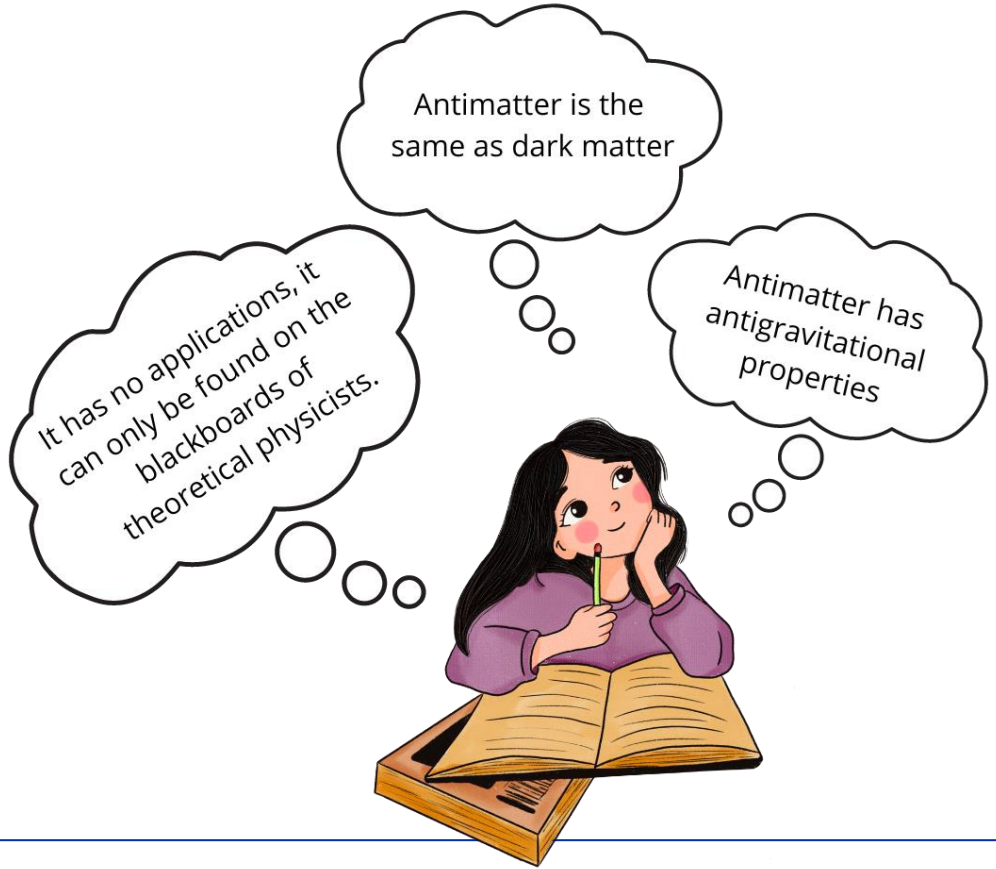
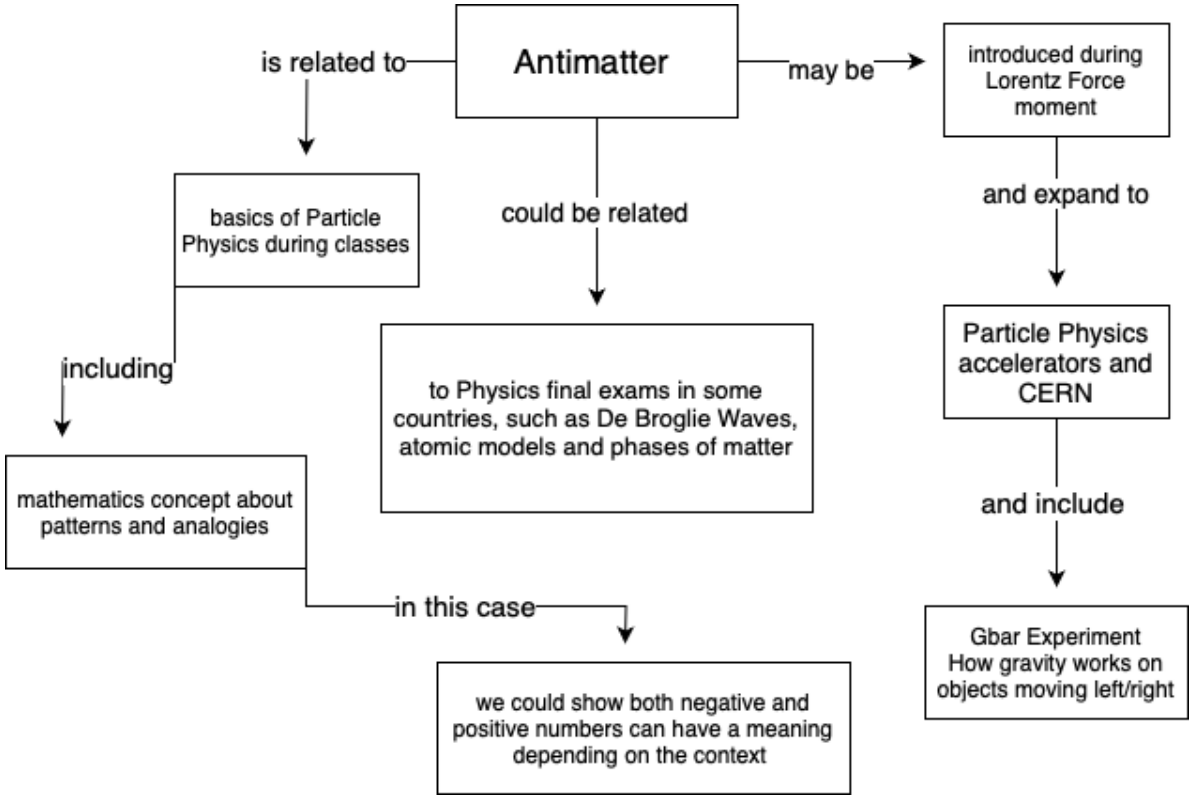
ITW2024 Study Group 9

Antimatter Research

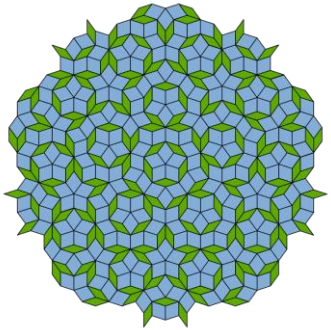
Potential Students' Conceptions & Challenges



Curriculum & Classroom Connections

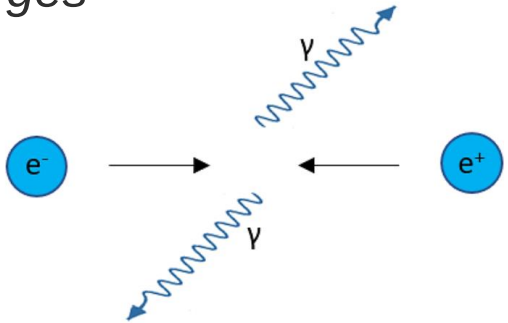


Key Ideas

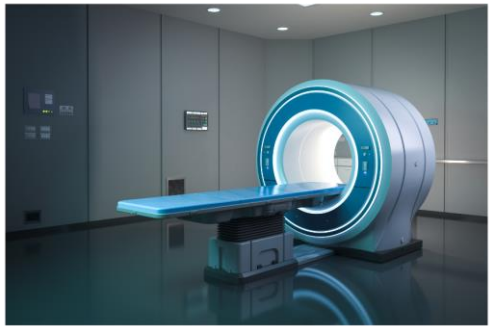


There are patterns in nature

Antimatter particles have the same properties as matter particles but with opposite charges

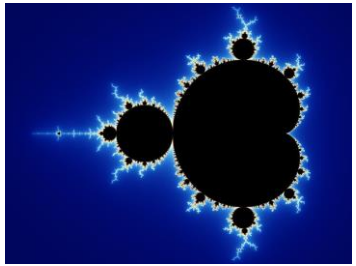


Examples and applications (positive beta-decay, PET scan)



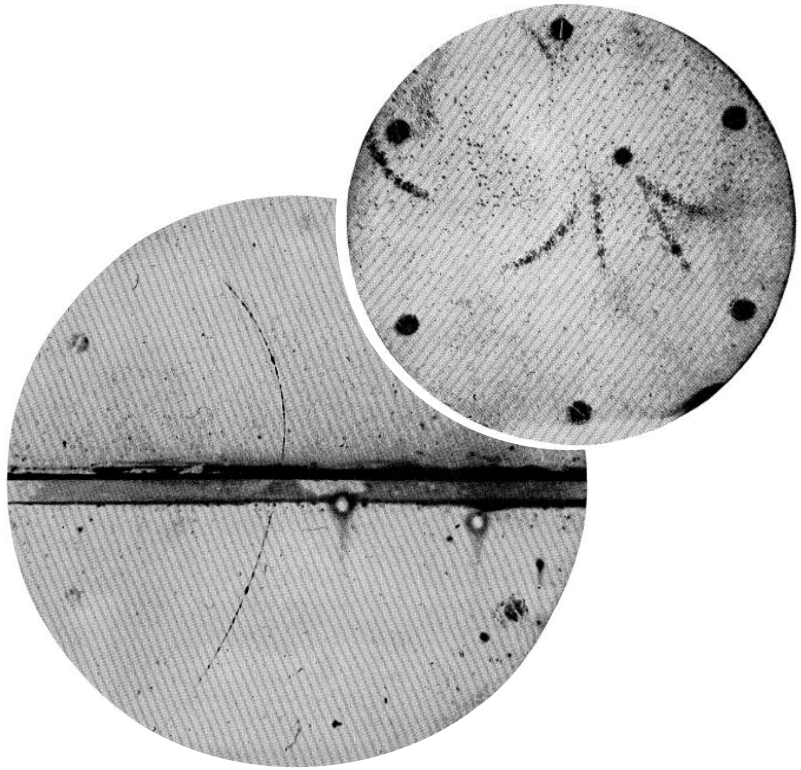
Pair production and annihilation, energy scales

$$E = MC^2$$



Best Practice Example

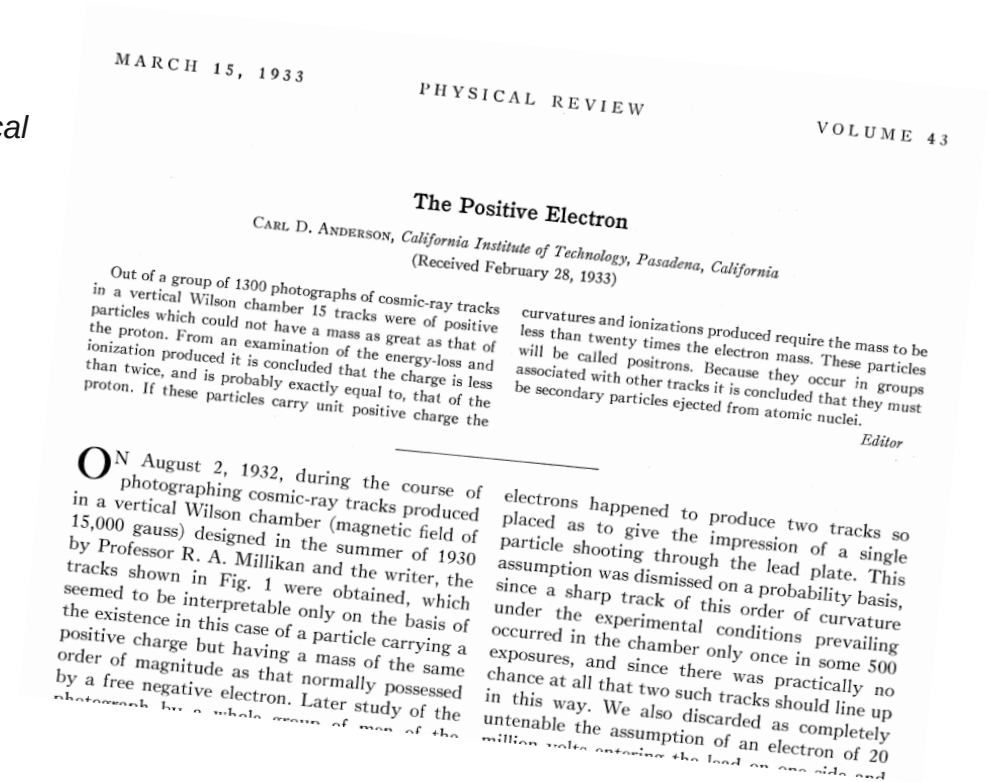
1. Solicit prior knowledge of students (e.g. post-it or mentimeter).
2. Introduction of cloud chambers and particle tracks (e.g. in connection with radioactivity) *[Real-world application]*
3. “Replaying” Anderson’s discovery of the positron as an investigation with guided questions and interactive elements. *[Process of Inquiry]*
4. Generalizing the discovery: each particle has its antiparticle (e.g. antiproton, antihydrogen). *[Nature of Science]*
5. Applications of antimatter: positive beta-decay, principle of PET.
6. Summary and feedback (formative assessment) with concept map.



Images: Anderson, C.D. (1933). The positive electron. *Physical Review, 43*(6), 491. Fig. 1.& 3.

Useful Material & Resources

- *Discovery of positron article*
  Anderson, C.D. (1933). The positive electron. *Physical Review, 43*(6), 491. (link)
- *Short explanatory video to PET scan*
  https://youtu.be/yrTy03O0gWw (and more…)
- *CERN webpage on antimatter*
  https://home.cern/science/physics/antimatter



MARCH 15, 1933 PHYSICAL REVIEW VOLUME 43

The Positive Electron

CARL D. ANDERSON, *California Institute of Technology, Pasadena, California*

(Received February 28, 1933)

Out of a group of 1300 photographs of cosmic-ray tracks in a vertical Wilson chamber 15 tracks were of positive particles which could not have a mass as great as that of the proton. From an examination of the energy-loss and ionization produced it is concluded that the charge is less than twice, and is probably exactly equal to, that of the proton. If these particles carry unit positive charge the curvatures and ionizations produced require the mass to be less than twenty times the electron mass. These particles will be called positrons. Because they occur in groups associated with other tracks it is concluded that they must be secondary particles ejected from atomic nuclei.

Editor

ON August 2, 1932, during the course of photographing cosmic-ray tracks produced in a vertical Wilson chamber (magnetic field of 15,000 gauss) designed in the summer of 1930 by Professor R. A. Millikan and the writer, the tracks shown in Fig. 1 were obtained, which seemed to be interpretable only on the basis of the existence in this case of a particle carrying a positive charge but having a mass of the same order of magnitude as that normally possessed by a free negative electron. Later study of the photograph by a whole group of men of the electrons happened to produce two tracks so placed as to give the impression of a single particle shooting through the lead plate. This assumption was dismissed on a probability basis, since a sharp track of this order of curvature under the experimental conditions prevailing occurred in the chamber only once in some 500 exposures, and since there was practically no chance at all that two such tracks should line up in this way. We also discarded as completely untenable the assumption of an electron of 20 million volts entering the lead on one side and

Images: https://upload.wikimedia.org/wikipedia/en/a/ae/CERN_logo.svg, https://upload.wikimedia.org/wikipedia/commons/e/e1/Logo_of_YouTube_%282015-2017%29.svg

ITW2024 Study Group 9

Gabriela (Brazil), Maajida (USA), Attila (Hungary), Ojars (Latvia), Vlado (Montenegro)

- Our thinking has become more clear and at the same time more humble.
- We learnt a lot new about particle physics and CERN, including recent findings.
- International cooperation can be really fruitful.