spring workshop on gravity and cosmology

Thursday, May 16, 2019 - Friday, May 17, 2019

University of Warsaw

Book of Abstracts

Contents

inflation and PBH / **3**

Merger rate of primordial black hole binaries:I

Discovery of black hole binaries by LIGO/Virgo provoked a renewed interest in primordial black holes (PBHs). After I give a brief introduction of PBHs, I explain how PBHs form binaries and compute their merger rate.

inflation and PBH / **4**

Merger rate of primordial black hole binaries:II

This is a continuation of my first talk.

inflation and PBH / **5**

Early Universe Models in Light of the Swampland Constraints

Cosmological inflation has been the main paradigm for early universe cosmology since the early 1980s, but we are still lacking an embedding of inflation into fundamental physics. I will discuss constraints on inflation, and on other scenarios of early universe cosmology, which arise when one tries to embed the scenarios into superstring theory.

Inflation and PBH (II) / **6**

Stochastic inflation beyond slow roll

I will discuss how to apply stochastic formalism for inflation beyond the usual slow-roll approximation. We verify that the assumptions on which the stochastic formalism relies still hold even far from the slow-roll attractor. In particular this requires the separate universe assumption to hold for long-wavelength perturbations of the scalar field beyond slow roll. In general, there is a gauge correction to the amplitude of the stochastic noise which is usually calculated in the spatially-flat gauge. We show that if the number of e-folds is used as the time variable (the uniform-N gauge) then these corrections vanish in the slow-roll limit, but we explain how to calculate them in general.

Inflation and PBH (II) / **7**

Stochastic Inflation and Primordial Black Holes

Primordial black holes can be seeded by large cosmological fluctuations produced during inflation. This happens if the potential for inflation is sufficiently flat in some regions. However, in such regions, the dynamics of the inflaton is dominated by quantum diffusion rather than by classical slow roll. This implies that the standard method to calculate the amplitude of the fluctuations, hence

the abundance of black holes, breaks down. We show how a proper calculation of inflationary perturbations that incorporates the effect of quantum diffusion can be performed using the formalism of stochastic inflation. We discuss how the predictions for the primordial black holes abundance change, hence how the constraints on the inflationary potential coming from their non detection are modified.

Inflation and PBH (III) / **8**

Inflationary correlators from the stochastic spectral expansion

Continuing on the topic of the stochastic formalism, in this talk I will present the lesser known stochastic spectral expansion and show how it can be used to calculate correlation functions generated during inflation. I also discuss the shortcomings of some of the commonly used approximations and present the full stochastic calculation for the isocurvature spectrum of a decoupled spectator, which demonstrates that it is a viable candidate of dark matter, contrary to popular belief. arXiv:1904.11917 & arXiv:1811.02586

Inflation and PBH (II) / **9**

Testing PBHs by gravitational-wave observations

Given a possibility that black holes detected by LIGO/Virgo are PBHs, a next direction we should proceed is to propose ideas for testing the PBH hypothesis. I will introduce my recent proposal that makes use of the mass distribution as well as other proposals.

Inflation and PBH (III) / **10**

Primordial Black Holes abundance

In this talk I will discuss how to calculate the abundance of primordial black holes given an inflationary power spectrum

Inflation and PBH (II) / **11**

free discussion

Inflation and PBH (III) / **12**

Numerical simulation of Primordial Black Holes

In this talk I will present a fast and new procedure to calculate the averaged mass excess threshold δc of primordial black holes from a given cosmological perturbation profile using pseudo-spectral methods, numerically solving the Misner-Sharp equations. I apply the method in the cosmological context to put constraints on the inflationary power spectrum.

Inflation and PBH (III) / 13

Failure of the stochastic approach to inflation beyond slow-roll

After giving a pedagogical review I will clarify that the stochastic approach to inflation is generically reliable only at zeroth order in the (geometrical) slow-roll parameter ϵ_1 if and only if ϵ2_2≪6/ϵ_1, with the notable exception of slow-roll. This is due to the failure of the stochastic ΔN formalism in its standard formulation. However, by keeping the formalism in its regime of validity, I will show that, in ultra-slow-roll, the stochastic approach to inflation reproduces the power spectrum calculated from the linear theory approach.

Inflation and PBH (III) / 14

free discussion

Inflation and PBH (III) / 15

Properties of the primordial power spectrum for PBH production

I will discuss the properties of the primordial power spectrum so that PBHs are produced in accordance with the constraints coming from the CMB and BBN observables. I will mainly focus on the large wavenumbers of the power spectrum where, if there is a peak, PBH with sub-solar masses are generated. Then I will describe the scenario that the dark matter in the universe is comprised either of PBHs or the evaporation remnants of PBHs. I will present inflationary models that can trigger the PBH formation in the framework of α-attractors, introducing also an explicit example, that of a runaway inflationary model.

Inflation and PBH (III) / 16

Oscillations that mimick weak lensing

The latest Planck's analysis of the power spectrum finds 10% more lensing smoothing than predicted by LCDM at 2 sigma. If it is not a statistical fluke, it could indicate new physics that mimick the smoothing effect of lensing. What could that be and how was generated? First, I will show you that oscillations in the primordial power spectrum with the same frequency as the acoustic peaks but out of phase, resemble the effects of lensing. Then, I will focus on the general mechanisms that could have created these oscillations during inflation and we will see that it is not that easy.

Nevertheless, I will provide you with a concrete example that works: a bump in the sound speed of scalar perturbations.

Inflation and PBH (III) / 17

free discussion