Future Perspectives on Primordial Black Holes

Monday, 11 December 2023 - Wednesday, 13 December 2023

Botanical Garden of Sapienza University

Book of Abstracts

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Detection of PBH with Einstein Telescope: forecast for statistical methods to distinguish between different BH populations

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In this talk I will present forecasts on the capability of the Einstein Telescope to identify and measure the abundance of a subdominant population of distant PBHs, distinguishing it from Astrophysical Black Holes (ABH), using the difference in the redshift evolution of the merger rate of the two populations as our discriminant. After presenting our model for the merger rates and I will show how we generate realistic mock catalogues of the luminosity distances and errors that would be obtained from GW signals observed by the Einstein Telescope. I will then present two independent statistical methods to analyse the mock data, and I will show in our results the limiting fraction of dark matter in PBHs for which these methods would be able to obtain a detection of their existence.

PhD student session / 2

A resampling search method for light primordial black hole binary inspirals

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Sub-solar mass binary inspirals, e.g. from primordial black holes with masses of the order of $\mathcal{O}(10^{-5})M_{\odot} - \mathcal{O}(10^{-3})M_{\odot}$, generate long transient signals that last of the orders of hours - years. A detection of such a signal would have profound implications on the understanding of cosmology, dark matter, and physics of the very early universe. We present an implementation of a resampling algorithm to search for such signals in gravitational wave data. An estimate for the distance sensitivity of the technique suggests that the Galactic Centre can be probed for large portions of the parameter space studied. We also present preliminary results about efficiently construct a search grid and the expected computational cost of a directed search towards the Galactic Centre.

Contributed Talks / 3

Gravitational wave signatures of "magnetised" supermassive primordial black holes

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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 vortex-like motion of the primordial plasma around them at the epoch of their formation. Interestingly enough, we find 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. We also 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 as a function of their mass, which are comparable with constraints on from large-scale structure probes; hence promoting the portal of magnetically induced GWs as a new probe to explore the enigmatic nature of supermassive PBHs.

Contributed Talks / **4**

Timekeepers of the Universe: The recent gravitational wave observation by PTA and PBH.

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The recent data releases by multiple pulsar timing array (PTA) experiments show evidence for Hellings-Downs angular correlations indicating that the observed stochastic common spectrum can be interpreted as a stochastic gravitational wave background. We study whether the signal may originate from gravitational waves induced by high-amplitude primordial curvature perturbations. Such large perturbations may be accompanied by the generation of a sizeable primordial black hole (PBH) abundance. We discuss in which scenarios the inclusion of non-Gaussianities in the computation of the abundance can lead to a signal compatible with the PTA experiments without overproducing PBHs

Contributed Talks / **5**

Revisiting CMB constraints on PBH + WIMP scenarios

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Primordial black holes (PBHs) may have formed in the early Universe, and yet constitute only a subdominant component of the dark matter. In that case, the rest of the dark matter is expected to build up mini-halos with steep density profiles (“spikes”) around the PBHs. If this second dark matter component is in the form of Weakly Interacting Massive Particles (WIMPs), their annihilation rate would be enhanced by the high density environment of the spikes, a scenario that was shown to lead to extremely strong constraints on WIMPs. In this work, we revisit constraints that can be set on this mixed WIMP+PBH scenario from the observation of the cosmic microwave background. In particular, we improve on proevious calculations in the literature thanks to a careful computation of the dark matter spike profile as a function of black hole mass, dark matter particle mass and temperature of kinetic decoupling.

Contributed Talks / **7**

Back-reaction in the early universe

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Single-field models of inflation that feature a non-attractor phase might lead to enhanced scalar fluctuation on scales much smaller than those seeding the large-scale structure formation. In this scenario, it is possible that the spike of power at high wavenumber might spoil the successful predictions of a nearly Gaussian, scale-invariant power on large scales, e.g. in the form of loop corrections to the large-scale power spectrum. In this talk we discuss analytical estimates for the 1-loop correction. We employ the δN formalism, and relate our results to those obtained in the literature by applying the in-in formalism.

PhD student session / **8**

Primordial black holes from strong first order phase transitions

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This talk is aimed to analyze the possibility of Primordial Black Holes (PBHs) production during supercooled first order phase transitions in the Early Universe.
The transition proceeds through the nucleation of bubbles of the broken phase in an initial background of the symmetric phase, which later collide and percolate, finishing the conversion of the Universe, with their nucleation rate assumed to be given by generic action expanded to the quadratic order.
We focus on a scenario in which PBHs are produced purely by the collapse of overdense regions which remain long enough in the false vacuum state, where bubble nucleation is effectively postponed.
We present a description of such regions and determine the conditions of their gravitational collapse.
We find the final mass function and abundance of PBHs created in such manner to be highly dependent on the history of the transition and we identify the regions in parameter space for which PBHs' abundance matches that of Dark Matter inferred from observations.

PhD student session / **9**

The impact of primordial black holes on the stellar mass function of ultra-faint dwarf galaxies

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In the hypothesis of primordial black holes constituting the dark matter, stars forming in dark matter dominated environments with low velocity dispersions, such as ultra-faint dwarf galaxies, may capture a primordial black hole at birth. The capture probability is non-negligible for primordial black holes of masses around 10^{20} g, and increases with the stellar mass. Moreover, infected stars are turned into virtually invisible black holes in cosmologically short timescales. Hence, the number of observed heavy stars in ultra-faint dwarf galaxies should be suppressed if the dark matter was made of asteroid-mass primordial black holes. This would impact the measured mass distribution of stars, making it top-light (i.e. depleted in the high-mass range). Using simulated data that mimic the present-day observational power of telescopes, we show that already existing measurements of the mass function of stars in local ultra-faint dwarf galaxies could be used to constrain the fraction of dark matter made of primordial black holes in the —currently unconstrained —mass range of 10^{19}—10^{21} g.

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Projected gravitational wave constraints on primordial black hole abundance for extended mass distributions

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We investigate the projected minimum constraints set by next-generation gravitational wave detectors Einstein Telescope and LISA on the abundance of primordial black holes relative to dark matter for extended primordial black hole mass distributions. We use the IMRPhenomXAS waveform package to simulate binary sources up to mass ratios $q = 1000$ and redshifts $z = 300$. We consider positive and negative slope power law profiles for our extended mass distributions. Our results suggest that positively sloped distributions tend to raise the minimum constraint relative to the monochromatic cases by at least an order of magnitude, although this is less pronounced at high redshifts.

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Primordial black hole merger rates from a toy model mass distribution: the case for two monochromatic distributions

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The merger rate for primordial black holes is well-modeled for monochromatic and narrow-width mass distributions. However, it may be more realistic to consider primordial black hole binaries which sample from an extended mass distribution. In this paper, we set the groundwork by computing for the merger rate arising from a toy model distribution consisting of two monochromatic

distributions. Ignoring suppression, we find that the overall merger rate reaches a minimum at binary mass ratios $q \approx 58$ for distributions highly biased towards the larger mass. The non-monotonic behaviour of the merger rate with respect to the binary mass ratio may have an appreciable impact on gravitational wave constraints.

PhD student session / **13**

Gravothermalizing into primordial black holes

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Very little is known about the universe's history from after the end of inflation until the Big Bang nucleosynthesis (BBN), which spans more than 10^{39} orders of magnitude in time scales. In this work, we show that if there was a long period of matter domination in this unknown period, and if the particle causing the matter domination has moderate self-interactions, then the matter particles can undergo gravothermal collapse to form primordial black holes (PBHs). We show that there is a critical mass threshold below which the $4 \to 2$ self-annihilations of the particles inhibit collapse to a black hole, instead producing a 'cannibal star'. For a conservative estimate of PBH abundance, we find a significant parameter space that predicts present-day PBH abundance of the same order as the dark matter abundance and with a mass range $10^{17} - 10^{21}$ g. For an optimistic estimate of PBH abundance, we find that PBHs with masses less than 10^9 g can reheat the universe prior to BBN.

Contributed Talks / **15**

Compaction function profiles from stochastic inflation

Author: Eemeli Tomberg[1]

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Strong perturbations from cosmic inflation produce primordial black holes (PBHs). The method of stochastic inflation lets us compute the perturbations beyond linear order. I discuss recent progress in numerical stochastic computations, focusing on the compaction function, a quantity controlling the PBH collapse. The numerical stochastic method allows us, for the first time, to produce full radial profiles of the compaction function needed for accurate estimates of PBH abundance and mass distribution. I discuss the nature of these profiles in an example model of single-field ultra-slow-roll inflation. I highlight their noisy, stochastic nature and raise the question of the correct way to assess the collapse threshold in a realistic model.

PhD student session / **16**

Scalar Induced Gravitational Waves: from early universe to PBH evolution

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Observations of gravitational waves (GWs) have opened up a new door to study the most energetic phenomena in our Universe. Among the variety of signals that we expect to observe with current and next generation of detectors, Primordial GW offer the exciting opportunity to explore the physics of the early Universe. They are generated from quantum vacuum fluctuations and come in the form of a stochastic background (SGWB). One contribution to the latter arises from "scalar-induced"GWs (SIGWs), that are produced by second-order effects and coupling of scalar perturbations.

Morerover primordial fluctuations producing SIGWs can additionally collapse to form primordial black holes (PBHs), providing a new channel to study their formations scenario and abundance.

In this talk I will present the computation of the source term of SIGW in a generic gauge and how this can be used to probe non-standard cosmological scenarios using GW interferometers.

Contributed Talks / **19**

Subsolar-mass Black Hole Searches

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Detecting a subsolar-mass black hole is one of the two possible ways to prove the existence of PBHs. I will review the recent searches for subsolar-mass black holes and the analysis of the possible candidates, as well as the merger rate predictions for subsolar PBH binaries with a focus on extended PBH mass distributions.

Contributed Talks / **20**

On the Cosmological Bound on Primordial Black Holes

Authors: Dominic Agius[1]; Gregory Suczewski[2]

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Primordial Black Holes (PBHs) may exist, contributing to the Dark Matter abundance. In this talk, we revisit the cosmological bound on PBHs – driven by the accurate measurements of the anisotropies in the Cosmic Microwave Background (CMB) – putting under the spotlight the role of the modeling of accretion physics as well as other sources of uncertainty related to PBH properties and the environmental baryonic gas. We present an up-to-date bound from the CMB on *heavy* PBHs, *i.e.* between tens to $\mathcal{O}(10^4)\,M_\odot$.

Contributed Talks / **21**

Anatomy of single-field inflationary models for primordial black holes

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In this presentation, we will outline the essential features and the phenomenology of single-field inflationary scenarios that can produce enhanced curvature power spectra associated with the production of primordial black holes. We will present a simple analytic set-up capable of capturing the spectral shapes in typical models presented in the literature. We will also discuss models capable of generating sizeable spectral oscillations and the presence or absence of "dips" - features where the power spectrum nearly vanishes.

PhD student session / **22**

Impact of Dark Matter spikes on the merger rates of Primordial Black Holes

Author: Pratibha Jangra[1]

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Primordial Black Holes (PBHs) may form in the early Universe by formation mechanisms such as large density fluctuations, bubble collisions, collapse of domain walls or collapse of cosmic strings. PBHs are considered as one of the possible candidates for dark matter. A huge amount of work has been done on PBHs because it is considered that the merger of PBHs binaries can also lead to the origin of gravitational waves seen by LIGO/VIRGO/KAGRA (LVK) Scientific Collaboration. We study the current merger rate of PBHs binaries based on the assumption that PBHs are non-particle candidates of dark matter having a spike of non-annihilating cold dark matter particles such as axions around them. For that we extend the previous calculations of the merger rate of PBH binaries for extended PBH mass functions. Using analytical and numerical approaches, we calculate the current merger rates of PBH binaries with DM spikes assuming that either the DM spikes are completely thrown out of the binaries or they remain static during the merger. We found that the presence of DM spikes alters the distribution of final merger time and size of binaries in such a way that it can lead to either increase or decrease in the merger rate of PBH binaries, in comparison to the PBH binaries without DM spikes. Also, the binary black hole mergers seen in third Gravitational-Wave Transient Catalog (GWTC - 3) of LVK Collaboration can be very well explained by the mergers of PBH binaries with and without DM spikes for Lognormal and Power Law mass function (MF) in PBH mass range $5\,\mathrm{M}_\odot \leq m_{\mathrm{pbh}} \leq 100\,\mathrm{M}_\odot$ and $10^{-2}\,\mathrm{M}_\odot \leq m_{\mathrm{pbh}} \leq 100\,\mathrm{M}_\odot$ respectively, leading to $f_{\mathrm{pbh}} \leq \mathcal{O}(10^{-5} - 10^{-3})$ which is consistent with the previous results. As per our assumptions about the presence of DM spikes around PBHs, this work applies very well to the binaries having either comparable PBH masses or highly assymetric PBH masses, but a general formalism can be developed in future which can apply to binaries having PBHs in any mass ratios.

Contributed Talks / **24**

Clustering of PBHs in the stochastic-δN formalism

Authors: Chiara Animali[1]; Vincent Vennin[1]

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Primordial black holes may form in the early universe from the collapse of rare, enhanced curvature perturbations. In the presence of such large perturbations, quantum diffusion cannot be neglected. Remarkably, it can be incorporated through the stochastic-δN formalism, which can be used to reconstruct the statistics of the curvature perturbation when non negligible quantum diffusion is at play. A general result of this procedure is the presence of heavy exponential tails in the probability density function of cosmological inhomogeneities, which largely affect predictions for PBHs.

I will present how the stochastic-δN formalism can be extended to arbitrary coarse graining and to multiple point statistics. In particular, the latter will be used to derive the two-point statistics of high threshold perturbations, which is needed to derive their spatial correlation. This formalism can be used to investigate whether quantum diffusion affects the spatial distribution of primordial black holes, inducing small-scale clustering at formation. I will present this analysis in single toy models and compare our findings with results obtained by assuming that primordial black holes arise from gaussian perturbations.

Contributed Talks / **25**

Milky Way Black Holes Hiding in Plain Sight

Author: William Dawson[1]

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We will present our investigation into the abundance and properties of black holes through photometric gravitational microlensing surveys of the Milky Way. We have used the PopSyCLE simulation suite to estimate the abundance and characteristics of black holes in existing and future surveys, both for stellar end-product and primordial formation mechanisms. Based on these simulations we have determined optimal filters for black hole identification in photometric light curve surveys and used these simulations in conjunction with the microlensing survey data to estimate the mass and class (i.e., star, black hole, neutron star, etc.) probability density functions. Our method provides a new means of finding far more black holes than traditional approaches, as well as a new means of constraining the properties of the Milky Way. An underlying thread of the presentation will discuss the microlensing communities historical use of biased estimators (e.g., histograms of single point estimators), introduce alternative unbiased estimators, and discuss the impact to physical interpretations both past and present.

PhD student session / **27**

PBHs in no-scale Supergravity and their associated GW signal in Nanograv and beyond

Author: Charalampos Tzerefos[1]

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In this talk, I am going to present our recent work where we derive a characteristic three-peaked GW signal within the framework of no-scale Supergravity, which arises as a low energy limit of superstring theory. We concentrate on the primordial gravitational wave (GW) spectrum induced due to second-order gravitational interactions by inflationary curvature perturbations as well as by isocurvature energy density perturbations of primordial black holes (PBHs) both amplified due to the presence of an early matter-dominated era (eMD) before Big Bang Nucleosynthesis (BBN). In particular, we work with inflection-point inflationary potentials naturally realised within Wess-Zumino type no-scale Supergravity and giving rise to the formation of microscopic PBHs triggering an eMD era and evaporating before BBN. Remarkably, we obtain an abundant production of gravitational waves at the frequency ranges of nHz, Hz and kHz and in strong agreement with NANOGrav/PTA GW data.

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Detectability of Primordial Black Holes at the Galactic Center with Gravitational Waves

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In our work we characterized the expected gravitational wave signal detectable by the planned spaceborne interferometer LISA and the proposed next generation spaceborne interferometer μAres arising from a population of primordial black holes orbiting SgrA. *Assuming that such objects indeed form the entire diffuse mass allowed by the observed orbits of stars in the Galactic center* ($< 4 \times 10^3$ $M_\odot$ *within a radius of* 10^{-3} *pc from SgrA*), I will present our results in terms of the expected signal in gravitational waves, either from resolved and non-resolved sources under assumptions of circular or eccentric orbits as well as different monochromatic mass functions.

Contributed Talks / 30

Does the size of the one-loop correction rule out PBH formation?

Author: Matthew Davies[1]

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To produce an appreciable quantity of primordial black holes (PBHs), there needs to be a significant enhancement of the amplitude of the primordial power spectrum at short-scales. Large enhancements on short-scales, however, can induce a large contribution to the one-loop correction to the power spectrum on CMB scales. The size of this correction has been hotly debated since Kristiano and Yokoyama's claim that, in a wide class of PBH-producing models, the loop correction to CMB scales is too large and breaks perturbativity. In this talk we'll explore some of the key points of contention in the literature and present new results for the loop correction computed numerically from a potential.

Plenary Session / **36**

Welcome Introduction

Authors: Antonio Masiero[1]; Paolo Valente[1]

[1] *Istituto Nazionale di Fisica Nucleare*

Plenary Session / **37**

Primordial Black Holes after 50 years: a positive perspective

Author: Bernard Carr[1]

[1] *Queen Mary University of London*

This talk presents a historical perspective of the study of primordial black holes (PBHs), my first talk on the subject being 50 years since. PBH papers have usually focused on constraints on their abundance, this having interesting implications for cosmology even if they never formed. However, in recent years attention has turned to the possibility that they might actually exist and solve various cosmological conundra. Numerous arguments will be reviewed, based on observational evidence from a variety of lensing, dynamical, accretion and gravitational-wave effects. This represents what might be termed a positivist perspective. The most exciting possibility is that PBHs provide the dark matter, in which case their Poisson clustering could have important implications for later structure formation. Also if they form at the QCD phase transition, the tiny collapse fraction required might naturally explain the cosmic photon-to-baryon ratio and the comparability of the PBH and baryon densities. Even if PBHs provide only a small fraction of the dark matter, they might still explain some of the galactic and quasar microlensing events, the LIGO/Virgo/KAGRA gravitational wave events, the spatial coherence in the fluctuations of the source-subtracted cosmic infrared and soft X-ray backgrounds, some anomalies associated with Ultra Faint Dwarf galaxies, and the supermassive black holes in galactic nuclei. With a suitable extended mass spectrum, they might even explain all these anomalies. So an exciting new era in PBH research has began and observations are already probing this proposal.

Plenary Session / **38**

Primordial black hole formation from cosmological perturbations: recent developments

Author: Tomohiro Harada[1]

[1] *Rikkyo University (Tokyo)*

Primordial black holes may have been formed from sufficiently large amplitude perturbations in the early Universe. The central aim of the formation studies is to predict the abundance and other properties of PBHs, given the cosmological scenario. Both numerical relativity simulations and analytical investigations play an important role. In this talk I will introduce some of the recent developments, focusing on the dynamics in different situations.

Plenary Session / **39**

Primordial black holes: A fine (tuned) opportunity for probing inflation

Author: Christian Byrnes[1]

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From the origin of the merging compact objects seen by LIGO-Virgo-KAGRA to the source of the stochastic gravitational waves seen by pulsar timing arrays via the QCD transition, there is a happy coincidence of scales which could point to primordial black holes. Combined with the long running dark matter search and hunt for new observables from inflation, there are many reasons to hope to learn a lot from PBHs. However, generating such black holes in a simple inflationary model remains far from simple.

Plenary Session / **41**

Primordial black holes from single field inflation?

Author: Jun'ichi Yokoyama[1]

[1] *University of Tokyo*

In this talk, I discuss one-loop quantum correction to the spectrum of curvature perturbation in inflationary models with enhanced power spectrum on small scale due to the so-called ultra slow-roll
behavior.

Special Event / **55**

From the past to the future of time

Author: Stefano Liberati[1]

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Time has been a constant puzzle for mankind and the development of modern science just served to even more pinpoint the tantalising nature of this concept and its apparent clash with the current physical understanding of the world. In this brief seminar I will try to convey a brief history of time

and try to point out foreseeable developments of our understanding of its nature within the fabric of reality.

Special Event / **56**

Shapes and a Dynamical Arrow of Time

Author: Julian Barbour[1]

[1] *University of Oxford*

I will show that if the philosophically dubious absolute elements which Newton introduced when he created dynamics are eliminated, his theory of gravity applied to a model universe leads to a theory of time and its arrow that is a direct consequence of Newton's laws. The arrow, which does not arise from a special condition of low entropy in the early universe that must be imposed in addition to the dynamical laws, points in the direction of increasing order and not, as widely believed on the basis of the second law of thermodynamics, entropic disorder. I will also draw attention to the dramatic change of perspective that results from the recognition that no ruler exists outside the universe to measure its size. Only the shape of the universe is physically meaningful. Since from the point of view of group theory Newton's and Einstein's theories of gravity have the same architectonic structure, these Newtonian features may well be true of our universe described by Einstein's theory.

Special Event / **57**

Paradoxes and metaphors of time in between physics and philosophy

Author: Silvia De Bianchi[1]

[1] *University of Milan*

In this contribution I describe the fundamental tension that characterized Western culture in representing time as being fundamental and emergent, especially in fundamental physics and cosmology. I shall discuss the reasons of the persistence of this tension in current physics and then show why in what appears to be a conflict without resolution there is also a stimulating tool for research.

Special Event / **65**

Welcome Introduction

Special Event / **66**

Mach Principle and the nature of Inertia

Author: Luciano Pietronero[1]

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The gravitational mass is a local property of particles like the electric charge, while the inertial mass is the resistance to acceleration, quite a different property. Mach's principle states that inertial forces should be due to the interaction of a body with all the other masses in the universe. In General Relativity this principle is not fully present and is replaced by the equivalence principle, according to which inertial and gravitational masses are linked by the gravitational constant, which is a fixed number. However, according to a strict interpretation of Mach's principle, the inertial mass should be non local and depend on all the other masses of the universe and their positions. In this perspective the gravitational constant cannot be just a fixed number. In 1918 Thirring studied the metric inside a rotating spherical mass shell and it was clearly inspired by the conceptual problem of Mach's principle. This study revealed the appearance of a force with the structure of Coriolis force. No centrifugal like force was present but there was also a curious vertical force. In 1973 we considered a cylindrical rotational symmetry and extended the approach to second order in the gravitational constant. We found that a rotating cylinder leads to a metric which gives exactly the Coriolis term and the centrifugal one with the correct relations. Recently we have reconsidered this problem extending to the case of a linear acceleration. All these results strongly point to the idea that real inertia is the outcome of a relative motion and this would require a generalization of GR theory.

Special Event / **67**

Open moderated discussion

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Plenary Session / **68**

Searching for Primordial Black Holes from the QCD Epoch Using Gravitational Waves

Author: Gabriele Franciolini[1]

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Primordial Black Holes (PBHs) might comprise a significant fraction of dark matter in the Universe and can give rise to observable signatures in current and future gravitational wave (GW) experiments. Focusing on PBHs in the mass range probed by the LIGO/Virgo/Kagra detectors, I will present the results of Bayesian multi-population inference on the most recent dataset. The analysis includes a subpopulation of PBH mergers modeled from first principles, taking into account the softening of the equation of state during the QCD era. These findings allow for setting constraints on both the PBH abundance and the inflationary dynamics underlying PBH formation within the standard scenario. I will then discuss how future observations can improve upon these constraints by searching for specific signatures of PBH mergers.

Plenary Session / **69**

Merger rate of primordial black holes

Author: Martti Raidal[1]

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I shall present some details how to compute the PBH merger rate and show results of a dedicated simulation of PBH clustering at the early Universe. I apply the results to fit LIGO data and derive constraints on PBH abundance. I discuss the possibility that LIGO has observed two populations of black holes, astrophysical and primordial.

Plenary Session / **70**

Exploring the Gravitational Wave Universe with PTAs: where we are and where we are going

Author: Andrea Mitridate[1]

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By tracking the arrival times of radio pulses from a collection of pulsars in the Milky Way, several pulsar timing array collaborations have found evidence for a background of gravitational waves permeating our galaxy. In this talk, I will present this evidence and discuss possible paths forward to discriminate between astrophysical and cosmological interpretations of this background.

Plenary Session / **71**

Calculating the abundance of primordial black holes: complications and opportunities

Author: Sam Young[1]

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With modern and upcoming surveys providing ever tightening constraints, and even potential detections, it is becoming more important than ever to make robust and precise calculations for the abundance of primordial black holes (PBHs). Their abundance depends strongly on the primordial power spectrum, and constraints on the PBH abundance have historically been used to place unique constraints on the power spectrum, although complications such as non-Gaussian distributions and phase transition are often neglected - the effects of which can be degenerate with the effect of the power spectrum. However, by considering other factors, such as the initial clustering mass function, these complications can provide an opportunity to reveal more information about the early universe. In this talk, I will first describe how the abundance and mass function can be calculated, before discussing how phase transitions and non-Gaussianities can leave characteristic signatures in the PBH mass function, abundance and clustering.

Plenary Session / **72**

Dark and shiny dresses around Primordial Black Holes

Author: Daniele Gaggero[1]

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I will discuss the interplay between the phenomenology of primordial black holes and the dark matter searches. I will first briefly review the most relevant constraints on PBH abundance, highlighting the caveats and uncertainties. Then, I will discuss how a sub-dominant component of PBHs interacts with the bulk of the DM. In particular, I will describe how a DM "mini-halo" is expected to form around PBHs, with relevant phenomenological consequences. The focus will be on two effects in particular. (i) The dark mini-halo can alter the evolution of a PBH binaries due to dynamical friction. I will discuss the impact of friction on the merger rate of a population of PBHs, and the subsequent impact on current bounds and future high-redshift searches. (ii) If the bulk of the DM is composed of WIMPs, the mini-halos would shine in gamma rays. Hence, a hypotetical future detection of a sub-dominant component of PBHs could allow to set very stringent constraints on the WIMP annihilation cross section.

PhD student session / **73**

Constraints on primordial black holes beyond the Hawking picture

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The energy injection through Hawking evaporation has been used to put strong constraints on primordial black holes as a dark matter candidate at masses below 10^18 g. However, recent work has shown that Hawking's semiclassical approximation breaks down at latest after half-decay. Beyond this point, the evaporation could be significantly suppressed. In this work, we review existing cosmological and astrophysical bounds on primordial black holes. We show that the constraints disappear completely for a reasonable range of parameters, which opens a new window on light primordial black holes as a dark matter candidate.