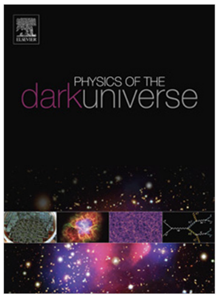
Accepted Manuscript



Primordial black holes from single field models of inflation

Juan García-Bellido, Ester Ruiz Morales

PII: S2212-6864(17)30049-3
DOI: http://dx.doi.org/10.1016/j.dark.2017.09.007
Reference: DARK 173

To appear in: *Physics of the Dark Universe*

Received date : 11 September 2017
Revised date : 13 September 2017
Accepted date : 14 September 2017

Please cite this article as: J. García-Bellido, E.R. Morales, Primordial black holes from single field models of inflation, *Physics of the Dark Universe* (2017), http://dx.doi.org/10.1016/j.dark.2017.09.007

IFT-UAM/CSIC-17-007

Primordial black holes from single field models of inflation

Juan García-Bellido*
Instituto de Física Teórica UAM-CSIC, Universidad Autonóma de Madrid,
Nicolás Cabrera 13, Cantoblanco, 28049 Madrid, Spain
CERN, Theoretical Physics Department, 1211 Geneva, Switzerland

Ester Ruiz Morales†
Departamento de Física, Universidad Politécnica de Madrid, Ronda de Valencia 3, 28012 Madrid, Spain
CERN, Theoretical Physics Department, 1211 Geneva, Switzerland
(Dated: September 23, 2017)

Primordial black holes (PBH) have been shown to arise from high peaks in the matter power spectra of multi-field models of inflation. Here we show, with a simple toy model, that it is also possible to generate a peak in the curvature power spectrum of single-field inflation. We assume that the effective dynamics of the inflaton field presents a near-inflection point which slows down the field right before the end of inflation and gives rise to a prominent spike in the fluctuation power spectrum at scales much smaller than those probed by Cosmic Microwave Background (CMB) and Large Scale Structure (LSS) observations. This peak will give rise, upon reentry during the radiation era, to PBH via gravitational collapse. The mass and abundance of these PBH is such that they could constitute the totality of the Dark Matter today. We satisfy all CMB and LSS constraints and predict a very broad range of PBH masses. Some of these PBH are light enough that they will evaporate before structure formation, leaving behind a large curvature fluctuation on small scales. This broad mass distribution of PBH as Dark Matter will be tested in the future by AdvLIGO and LISA interferometers.

PACS numbers: 98.80.Cq

I. INTRODUCTION

The nature of Dark Matter (DM) is one of the remaining mysteries of Modern Cosmology. We know it exists since at least 1933, from the first observations of galaxy cluster dynamics by Fritz Zwicky, all the way to full consistency with CMB anisotropies observed by Planck, and LSS formation measured by galaxy surveys. Its nature is still unknown. For a recent review see [1]. There are more than forty orders of magnitude in mass for the range of possible fundamental constituents, from ultralight axions [2] to supermassive black holes [3, 4]. Some of the possible Particle Dark Matter (PDM) candidates have recently been strongly constrained as the dominant component of DM (e.g. massive neutrinos, WIMPS, heavy axions, etc.), although there is still room for more exotic components.

In this paper we explore the possibility that DM is composed primarily of Primordial Black Holes. The first time a connection between PBH and DM was made was in the paper of Chapline [5], where the lightmass PBH of Carr and Hawking [6] were supposed to constitute part of the DM. Later on, in 1993, Dolgov and Silk [7] suggested a model of matter fluctuations which used the QCD transition as a trigger for the formation of PBHs of order a solar mass, which was later developed by Jedamzik [8]. These papers relied on the first order nature of the QCD transition to amplify the minute matter fluctuations produced during inflation into high density regions that would gravitationally collapse to form the PBH. We know nowadays that the QCD transition is not first order but a crossover [9], so such a mechanism is ruled out.

An alternative is to produce a large peak in the curvature power spectrum which would collapse to form black holes even without a phase transition. The first time such a peak was used to generate PBH as the main component of DM was proposed by García-Bellido, Linde and Wands in 1996, based on a two-field hybrid model of inflation [10]. Soon afterwards, many papers appeared in the literature making use of peaks in the spectrum [11–14] to generate a whole range of masses for PBHs as the main constituent of DM. Broad peaks arise from quantum diffusion of the inflaton field that backreact on the metric and induce large curvature perturbations [13, 15]. When those fluctuations re-enter the horizon during the radiation era, their gradients induce a gravitational collapse that cannot be overcome even by

*Electronic address: Juan.GarciaBellido@uam.es
†Electronic address: Ester.Ruiz.Morales@upm.es