological consequences, specifically regarding PBHs as a dark matter candidate. It is not easy to find an entirely convincing candidate, but I will use a somewhat generic framework and onetoy' metric—the Thakurta metric—to demonstrate how the constraints on PBH dark matter might depend heavily on the early-universe cosmological black hole metric. Based partly on: https://arxiv.org/abs/2008.10743, https://arxiv.org/abs/2103.02815, https://arxiv.org/abs/2112.13921.

Primary author: PICKER, Zachary (UCLA)

Presenter: PICKER, Zachary (UCLA)

Session Classification: Session 8

Contribution ID: **56** Type: **Talk**

Constraining primordial black holes from observation of stars in dwarf galaxies

Monday, June 19, 2023 5:40 PM (20 minutes)

We will discuss constraints on the abundance of primordial black holes of masses around 10^20 g that may result from their cature by main sequence stars in dwarf galaxies, with subsequent destruction of the infected stars. We show that capture of PBH at the stage of star formation is efficient and may significantly affect the star population in some of the observed dwarf galaxies – those having higher dark matter density and lower velocity dispersion. We identify Triangulum II as one of the best candidates which may exclude 100% of dark matter composed of PBH with masses around 10^{20} g.

Primary author: TINYAKOV, Petr (Universite Libre de Bruxelles (ULB))

Presenter: TINYAKOV, Petr (Universite Libre de Bruxelles (ULB))

Session Classification: Session 4

Contribution ID: **57** Type: **Highlight talk**

Direct detection of light dark matter from evaporating primordial black holes

Wednesday, June 21, 2023 10:20 AM (10 minutes)

Light Dark Matter has recently gained a lot of attention. Generally, direct detection of sub-GeV Dark Matter is challenging since it induces low recoil energies. The problem is solved by considering light Dark Matter with considerable kinetic energies. In this talk, we point out that Primordial Black Hole evaporation is a source of boosted light dark Matter with energies of tens to hundreds of MeV. Considering XENON1T data, we constrain the mixed parameter space of Primordial Black Holes and sub-GeV Dark Matter.

Presenter: CALABRESE, Roberta (Università degli studi di Napoli "Federico II")

Session Classification: Session 9

Contribution ID: **59** Type: **Highlight talk**

Limits on light primordial black holes from high-scale leptogenesis

Wednesday, June 21, 2023 6:00 PM (10 minutes)

Among mechanisms for generating the baryon asymmetry of the universe, leptogenesis is attractive since it simultaneously explains the small neutrino masses via the seesaw mechanism. Experiments offer some valuable constraints, but the parameter space of even minimal leptogenesis models are high-dimensional and difficult to probe directly. However considering a simple and well studied realisation, the SM is extended by three right-handed neutrinos N_i with $M_{N_i} > 10^{12}$GeV, the parameter space of leptogenesis can be indirectly and severely constrained by populations of Primordial Black Holes (PBHs). PBHs may form via the collapse of inflationary perturbations and inject particles and entropy into the universe. For $M_{PBH} < 10^{9}$GeV they evaporate completely before Big Bang Nucleosynthesis, potentially altering the dynamics of leptogenesis. While previous works have pointed out that PBHs can extend viable leptogenesis parameter space, in this talk I will discuss how PBHs may also rule out certain leptogenesis scenarios (and vice versa), by characterising the strong incompatibility between PBHs and the simple case of high-scale leptogenesis we study.

Presenter: GUNN, Jacob (University of Naples Federico II)

Session Classification: Session 12

Contribution ID: **60** Type: **Highlight talk**

Effect of Trans-Planckian Black Holes on primordial spectra

Tuesday, June 20, 2023 6:00 PM (10 minutes)

We investigate the impact of stochastic quantum noise due to trans–Planckian effects on the primordial power spectrum for gravity waves during inflation. Given an energy scale Lambda, expected to be close to the Planck scale m_Pl and larger than the Hubble scale H, this noise is described in terms of a source term in the evolution equation for comoving modes k which changes its amplitude growth from early times as long as the mode physical wavelength is smaller than Lambda^-1. We model the source term as due to a gas of black holes in the trans–Planckian regime and the corresponding Hawking radiation. In fact, for energy scales larger than, or of the order of Lambda, it is expected that trapped surfaces may form due to large energy densities. At later times the evolution then follows the standard sourceless evolution. We find that this mechanism still leads to a scale-invariant power spectrum of tensor perturbations, with an amplitude that depends upon the ratio Lambda/m_Pl. This result is compatible with recent observations and can allow the slow-roll parameter space to scan a new range of values. Finally, we also discuss, for a more general model, the forecast on the primordial tensor non-gaussianity in the presence of stochastic sources

Presenter: CIELO, Mattia (Università di Napoli Federico II & INFN Sezione di Napoli)

Session Classification: Session 8

Contribution ID: **61** Type: **Talk**

Primordial Black Holes and the Tail of the Primordial PDF

Wednesday, June 21, 2023 11:40 AM (20 minutes)

Primordial Black Holes (PBHs) are interesting compact objects which might have formed due to the gravitational collapse of large density fluctuations in the early universe, which can be generated by quantum fluctuations during inflation. Since PBHs form from rare and non-linear over-densities, their abundance is highly sensitive to the non-Gaussian tail of the primordial probability distribution function (PDF) . Hence, it is important to determine the full PDF of primordial fluctuations, which can be carried out non-perturbatively using the 'Stochastic inflation' framework. A thorough development of stochastic inflation beyond slow roll has thus attracted a lot of interest in the recent years. In this talk, the speaker will discuss some of the new theoretical developments made in this direction.

Presenter: MISHRA, Swagat Saurav (University of Nottingham, UK)

Session Classification: Session 10

Contribution ID: **62** Type: **Talk**

Black Hole Explosions Beyond the Standard Model

Wednesday, June 21, 2023 12:00 PM (20 minutes)

The observation of an evaporating black hole would provide definitive information on the elementary particles present in nature. In particular, it could discover or exclude particles beyond those present in the standard model of particle physics. We consider a wide range of motivated scenarios beyond the standard model and identify those which would be best probed in the event of an observation. We characterise the photon spectra as a function of time for representative models and show that observation of an evaporating black hole at a distance of 0.01 parsecs could probe dark sector models containing one or more copies of the Standard Model particles, with any mass scale up to 300 TeV.

Presenter: BAKER, Michael (University of Melbourne)

Session Classification: Session 10

Contribution ID: **63** Type: **Talk**

PBHs: 50 years on

Monday, June 19, 2023 9:40 AM (40 minutes)

Presenter: CARR, Bernard (Queen Mary University of London)

Session Classification: Session 1

Contribution ID: **64** Type: **Talk**

Primordial Black Holes in the Era of Gravitational Wave Astronomy

Monday, June 19, 2023 10:20 AM (40 minutes)

Presenter: RIOTTO, ANTONIO (UNIVERSITY OF GENEVA)

Session Classification: Session 1

Contribution ID: **65** Type: **Talk**

Primordial black holes and the 21cm line

Wednesday, June 21, 2023 9:20 AM (20 minutes)

Even a small population of primordial black holes with masses above a solar mass could profoundly impact the properties of the intergalactic medium. In this talk, I will show that future observations of the 21cm transition in neutral hydrogen during the cosmic dawn will likely provide one of the most stringent tests of solar mass primordial black holes.

Presenter: PALOMARES-RUIZ, Sergio (IFIC (CSIC - UV))

Session Classification: Session 9

Contribution ID: **66** Type: **Talk**

Cosmological Magnetic Fields from Primordial Kerr-Newman Black Holes

Wednesday, June 21, 2023 5:20 PM (20 minutes)

The origin of our universe's cosmological magnetic fields remains a mystery. In this study, we consider whether these magnetic fields could have been generated in the early universe by a population of charged, spinning primordial black holes. To this end, we calculate the strength and correlation length of the magnetic fields generated by this population, and describe their evolution up to the current epoch. We find that near-extremal black holes in the mass range M~10^28–10^36 g could potentially generate magnetic fields with present day values as large as B~10^{−20}–10^{−15} G; those with M⪆10^38 g could have produced even larger fields B⪆10^{−14} G. To motivate this scenario, we briefly discuss how new physics may have induced a chemical potential which could have briefly maintained the black holes in an electrically charged state in the early universe. Finally, we comment on a correlation between the parameters of the cosmological magnetic field and the stochastic gravitational wave background coming from the merger of primordial black hole binaries as the primary observable signature of this scenario.

Presenter: KRNJAIC, Gordan (Fermilab & University of Chicago)

Session Classification: Session 12

Contribution ID: **67** Type: **Talk**

Corrections to Hawking Radiation from Asteroid Mass Primordial Black Holes: I. Formalism of Dissipative Interactions in Quantum Electrodynamics

Tuesday, June 20, 2023 4:40 PM (20 minutes)

Primordial black holes (PBHs) within the mass range $10^{17} - 10^{22}$ g are a favorable candidate for describing the all of the dark matter content. Towards the lower end of this mass range, the Hawking temperature, $T_{\rm H}$, of these PBHs is $T_{\rm H} \geq 100$ keV, allowing for the creation of electron – positron pairs; thus making their Hawking radiation a useful constraint for most current and future MeV surveys. This motivates the need for realistic and rigorous accounts of the distribution and dynamics of emitted particles from Hawking radiation in order to properly model detected signals from high energy observations. This talk discusses the first in a series of papers to account for the $\mathcal{O}(\alpha)$ correction to the Hawking radiation spectrum in a Schwarzchild geometry. We begin by the usual canonical quantization of the photon and spinor (electron/positron) fields on the Schwarzschild geometry. Then we compute the correction to the rate of emission by standard time dependent perturbation theory from the interaction Hamiltonian. We conclude with the analytic expression for the \textit{dissipative} correction, i.e. corrections due to the creation and annihilation of electron/positrons in the plasma.

Presenter: VASQUEZ, Gabriel (The Ohio State University)

Session Classification: Session 8

Contribution ID: **68** Type: **Talk**

Primordial Blackhole Archaeology with Gravitational Waves from induced tensor perturbations and cosmic strings

Wednesday, June 21, 2023 3:00 PM (20 minutes)

Ultra-low mass primordial black holes (PBH) which may briefly dominate the energy density of the universe but completely evaporate before the big bang nucleosynthesis (BBN), may lead to interesting observable signatures. We propose a novel test of this scenario by detecting its characteristic doubly peaked gravitational wave (GW) spectrum in future GW observatories. Here the first-order adiabatic perturbation from inflation and from the isocurvature perturbations due to PBH distribution, source tensor perturbations in second-order and lead to two peaks in the induced GW background. These resonant peaks are generated at the beginning of standard radiation domination in the presence of a prior PBH-dominated era. We explore the possibility of probing a class of baryogenesis models wherein the emission of massive unstable particles from the PBH evaporation and their subsequent decay contributes to the matter-antimatter asymmetry. We then include spinning PBHs and consider the emission of light relativistic dark sector particles, which contribute to the dark radiation (DR) and massive stable dark sector particles, thereby accounting for the dark matter (DM) component of the universe. The ISGWB can be used to probe the non-thermal production of these heavy DM particles, which cannot be accessible in any laboratory searches. For the case of DR, we find novel complementarity measurements of ΔNeff from these emitted particles and the ISGWB from PBH domination. Our results indicate that the ISGWB has a weak dependence on the initial PBH spin. However, for gravitons as the DR particles, the initial PBH spin plays a significant role, and between the only above a critical value of the initial spin parameter a_*, which depends only on initial PBH mass, the graviton emission can be probed in the CMB experiment. In the second part of the talk we will discuss how such a PBH-dominated era can be probed successfully using gravitational waves (GW) emitted by local and global cosmic strings. In addition to the step-like suppression of the GW spectrum, we propose a novel feature – a knee in the step – which provides information on the duration of the PBH-dominated era. Detecting GW from cosmic strings by detectors like LISA, ET, or BBO would set constraints on PBHs with masses between 10^6 and 10^9 g for local strings with tension $G\mu = 10^{-11}$, and PBHs masses between 10^4 and 10^9 g for global strings with symmetry-breaking scale $\eta = 10^{15}$ GeV.

Presenter: GHOSHAL, Anish (University of Wasrsaw, Poland)

Session Classification: Session 11

Contribution ID: **69** Type: **Talk**

Beyond perturbative non-Gaussianity for primordial black holes

Monday, June 19, 2023 3:40 PM (20 minutes)

Primordial black holes (PBHs) may form from large density fluctuations in the early universe. These fluctuations are rare, and so lie in the tail of the probability distribution function. Non-Gaussianity may enhance this tail, and will have a significant impact on PBH formation. The typical perturbative treatment of non-Gaussianity is insufficient for strong deviations from Gaussianity in the far tail. I will present a non-perturbative treatment of far-tail non-Gaussianities and discuss the impact on PBH formation.

Presenter: Dr GOW, Andrew (Institute of Cosmology & Gravitation, University of Portsmouth)

Session Classification: Session 3