Speech by the Laureate Prof. George P. Efstathiou at the Award Ceremony of the Nemitsas Foundation Prize in Physics on 10th October 2013

President Anastasiades, Mr and Mrs. Nemistas and members of the Foundation, ladies and gentlemen. It is a tremendous honour, For myself, and my family to receive this award. I am particularly happy that my parents are able to be here at this event.

When I spoke with Takis about the award ceremony, he asked whether I would give the speech in Greek or English. The difficulty is that my Greek (or more accurately village Cypriot) is at about the level of a six year old child. What was I to do – people will expect to hear from a highly educated person, but as soon as I open my mouth I will sound like an idiot. On the other hand, I couldn't come to Cyprus, to receive a prize celebrating our nation, and speak entirely in English. So, I will give the speech the first part in Greek – and I apologise in advance for my mistakes – and then I will tell you a little but about my science in English, since I have no technical vocabulary in Greek.

My family comes from the `gochina horka' area of Cyprus – with a background in potato farming on my father's side and small business on my mother's side. My father left for England in 1949 and my mother shortly afterwards. I was born in London in 1955. I have been to Cyprus many times, and I have been amazed at the changes to the island over the years. Here is a photograph of at Protaras when I was 17 and there was not a hotel in sight! I am the one with long hair, my brother James, who is geophysicist working in Abu Dhabi is on my right next to my mother. My brother Stathi , who is a professor of Virology at the University of Cambridge, is on my left.

As a child, I was always interested in science, particularly astronomy: where did the planets and stars come from? How did the Universe begin? Does the Universe end?

Like many young people, I was strongly influenced by an inspirational high school teacher, Dick Yarrow, who I would like to acknowledge here. He taught me Physics -- this is the science of how the Universe works and how matter in the Universe behaves. It is through Physics that we can tackle the `big questions' that enthralled me as a child. So, I have pursued Physics ever since, as an undergraduate at Oxford, a PhD student at Durham, followed by postdoctoral appointments in Berkeley California and in Cambridge, where I have spent most of my academic career.

Now I want to tell you a little bit about my science, and so I will switch to English.

Modern physics is based on three key principles encapsulated by three constants of Nature: The theory of gravity described by Newton's gravitational constant G which measures the strength of the gravitational force; Einstein's principle of relativity which links together space and time via the speed of light c; and Planck's theory of quantum mechanics in which the Planck constant h distinguishes the quantum from the classical world.

What we are trying to do in Physics is to understand everything about our Universe in terms of these principles: gravity, relativity and quantum mechanics.

Now this immediately raises a fundamental problem, because the constants G, c and h define a 'natural' set of units for Physics – often called `Planck units'. These seem anything but natural to us. The natural unit of time is less than a trillionth, trillionth, trillionth of a second-- very much less than the age of the Universe (nearly 14 billion years). The natural unit of length is microscopically small, much less than the size of our observable Universe and the natural unit of energy is enormously high – 14 orders of magnitude higher than the energy achieved at the Large Hadron Collider at CERN.

So if the natural time unit is 10^{-44} seconds, why is our Universe so old? Why is our Universe so big? Did it `begin' at 10^{-44} seconds or was there something there beforehand? You see that the big questions of modern cosmology are very similar to the questions that might be asked by a six year old child!

Is it possible to answer these questions? The answer is yes and this is what my collaborators and I have been doing over the last few years with the aptly named Planck satellite. We launched this satellite in May 2009 and it has been measuring the temperature irregularities of the cosmic microwave background radiation – the remnant radiation from the hot big bang,which has cooled as the Universe has expanded and now has a temperature of only 2.7 Kelvin.

This is a picture of my research team in Cambridge, which has worked very hard on the Planck data. We announced the first results in March of this year.

This is the map produced by Planck. It shows temperature differences of about 1000^{th} of a percent in different directions of the sky. The is a very importance picture – every bit of information that we can extract from this map tells us about Physics at the time that these irregularities were generated, which we believe happened just 10^{-35} seconds after the birth of the Universe.

What have we learnt? This picture shows the amplitude of the temperature fluctuations plotted as a function of their angular size. The red points show the results from the Planck satellite and the line shows a theoretical prediction. The agreement is basically perfect – we have clearly uncovered a fundamental truth about the birth of our Universe.

The theory is based on the idea that the irregularies started as quantum mechanical fluctuations in a tiny region of space. The Universe then expanded faster than the speed of light to make the entire observable Universe, stretching the quantum fluctuations to huge scales. Everything that we see in our Universe, the planets, stars, and galaxies, came from these quantum fluctuations. This is how we can understand why the Universe is so much bigger and older that implied by the natural scales of Physics.

It is an incredible human achievement that we have been able to test Physics at such early times, before even the matter in the Universe was created.

If this theory is correct, then it is likely that our Universe is part of a much greater structure – just a little patch of an eternal multiverse. Furthermore, our current understanding of quantum gravity implies the existence of extra dimensions – five or six additional space dimensions to the three dimensions that we are familiar with. Is it possible to test these ideas? The answer is yes – and that is the focus of my research in the immediate future.

In closing, I would like to thank you all for coming to this ceremony and for honouring me with this prestigious award.

Thank you.