Focus Week on Primordial Black Holes

Report of Contributions

https://indico.ipmu.jp/e/301

Contribution ID: **1** Type: **not specified**

Bernard Carr: PRIMORDIAL BLACK HOLES AS THE SOLUTION OF MANY COSMOLOGICAL CONUNDRA

Monday 2 December 2019 13:00 (45 minutes)

Studies of primordial black holes (PBHs) have often focused on constraints on their abundance since this has interesting implications for cosmology even if they never formed. However, in recent years attention has turned to the possibility that they actually exist and solve various cosmological conundra. The most exciting possibility is that they provide the dark matter, although this is only feasible in a few mass windows. In particular, 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 OGLE and quasar microlensing events, the LIGO/Virgo 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 various observations will probe this proposal in the near future.

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

Masahiro Takada: Constraining PBH with microlensing

Monday 2 December 2019 13:50 (45 minutes)

I here describe how microlensing is powerful to constrain the abundance of PBH.

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

Shi Pi: Universal infrared scaling of induced gravitational waves

Monday 2 December 2019 14:40 (20 minutes)

I will talk about the general infrared behavior of the power spectrum of a stochastic gravitational wave background Ω_{GW} produced by stress tensor with bilinear structure, focusing on the gravitational waves induced by scalar perturbations. If the source term is bounded in both frequency and time and reenters the Hubble horizon in a radiation-dominated stage, we have a universal k^3-scaling for k smaller than all the physical scales associated with the source, like the peak frequency, peak width, and time duration, etc. I will also talk about possible violations of these conditions and their physical implications.

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

Ruth Gregory: Primordial Black Holes and Higgs Vacuum Decay

Tuesday 3 December 2019 10:00 (45 minutes)

The recent discovery of the Higgs and its mass suggests that our vacuum may by metastable. I will review how we calculate the probability of vacuum decay and discuss how black holes alter this rate. This leads to a constraint either on primordial black hole formation or the Higgs potential.

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

Alexander Kusenko: PBH production via scalar field fragmentation

Tuesday 3 December 2019 11:10 (45 minutes)

I will discuss a novel class of scenarios for PBH formation, which do not place any particular requirements on inflation. A scalar field with a relatively small mass can develop a large VEV during inflation. Relaxation of such a field after inflation can result in fragmentation via a well-known instability, with formation of matter in the form of scalar lumps or Q-balls. If this kind of matter comes to dominate the energy density temporarily, until the lumps decay, then PBH can form from the relatively large fluctuations associated with the small number of "particles" per volume.

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

Volodymyr Takhistov ⁚ Gaining Insight into PBH Dark Matter with Compact Stars

Tuesday 3 December 2019 13:00 (45 minutes)

Recent re-evaluations of PBH constraints show that the parameter space window for small PBHs to constitute all of the DM is significantly larger than previously thought. I will discuss how novel signals from tiny PBHs interacting with compact stars can not only lead to new insights into this difficult to probe parameter region of dark matter, but also contribute to resolution of long-standing astronomical puzzles such as the origin of gold and other heavy elements.

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

George Fuller: Supermassive Stars and Black Hole Seeds: A narrow mass range with triple trouble; Dark Sector production of supermassive black hole seeds

Tuesday 3 December 2019 13:50 (45 minutes)

I discuss two topics: (1) A narrow range of masses for primordial metallicity supermassive stars exhibit a coincidence of three factors that may or may not set them up for explosion after the general relativistic instability initiates their collapse; and (2) Late vacuum phase transitions and a variety of other dark sector beyond-standard-model physics may generate fluctuations which give rise to black holes

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

Hayato Motohashi: Constant roll and primordial black holes

Tuesday 3 December 2019 14:40 (20 minutes)

Constant-roll inflation is an interesting phenomenological class of inflationary models in which the assumption of inflaton slow-roll is replaced by more general constant-roll condition, and the second slow-roll parameter is not necessarily negligible. The constant-roll inflation with small positive value of the constant-roll parameter has been known to produce a slightly red-tilted curvature power spectrum compatible with the current observational constraints. In this work, we shed light on the constant-roll inflation with the constant-roll parameter with the range $-3/2 < \beta < 0$, which allows for a constant-roll attractor stage generating a blue-tilted curvature power spectrum without superhorizon growth, and investigate its application to production of primordial black holes. References: [1] H. Motohashi, A. A. Starobinsky, J. Yokoyama, JCAP 1509 (2015) 09, 018, [arXiv:1411.5021]. [2] H. Motohashi, S. Mukohyama, M. Oliosi, [arXiv:1910.13235].

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

Edoardo Vitagliano: Exploring Primordial Black Holes from Multiverse with Optical Telescopes

Wednesday 4 December 2019 10:00 (45 minutes)

Primordial black holes (PBHs) have long been considered a viable candidate for the dark matter. While the abundance of PBHs with large masses has been constrained with a multitude of astrophysical observations, recent re-analyses of bounds on smaller PBHs have opened a significant window of the previously excluded parameter space for PBHs to constitute the dark matter (DM). In light of this, we revisit and generalize the treatment of PBHs generated by vacuum bubble nucleation during inflation that can constitute all of the DM. The resulting PBHs have a broad mass spectrum distribution with an extended tail that could be detected with optical surveys and that can naturally explain the candidate event in Subaru Hyper Suprime-Cam (HSC) data. Future observations of HSC and other optical surveys such as LSST will be able to not only probe the formation epoch of such black holes, but entirely rule out this generic formation mechanism as the dominant source of PBH dark matter.

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

Kazunori Kohri: Formations and evolutions of PBHs in the matter-dominated Universe

Wednesday 4 December 2019 11:10 (45 minutes)

Primordial Black Holes (PBHs) can be produced even in the early matter dominated Universe due to collapses of regions which have large curvature perturbation produced by inflation.

I will review the current status of formations and evolutions of PBHs in the early matter dominated Universe. If time allows, I will also mention cosmological and astrophysical constraints on PBHs with introducing my own bounds on PBHs in terms of polarization of Cosmic Microwave Background photons due to cosmological accretions onto PBHs (arXiv:1707.04206 [astro-ph.CO]), cosmological/gamma-ray/cosmic-rays bounds on evaporating PBHs (arXiv:0912.5297 [astro-ph.CO]), Higgs phenomenology (arXiv:1708.02138 [hep-ph]), stochastic GWs (arXiv:1903.05924 [astro-ph.CO], arXiv:1903.05924 [astro-ph.CO]), dark matter (arXiv:1802.06785 [astro-ph.CO]), ultra-compact mini halo formations (arXiv:1712.08820 [astro-ph.CO] and arXiv:1905.04477 [astro-ph.CO]), clustering (arXiv:1909.04053 [astro-ph.CO]) and so on.

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

Chris Byrnes: Determining the origin of LIGO's merging black holes

Wednesday 4 December 2019 13:00 (45 minutes)

Although there is a reasonably broad consensus that primordial black holes in the mass range detected by LIGO and Virgo cannot make up more than a small fraction of the dark matter, it remains possible that all of the black holes whose merger LIGO has detected were primordial in origin. I will briefly summarise the evidence and challenges behind this claim, and then focus on how current and future data can be used to discriminate between astrophysical and primordial black holes. I will discuss the black hole mass function, the mass ratio of the merging pairs, and how the merger rate is modified by (small) amounts of primordial non-Gaussianity. Finally, I will briefly show that the QCD transition when the horizon mass was about one solar mass may lead to a large enhancement in the formation rate of primordial black holes with mass below the Chandrasekhar mass limit.

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

Cristiano Germani : Universal threshold and non-linear PBHs statistics

Wednesday 4 December 2019 13:50 (45 minutes)

Abs: In the first part of this talk I will show that the threshold for PBHs formation, in a radiation dominated universe, can be analytically given by the use of a universal formula for the averaged compaction function. In the second part, I will present the full non-linear statistics of PBH abundance related to Gaussian curvature perturbations.

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

Tomohiro Harada: Effect of Inhomogeneity on Primordial Black Hole Formation in the Matter Dominated Era

Wednesday 4 December 2019 14:40 (20 minutes)

We investigate the effect of inhomogeneity on primordial black hole formation in the matter dominated era. In the gravitational collapse of an inhomogeneous density distribution, a black hole forms if the apparent horizon prevents information of the central region of the configuration from leaking. Since information cannot propagate faster than the speed of light, we identify the threshold of the black hole formation by considering the finite speed for propagation of information. We show that the production probability β_inhom(σ) of primordial black holes, where σ is the density fluctuation at horizon entry, is significantly enhanced from that derived in previous work in which the speed of propagation was effectively regarded as infinite. For σ≪1, we obtain βinhom≃3.70σ^(3/2), which is larger by about an order of magnitude than the probability derived in earlier work by assuming instantaneous propagation of information.

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

Masahiro Kawasaki : Particle physics models for primordial black hole formation

Thursday 5 December 2019 10:00 (45 minutes)

We present two scenarios for primordial black hole (PBH) formation. One is PBH formation by Affleck-Dine mechanism which produces high baryon bubbles after inflation.
Those high baryon bubbles produce high density contrasts and collapse, which leads to formation of PBHs. This scenario can account for LIGO PBHs or seeds for supermassive BHs.
The other scenario is PBH formation from non-topological solitons. We perform lattice simulation for
oscillon formation and show that oscillons may produce density fluctuations large enough for PBH formation.
This scenario could account for a significant fraction of dark matter.

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

Alexander Dolgov: Astronomical data in favor of abundant population of PBH in the universe and the mechanism of their formation.

Thursday 5 December 2019 11:10 (45 minutes)

A review is presented on the recent astronomical data, which indicate that the bulk of black holes in the universe in all mass ranges are mostly primordial. A mechanism of PBH formation with the necessary properties is discussed.

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

Antonio Riotto: Primordial Black Holes and Gravitational Waves

Thursday 5 December 2019 13:00 (45 minutes)

We will discuss some aspects of primordial black holes and how LISA will be able to detect the associated gravitational waves.

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

Alexandros Kehagias: Unstable modes in Kerr Black Holes

Thursday 5 December 2019 13:50 (45 minutes)

I will discuss stability issues of classical fields in the Kerr black hole backgrounds.
In particular, I will describe mass bounds for instability of massive scalar and vector modes in the subcritical regime. In addition, some results on the construction of massive vector growing modes will be presented.

Blackboard was used. No material files attached.

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

Minxi He: On the formation threshold of rotating primordial black holes

Thursday 5 December 2019 14:40 (20 minutes)

The spin of black holes is one of the important observables in gravitational wave detection. As LIGO/Virgo have found a number of events of black hole mergers and some of them are of small effective spins, one possibility is that these black holes are primordial because it is believed that primordial black holes (PBH) have small spin. One important factor that affects the spin distribution of PBHs is the modified formation threshold by rotation. We discuss the effect of the angular momentum on the formation threshold of primordial black holes formed in the radiation-dominated epoch by direct gravitational collapse of large primordial density perturbations. We find that the threshold is increased in proportional to the square of the angular momentum.

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

Savvas Koushiappas: Detecting primordial black holes

Friday 6 December 2019 10:00 (45 minutes)

I will discuss how we can infer the existence of primordial black holes. I will focus on stellar kinematics, merger rates and the possibility of a WIMP particle dark matter / primordial black hole co-existence using 1-point function statistics.

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

Misao Sasaki: TBA

Friday 6 December 2019 11:10 (45 minutes)

TBA

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

Yuichiro Tada: Primordial black hole tower: Dark matter, earth-mass, and LIGO black holes

Friday 6 December 2019 13:00 (20 minutes)

We investigate a possibility of primordial black hole (PBH) formation with a hierarchical mass spectrum in multiple phases of inflation. As an example, we find that one can simultaneously realize a mass spectrum that has recently attracted a lot of attention: stellar-mass PBHs (~O(10)M_\odot) as a possible source of binary black holes detected by LIGO/Virgo collaboration, asteroid-mass (~O(10^-12)M_\odot) as a main component of dark matter, and earth-mass (~O(10^-5)M_\odot) as a source of ultrashort-timescale events in Optical Gravitational Lensing Experiment microlensing data. The recent refined de Sitter swampland conjecture may support such a multiphase inflationary scenario with hierarchical mass PBHs as a transition signal of each inflationary phase.

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

Teruaki Suyama: Clustering of primordial black holes with non-Gaussian initial fluctuations

Tuesday 3 December 2019 16:00 (20 minutes)

We formulate the two-point correlation function of primordial black holes (PBHs) at their formation time, based on the functional integration approach which has often been used in the context of halo clustering. We find that PBH clustering on super-Hubble scales could never be induced in the case where the initial primordial fluctuations are Gaussian, while it can be enhanced by the so-called local-type trispectrum (four-point correlation function) of the primordial curvature perturbations.

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

Chulmoon Yoo: Abundance of primordial black holes with local non-Gaussianity in peak theory

Tuesday 3 December 2019 16:25 (20 minutes)

We discuss the effect of local type non-Gaussianity on the abundance of primordial black holes (PBH) based on the peak theory. We provide the PBH formation criterion based on the so-called compaction function and use the peak theory statistics associated with the curvature perturbation with the local type non-Gaussianity. Providing a method to estimate the PBH abundance, we demonstrate the effects of non-Gaussianity. It is explicitly shown that the value of non-linear parameter |fNL| ~ 1 induces a similar effect to a few factors of difference in the amplitude of the power spectrum.

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

Anand Hedge: Gravitational Thomas Precession: New Window to Study PBHs

Friday 6 December 2019 13:25 (20 minutes)

Thomas Precession eect is purely a relativistic eect which has been studied extensively in the premises of Special Relativity. From a relativist's perspective, it is due to the non-commutative nature of Lorentz groups. Thomas Precession in the context of general relativity can be realized as a Fermi-Walker transport equa- tion. In this paper, we study Thomas Precession of spin vector upon a passage of gravitational waves. We observe that, the gravitational waves produce Gravitational Thomas Precession when they pass through the system characterized by spin. Conventionally the consequence of Thomas Precession in special relativistic regime can be observed in the ne structure of Hydrogen. We nd out that, in the case if simplied toy model of binary mergers, the ne structure energy levels of hydrogen to be shifted. This is unique signature of the source and encoded like a memory in the atomic spectra. We further propose this eect can be observed in events involving Primordial Black Holes(PBHs) of mass as light as O(10⊠13)M. In this paper we examine the signatures of distribution of primordial blackholes us- ing aforementioned gravitational Thomas Precession. Further we propose the idea of mapping the background in terms of this new Gravitational Thomas Precession eect and thereby, use it to probe and put constraint on mass spectrum.

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

Yi-Peng Wu: Statistical bias for black hole mass functions from the inflationary power spectrum

Friday 6 December 2019 13:50 (20 minutes)

The spatial configuration near local extrema of the primordial density perturbation restricts the statistics of high-density peaks valid for the formation of
primordial black holes (PBHs). We argue that the condition for density extrema to be maxima in the peak statistics leads to an universal enhancement to the extended mass function of PBH estimated by the Press-Schechter method. For the inflationary spectrum
in the narrow-spike class, the mass function from the peak theory is up-lifted in all mass range, indicating a severer constraint to models in the favor of considering PBHs as all dark matter.