Anti-cluster Decay and Anti-alpha Decay of Antimatter Nuclei

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A broad extension of periodic system into the sector of antimatter could be possible in a remote future. Antimatter may exist in large amounts in far-away galaxies due to cosmic inflation in the primordial time of the universe. The antimatter character of Dirac's negative energy states of electrons became clear after discovery in 1932 of the positron by C.D. Anderson. A positron soon finds an electron, undergo annihilation, and produces a pair of 511 keV γ rays. Antiproton, $\bar{p}$, predicted by P. Dirac in 1933 was observed in 1955 by E.G. Segrè and O. Chamberlain at the LBL Bevatron. The antineutron, $\bar{n}$, was discovered in p-p collisions at the Bevatron by Cork et al. in 1956.

Antimatter is a material composed of antiparticles which bind with each other, e.g. e^+ and $\bar{p}$ can form an $\bar{H}$ atom. Charged antimatter can be confined by a combination of electric and magnetic fields, in a Penning trap. For uncharged antimatter the trap may use the dipole moment (electric or magnetic) of the trapped particles. Anti-atoms are difficult to produce; the antihydrogen ($\bar{H}$) was produced and confined for about 1000 s. Collaborations ATRAP, ALPHA and ASACUSA at CERN tried to create less energetic ("cold") antihydrogen, better suited to study. The antimatter helium-4 nucleus, ${}^4\bar{H}e$, or $\bar{\alpha}$, consists of two antiprotons and two antineutrons (baryon number $B = -4$). This is the heaviest observed antinucleus.

It was established that every antiparticle has the same mass with its particle counterpart; they differ essentially by the sign of electric charge: $\mathbf{m_{e^+} = m_{e^-}}$, $\mathbf{m_{\bar{p}} = m_p}$, $\mathbf{m_{\bar{n}} = m_n}$, etc. Also every antinucleus has the same mass or binding energy as its mirror nucleus. We expect that anti-alpha spontaneous emission from an antimatter nucleus will have the same Q-value and half-life as alpha emission from the corresponding mirror nucleus. This is the consequence of the invariance of binding energy as well as of the surface and Coulomb energy when passing from matter to antimatter nuclei. The Q-values and half-lives of all measured up to now 27 cluster radioactivities are given together with Q-values and half-lives of the most important competitor — α decay. The lightest anti-alpha emitter, ${}^8\bar{B}e$, will have a very short half-life of about $81.9 \cdot 10^{-18}$ s.