Antimatter Research

CERN ITW2018

International Teacher Weeks Programme
Leptons, quarks and their antiparticles are only mentioned for the final year.

Mentioned, only for the final year.

No particle physics mentioned, only for the final year and in “Physics Olympiad”.

Facultative
Aspects of Antimatter that can be Appropriately Introduced in the Classroom

- Standard Model
- Quarks and Antiquarks
- Matter-Antimatter pairs
- Medical Application

CLIL
Aspects of Antimatter that can be Appropriately Introduced in the Classroom

- Starting from science fiction
- Let’s find out something about antimatter!

Flipped Classroom
Cooperative Learning
Aspects of Antimatter that can be Appropriately Introduced in the Classroom

- Cosmological approach
- Experiments at CERN
CERN EXPERIMENTS

AEGIS
Antihydrogen Experiment: Gravity, Interferometry, Spectroscopy

ATRAP
Antihydrogen Trap

BASE
Baryon Antibaryon Symmetry Experiment

ALPHA
Antihydrogen atoms

ASACUSA アサクサ
Atomic Spectroscopy And Collisions Using Slow Antiprotons

GBAR
Gravitational Behaviour of Antihydrogen at Rest

AMS POCC
Alpha Magnetic Spectrometer
Anticipated student’s concepts of antimatter
we know everything

existing only in theory

exotic and out of this world

negative

different from matter only in electrical charge

influenced by science fiction

just another explosive

vanished immediately after the Big Bang

it’s not worth doing research in

we know everything
A practice example

Jigsaw strategy

- Jigsaw strategy is an interactive physics teaching method.
- In this method the teacher’s role is to facilitate learning.
- There are two different kinds of groups.
<table>
<thead>
<tr>
<th>Expert Groups</th>
<th>Jigsaw Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 students</td>
<td>25 students</td>
</tr>
<tr>
<td>5 groups</td>
<td>5 groups</td>
</tr>
<tr>
<td>5 students in each group</td>
<td>A student from each expert group</td>
</tr>
</tbody>
</table>
Expert Groups’ Questions

<table>
<thead>
<tr>
<th>Expert group 1</th>
<th>What is antimatter?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert group 2</td>
<td>What is the research that has been done about antimatter?</td>
</tr>
<tr>
<td>Expert group 3</td>
<td>How is antimatter used in our daily lives?</td>
</tr>
<tr>
<td>Expert group 4</td>
<td>What is the Standard Model?</td>
</tr>
<tr>
<td>Expert group 5</td>
<td>Where is antimatter?</td>
</tr>
</tbody>
</table>

- The teacher prepares a quiz including all the topics.
- S/he wants students answer these questions individually at the end of the practice.
Aspects of Antimatter we consider challenging to teach to students
Colour charge

- Is found only in quarks and gluons, completely unrelated to human perception of color.
- Is an inherent property of quarks and gluons that is relative to the "strong nuclear force".

Oscar W. Greenberg introduced the notion of color charge to explain how quarks could coexist inside some hadrons in otherwise identical quantum states without violating the Pauli exclusion principle.
Antimatter gravity could explain Universe's expansion?

The theoretical prediction of antigravity between matter and antimatter could have significant consequences, if it’s true. The force of this matter-antimatter repulsion could explain why the Universe is expanding at an accelerating rate, eliminating the need for dark energy and possibly dark matter.
Antimatter Applications

COULD ANTIMATTER BE USED TO FUEL SPACECRAFT?

Lesson Extension Activities

• Calculate the amount of antimatter needed to power a house for one year.

• How can I create antimatter at home?
  • Cheapest solution: buy a banana.

• How can I observe some positrons at home?
  • All you’d need to do is to build a cloud chamber and cosmic rays will do the rest for you. Positrons are created all the time by cosmic ray collisions in the Earth’s atmosphere.
Paul Dirac’s Relativistic Equation of Motion for the Electron

The equation brings together the two cornerstones of modern physics: quantum mechanics and relativity.

- Predicted the positron, antimatter partner of the electron
- Predicted that negative protons must also exist
- Speculated that half the stars may be made of antimatter

\[ E = mc^2 + \bar{m}c^2 \]

\[ (i\hat{\phi} - m)\psi = 0 \]
Other challenges in classroom

Are there antiphotons?

No. Or rather: the antiphoton is exactly the same as the photon so there isn’t a separate species.

What about antineutrons? Antineutrinos?

Yes. Although these are neutral so their antiparticles have the same charge (\(-0=0\)) they have other properties which are different.

Do antiparticles fall up?

Unknown
Thank you for your participation

Thank you for your attention and participation!