Kinetic energy of a system of particles

Book pp. 253-4

$$K_{\text{tot}} = K_{\text{cm}} + K_{\text{nt}}$$

where $$K_{\text{cm}} = \frac{1}{2} M V^2$$, $$V = \frac{d\vec{R}}{dt}$$

and $$K_{\text{nt}} = \text{KE of particles relative to } \text{CM}$$

Conservation of momentum

$$\vec{P} = \sum \vec{p}_i$$

Conservation of momentum

$$\Rightarrow \vec{F}_{\text{net ext}} = \frac{d\vec{P}}{dt}$$

Discovered of the neutrino

1847: Hermann von Helmoltz synthesizes prior events & states the principle of cons. of energy

1896: Henri Becquerel discovers radioactivity

Three types of radioactive emissions:

- \(\alpha\)-rays (from nucleus) \(E_\alpha = E_{\text{nucleus}}, i - E_{\text{neutrino}}, f\)
- \(\beta\)-rays (high-energy photon) \(E_\beta = E_{\text{nucleus}}, i - E_{\text{nucleus}}, f\)
- \(\beta\)-rays (electron) \(E_\beta = E_{\text{nucleus}}, i - E_{\text{nucleus}}, f\)

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Energy conservation appears to be violated for \(\beta\) emission!

Many scientists, including Niels Bohr, felt that cons. of energy didn't apply to nuclear events

1905: Einstein publishes special relativity

$$E^2 = m^2 c^4 + p^2 c^2 \Rightarrow \text{even massless particles can carry momentum}$$

1930: Wolfgang Pauli postulates a new particle, dubbed the neutrino by Fermi, which allows energy, momentum, & angular momentum in \(\beta\)-decay, but interacts very weakly with other particles & so is very hard to detect. Most other scientists are skeptical.

1933: Enrico Fermi publishes new theory of \(\beta\)-decay which includes the neutrino, and gives quantitative agreement with experiments.

1949: Chalmers Sherron shows experimentally that cons. of energy & momentum for \(\beta\)-decay is possible with the emission of a single nearly massless or massless particle.

1956: Clyde Cowan & Frederick Reines observe the neutrino (actually an anti-neutrino) at the Savannah River nuclear reactor.

Collisions

Perfectly elastic: the two objects stick together

Perfectly elastic: the objects don't stick, \( k_f = k_i \)

In between: the objects don't stick, \( k_f < k_i \)

All types: If \( \vec{F}_{\text{net ext}} \) is negligible during collision,

\[
\frac{d\vec{P}}{dt} = 0 \Rightarrow \vec{P}_f = \vec{P}_i
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