

TAP 535- 5: Creation from annihilation

Colliding electrons and positrons

The passage below is from *The New Physics*, edited by Paul Davies. Read the passage, in which some phrases or words are highlighted in bold. Write a fuller explanation of what is meant by each highlighted word or phrase. Questions to guide you are offered, but you can go further if you wish.

Electron–positron annihilation

Electrons colliding with **positrons** provide one of the most exciting ways of learning about bizarre varieties of matter.... The key feature is that positrons are the **antiparticles** of electrons. When matter and **antimatter** meet, they can **mutually annihilate**. The energy in their masses has been unlocked: $E_{\text{rest}} = mc^2$ at work.

What is the point of this?

Destroying the electrons and positrons is just the start. The aim is to watch what happens when their energy 'recongeals' into new forms of matter and antimatter. **It can return whence it came, into electron and positron**, but more interestingly it may produce new forms of matter with their corresponding antimatter. The hunt is on for those occasions when new forms of matter, not previously seen on Earth, **emerge from the encounter**. Exotic forms of matter can occur fleetingly in **the heat of stars**, and when we **temporarily simulate that heat** on Earth, so that we can capture these new varieties in earthbound laboratories.

This continuous destruction of matter and antimatter was common in the brief heat of the **primordial Big Bang**. **By annihilating electrons and positrons in the laboratory** we are reproducing conditions similar to those that occurred a split second after the Big Bang. We can create matter and antimatter, built for example of quarks and antiquarks, to order.

1. **Positrons**: what are they?
2. **Antiparticles**: what's the relation between a particle and antiparticle?
3. **Antimatter**: what is antimatter? Where can it be found?
4. **Mutually annihilate**: what happens? What vanishes and what does not vanish?

5. **$E_{\text{rest}} = mc^2$** : give an example of how to use this equation.

6. **It can return whence it came, into electron and positron**: what is happening here?

7. **Emerge from the encounter**: what emerges?

8. **The heat of stars**: why does it matter how hot the stars are?

9. **Temporarily simulate that heat**: how is this temporary simulation done? By heating stuff up?

10. **Primordial Big Bang**: what is this?

11. **By annihilating electrons and positrons in the laboratory**: how?

Practical advice

This passage comes from a book intended for a wide audience, but an audience with considerable knowledge of physics. Suggest to students that they should write enough to help a friend who is not studying physics at A-level at least to make sense of the passage. Remind them that this often means saying the same thing in one or two other ways. Examples always help, too, so encourage that.

Alternative approaches

You could choose a different passage, for example from a text about medical applications of particle physics.

Social and human context

New ideas often need new words. Learning physics is sometimes like learning a new language.

Example answers

1. Positrons: are antiparticles of electrons, they have the same mass but positive charge.
2. Antiparticles include the fact that antiparticles have all properties except mass opposite to those of their particle counterparts.
3. Antimatter: is made of antiparticles. No bulk antimatter is known in the Universe, but antiparticles can be produced in accelerators.
4. Mutually annihilate: the opposite properties of particle and antiparticle all cancel, and the rest energy (mass) goes into kinetic energy of a photon (which has zero mass).
5. $E_{\text{rest}} = mc^2$: you could show that the mass of an electron corresponds to 0.5 MeV approximately. Or give an example from nuclear reactions.
6. It can return whence it came, into electron and positron: a photon (near a nucleus) can create an electron–positron pair.
7. Emerge from the encounter: pairs of particles and antiparticles emerge.
8. The heat of stars: because the stars are hot, particles have a lot of random thermal energy per particle. This may be enough to cause an event in a collision.
9. Temporarily simulate that heat: accelerated particles are collided, so that their kinetic energy is available in the collision event.
10. Primordial Big Bang: the hypothetical origin of the Universe, when space and time were created and a hot fireball of space, time and matter exploded.
11. By annihilating electrons and positrons in the laboratory: the best way is to make accelerated particles collide head on, to get the maximum energy into the products of the collision.

External references

This activity is taken from Advancing Physics chapter 17, 50C