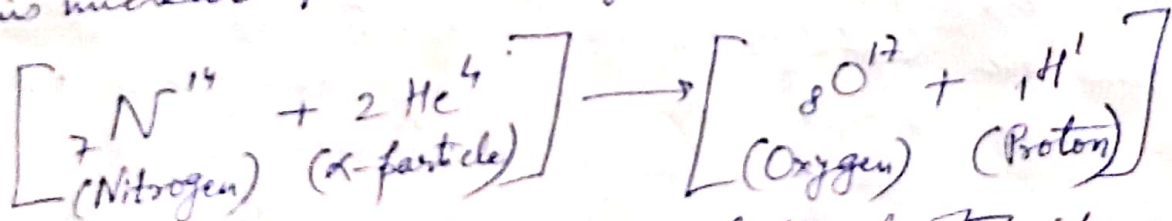


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Two Body Problem and nuclear forces

The Nuclear Force: Lord Rutherford, in 1919, through a series of investigations, was successful in carrying out the first ever induced nuclear transmutation, viz. the disintegration of nitrogen nucleus through its bombardment by α -particles obtained as a result of natural radio-activity of Radium and Thorium. The identification of the products of this artificial nuclear reaction led to the discovery of a fundamental particle the proton, which has had the status of being the first fundamental nuclear particle. This nuclear reaction may be written as:



After the discovery of the proton, it was erroneously contended that atomic nuclei were constituted of electrons and protons. But this nuclear model soon ran into difficulties under quantum mechanical examination; and then the structure and the constituent particles of the nucleus remained unexplained until 1932 when Chadwick, through a series of experiments performed by Bothe, Joliot and himself, discovered another uncharged fundamental particle - the neutron which has a mass almost equal to that of the proton. This fundamental neutral particle had the right properties to be called a nuclear constituent. Since then and to date, protons and neutrons are taken to be the building blocks of all atomic nuclei. The protons and neutrons, being nuclear constituents, are known under a common name also as 'nucleons'.

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$$\alpha = \frac{e^2}{(\hbar mc)} \cdot \frac{1}{cm} = \frac{e^2}{\hbar c} \text{ (in C.G.S. electromagnetic units)}$$

$$= \frac{(4.80298 \times 10^{-10} \text{ e.s.u. of charge})^2}{(1.0545 \times 10^{-27} \text{ erg-sec}) \times (3 \times 10^{10} \text{ cm/sec})}$$

$$= \frac{(4.80298 \times 10^{-10})^2}{(1.0545 \times 10^{-27}) \times (3 \times 10^{10})}$$

$$= 7.2972 \times 10^{-3}$$

[since erg = dyne-cm and dyne-cm = (e.s.u. of charge)²]

$$\approx \frac{1}{137.037} \approx \frac{1}{137} \frac{e^2}{\hbar c}$$

In S.I. units, $\alpha \approx \frac{1}{4\pi\epsilon_0} \frac{e^2}{\hbar c}$

$$= \frac{(9 \times 10^9 \text{ N-m}^2/\text{Coul}^2) \times (1.6 \times 10^{-19} \text{ Coul})^2}{(1.0545 \times 10^{-34} \text{ J-s}) \times (3 \times 10^8 \text{ m/s})}$$

$$= 7.2972 \times 10^{-3} \frac{\text{N-m}^2}{\text{N-m}^2}$$

[∴ Joule = Newton-meter]

A measure of the electromagnetic interaction is this coupling constant. This constant plays a fundamental role in atomic spectroscopy and therefore is known as fine structure constant.