VRIJE ASO-SCHOOL

BACK TO THE FUTURE OF PHYSICS

one small step towards the final frontiers

Topics

1. Gravitational waves

This is a very "hot" topic, since the first gravitational waves were discovered just a few years back and already honoured by the Nobel Prize in 2017.

Make a historical survey of gravitational waves from the predictions of Einstein, via various attempts to measure them, to the first successful measurements. In addition, make a survey of experimental facilities and of some of the gravitational waves measured after the first discovery.

2. Black holes

This has been a fascinating topic ever since it was first proposed. Very recently it has regained attention since the first black hole was photographed in 2019, and this year the Nobel Prize was awarded for work on black holes.

Explain what black holes are and how they are formed. List how they are observed (indirectly and directly). Discuss the theoretical evidence of the existence of black holes and summarize how scientists succeeded in taking a picture of a black hole. You can also refer to SF-films in which black holes appear.

3. The Standard Model

The Standard Model contains a description of the fundamental particles (quarks, leptons and more), their properties and their interactions.

List the fundamental particles and their properties (mass, charge and spin). Differentiate between mass-particles and force-particles. The Higgs boson is an elementary particle in the Standard Model. Explain its role in the Standard Model and summarize its discovery in 2012, as well as mentioning the Nobel Prize awarded in 2013. As an optional choice you can discuss the neutrino and the experimental difficulty to measure it.

4. CERN and LHC

The Large Hadron Collider (LHC) is the largest and most famous particle accelerator in the world.

Give a general overview of CERN and of LHC in particular. Discuss the experiments performed at LHC and give an overview of some famous results (e.g. the Higgs boson).

5. Antimatter

Antimatter has always been a hugely fascinating topic.

Describe in what way antimatter differs from ordinary matter. What happens when antimatter gets in contact with ordinary matter? Give a survey of experimental facts: How much (and what type of) antimatter is created in the laboratories? How long does it exist? Does antimatter have normal gravitation or anti-gravitation? How can you create a container for antimatter?

An initial sequence of the film *Angels and Demons* was filmed at CERN. In this sequence, some antimatter is created in an experiment and then stolen. Comment on the physical correctness of this sequence.

6. Nanotechnology

Nanotechnology is an extensive field of science including physics, chemistry and biology. Probably it is the most important field of modern physics with respect to how breakthrough developments in the imminent future will affect our lives.

Concentrating on the physics part, supply a general description of what nanotechnology is. Then choose a couple of topics within this field that in the near future could change our lives in a more or less dramatical way.

7. Nuclear physics in medicine

This is a very current topic. Examples are the injection of radioactive isotopes for diagnostics (finding tumours), the injection of radioactive isotopes for therapy (killing tumours), hadron therapy (killing tumours by radiating them by a beam of ions (protons or nuclei), PET (positron emission tomography).

Choose one or more of these examples and explain the physics behind them.

8. Photonics and spectral analysis

Today spectral analysis is used on the one hand to examine medicine, food, doping, etc. On the other hand it is used in astronomy to identify astrophysical objects.

Explain what spectral analysis is and discuss some current examples of its use.