

HERTZ LECTURE.

DESY Lecture on Physics 2017

IS IT POSSIBLE TO CREATE A UNIVERSE IN
QUANTUM TUNNELING

Edward FARHI*

Inflationary Cosmology: Is Our Universe Part of a Multiverse?

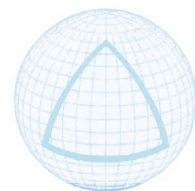
Prof. Dr. Alan Guth
(Massachusetts Institute of Technology)

27 September 2017

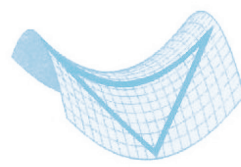
18:00 h, DESY Auditorium

Notkestraße 85 | 22607 Hamburg | Germany

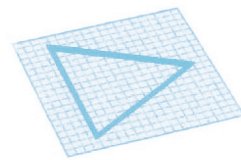
<http://www.desy.de/hertz>



Closed Geometry



Open Geometry



Flat Geometry

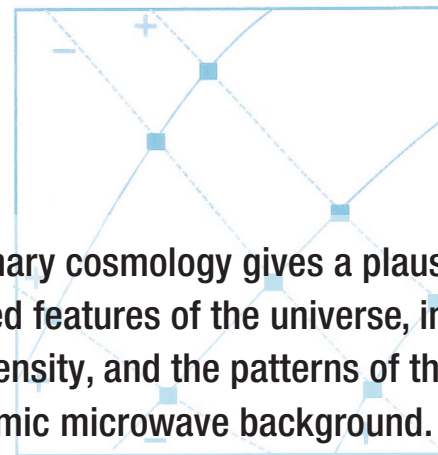
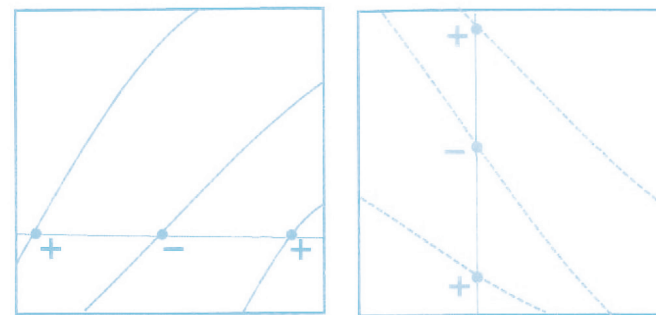


FIG. 1. Top left and right: The standard model of hot big-bang cosmology relies on the assumption of initial conditions which are very puzzling in two ways which I will refer to as the horizon and flatness problems. By "standard model" I refer to an ad hoc model of the universe by a Robertson-Walker metric. Details of this paper are given in the introduction. Before explaining the problems, I would like to mention that the standard model has a number of initial conditions which are very puzzling in two ways which I will refer to as the horizon and flatness problems. As $t \rightarrow 0$, the temperature T goes to infinity. However, when T is of the order of the Planck mass ($M_P \approx 1/\sqrt{\alpha}$), the equations of the standard model are undoubtedly meaningless, quantum gravitational effects are expected to become essential. Thus, within the scope of our knowledge, it is sensible to begin the hot big-bang scenario at a time t_0 which is not too far before this time. At this time, the universe is a small region of space. Of course, at these temperatures, we can make no sense of the sequences of events. In the standard model, the initial value of the thermal energy is taken to be

We calculated the same quantities using a GOE

$$N_{\text{saddle}} = 2(1 + \sqrt{2}) N_{\text{min}} \approx 4.82 N_{\text{min}}$$

Notice that to derive (12) we used an average symmetry of $U \rightarrow -U$. Therefore, (12) will not be valid for each realization of U .

generalizes to higher numbers of dimensions. If N_i is the number of negative eigenvalues in the Hessian, we get

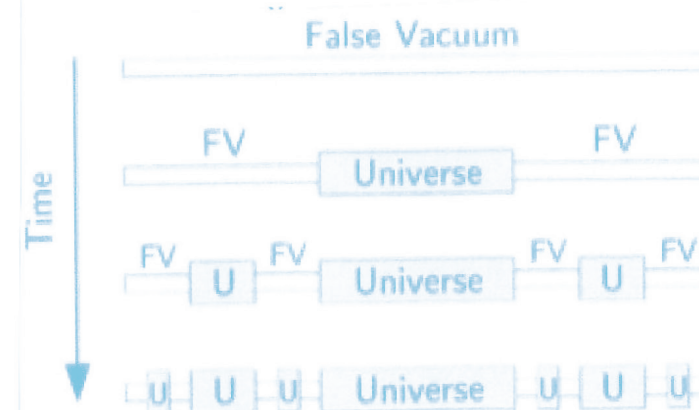


Fig. 3. A schematic illustration of eternal inflation.

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Inflationary universe: A possible solution to the horizon and flatness problems

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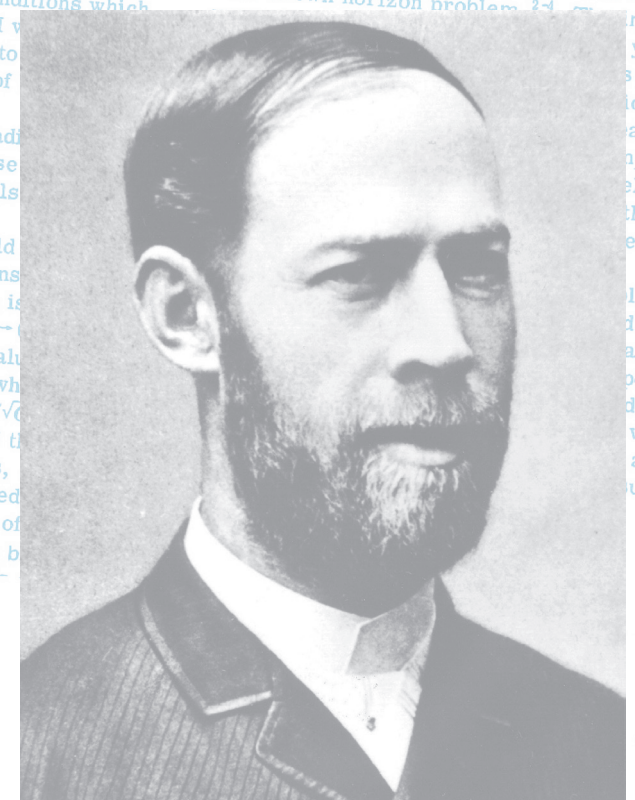
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305
(Received 11 August 1980)

The standard model of hot big-bang cosmology requires initial conditions which are problematic in two ways: (1) The early universe is assumed to be highly homogeneous, in spite of the fact that separated regions were causally disconnected (horizon problem); and (2) the initial value of the Hubble constant must be fine tuned to extraordinary accuracy to produce a universe as flat (i.e., near critical mass density) as the one we see today (flatness problem). These problems would disappear if, in its early history, the universe supercooled to temperatures 28 or more orders of magnitude below the critical temperature for some phase transition. A huge expansion factor would then result from a period of exponential growth, and the entropy of the universe would be multiplied by a huge factor when the latent heat is released. Such a scenario is completely natural in the context of grand unified models of elementary particle interactions. In such models, the supercooling is also relevant to the problem of monopole suppression. Unfortunately, the scenario seems to lead to some unacceptable consequences, so modifications must be sought.

I. INTRODUCTION: THE HORIZON AND FLATNESS PROBLEMS

The standard model of hot big-bang cosmology relies on the assumption of initial conditions which are very puzzling in two ways which I will refer to as the horizon and flatness problems. By "standard model" I refer to an ad hoc model of the universe by a Robertson-Walker metric. Details of this paper are given in the introduction. Before explaining the problems, I would like to mention that the standard model has a number of initial conditions which are very puzzling in two ways which I will refer to as the horizon and flatness problems. As $t \rightarrow 0$, the temperature T goes to infinity. However, when T is of the order of the Planck mass ($M_P \approx 1/\sqrt{\alpha}$), the equations of the standard model are undoubtedly meaningless, quantum gravitational effects are expected to become essential. Thus, within the scope of our knowledge, it is sensible to begin the hot big-bang scenario at a time t_0 which is not too far before this time. At this time, the universe is a small region of space. Of course, at these temperatures, we can make no sense of the sequences of events. In the standard model, the initial value of the thermal energy is taken to be

completely described. Now I can explain the puzzles. The first is the well-known horizon problem. The first is the initial uniformity of the universe. It is not clear how the universe could have been so uniform at the beginning. The second is the flatness problem. The universe appears to be very flat, but this is a fine-tuning problem. The universe appears to be very flat, but this is a fine-tuning problem.



Heinrich Hertz

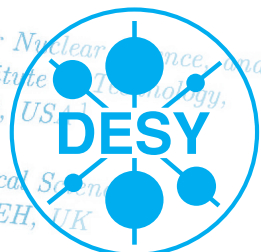
1857 Hamburg-Karlsruhe-Bonn 1894

MIT-CTP-2948, astro-ph/0002156

Inflation and Eternal Inflation

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Abstract

The basic workings of inflation