

Geoplanet Doctoral School, Spring semester, 2021/2022

Lecture: **“Selected topics in cosmology”**, by Dr Stanisław Bajtlik

Series of fifteen 2-hour lectures in the Spring Semester of 2021/2022

Lectures on Wednesdays, online and at 14:15, Copernicus Astronomical Center, ul. Bartycka 18, Warsaw.

Credits: 3 ECTS

Subjects:

1. “The Big Bang”

Abstract:

The Big Bang theory is the basic theory of the evolution of the Universe. Based on General Relativity, supported by many observations. The lecture will be a presentation of its history, basic theoretical assumptions and observational evidence confirming its correctness. Problems with paradoxes and restrictions on the earliest stages of evolution will be raised.

2. “The Realm of galaxies”

Abstract:

Galaxies, hundreds of billions of stars, are the basic building blocks of the structure of the Universe. The lecture will be a presentation of the history of their discovery, study of structure, chemical evolution, spatial distribution, the theory of formation.

3. “Dark matter and dark energy – the biggest unsolved problem in physics”

Abstract:

The evidence for the existence of dark matter has appeared since the 1930s. The seventies and eighties strengthened the view that the majority (90%) of the mass in galaxies and galaxy clusters is a non-luminous matter. The nature of this matter remains a mystery. Even more secret turned out to be "the dark energy", a medium with exotic properties, which would constitute about 70% of the mass of the Universe. Its existence is postulated to explain the observed, accelerated expansion of the Universe. The lecture will focus on presenting the observational basis of the hypotheses about the existence of dark matter and dark energy and their theoretical implications.

4. “The topology of the Universe”

Abstract:

The problem of the Universe's finiteness or infinity is related to its geometry, metric properties of space-time. The theory linking the metric properties of space-time with matter is General Relativity. The problem of topological properties of space-time remains open. There is no physical theory associated with matter. The lecture will present the surprising properties of space-time with non-trivial (multiconnected) topologies. In this context, versions of the twins paradox with surprising consequences will be discussed. The conclusions of these considerations have practical, important applications, for example for the operation of the GPS system.

5. “What is time?”

Abstract:

We all experience the passage of time. It is one of the basic physical quantities. Still, there is no single, universally accepted definition of time. How to measure the time. How to make time arrangements? How to convey time information? Are there perfect clocks? Why is time only flowing one way? Is time absolute or relative? What is cosmological time? How much time has elapsed in the history of the universe? This is the subject of this lecture.

6. “Is there life outside Earth?”

Abstract:

This is a unique question. Scholars and laymen are asking them in the same form. It is understandable to a wide audience. For philosophical, scientific and ideological reasons, it arouses the interest of many people. Searching for traces of life outside Earth is one of the most popular and best funded scientific topics. What are the scientific grounds for speculating on this topic? What are the methods of searching for traces of extraterrestrial life? What are the results so far and what are the prospects for success?

7. “Are the laws of physics universal?”

Abstract:

How do we know the laws of physics are universal? How do we prove that?

8. “Where the chemical elements come from?”

Abstract:

The lightest elements were formed in the primordial nucleosynthesis, during the first 3 minutes after the Big Bang. Where the other come from?

9. “Architecture not from Earth”

Abstract:

Space travels and colonisation of the Moon or Mars is now quite possible. What are the requirements and special challenges for designing the out of Earth spaces?

10. “The oldest time in the Universe”

Abstract:

Microwave background radiation is the oldest time in the Universe. What can we learn and get from it?

11. “The gravitational waves, a new window on the Universe”

Abstract:

Rapidly developing gravitational waves astronomy is providing a new way to study the Universe. We will discuss the results and new prospects.

12. “The history of the telescopes”

Abstract:

Since 1609 when Galileo used the first telescope for astronomical observations the progress in technology made astronomy the leading branch of science. We will discuss that process.

13. “Optical illusions”

Abstract:

We are all subject to optical illusions. We will discuss the scientific nature of them.

14. “The great mistakes of science”

Abstract:

It happens to everyone. Great scientists have been wrong many times. What were the reasons? How to avoid them? What do these experiences show?

15. “What is the best system for parliamentary elections?”

Abstract:

For the end of the semester I suggest a reflection on the electoral systems. What are the advantages and disadvantages of different systems. How mathematics/statistics can help?