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NEUTRONS

A powerful source for solid-state physics

At CERN, our two accelerators [the SC and the PS] both produce high-energy protons for use as projectiles and probes in the search for increased knowledge of the constitution of matter. High-energy electrons are also used in some laboratories. Another possible tool, although it is of more interest to those studying the normal physical states of matter (notably solid and liquid) rather than its ultimate constitution, is the neutron.

Nuclear-physics research carried out with feeble sources of neutrons in the 1930s led to the discovery of fission and eventually to the construction of nuclear reactors in all their many forms, some with a fantastically great production of neutrons. A great deal of work has been done on the gross effects of neutron irradiation on materials, but this is essentially applied research. For more fundamental research in this field and for studies in which the neutron is used more specifically as a probe, well-defined beams of neutrons of accurately known energy are required, as is the case when using protons. High intensity is also necessary. To achieve all this with neutrons emitted from a reactor, particularly while keeping to a minimum the heat produced at the same time, is no easy task. As yet, no such specialized "very high flux" reactor exists, though one approaching this description is now under construction at Brookhaven National Laboratory in the US.

Following an initial recommendation from L Kowarski who, besides being leader of the Data Handling Division at CERN, is also scientific adviser to the European Nuclear Energy Agency, the agency has recently launched a study project for a reactor of this kind in Europe. If built, it could become the heart of another centre for fundamental research, like CERN. It is, however, more likely that the internationally built and owned reactor, together with its supporting laboratories, would form an annex to one of the existing reactor-research centres.

● Original article p70.

PARTICLES

The "particles" of sub-nuclear physics

From the early days of just the proton and the electron, the list of so-called "fundamental particles" grew until a year or two ago some 30 particles and antiparticles were known or predicted. Then came the discovery of the first "resonances" or "excited states", and the list began rapidly to lengthen again. It now seems clear, however, that neither these new particles nor, perhaps, many of those in the earlier list are truly "fundamental" or "elementary". New ideas abound and a more rational classification will undoubtedly arise in time, but for the moment, for those not closely involved, a certain amount of confusion appears inevitable.

The known "particles" have been placed into two groups, arbitrarily defined to separate the older particles from the newer ones. It happens that these groups also correspond more or less to those of the "long-lived" and "short-lived" particles, by comparison with a "nuclear year", the time taken for a nucleon to revolve about the centre of a nucleus, about 10^{-22} s.

● Extracted from p66, where a second table also showed the "short-lived" particles.

The "elementary particles" – lifetime long compared with the nuclear year

			Particle name	Particle symbol and charge states	Mass (MeV)	Mean life (s)	Antiparticle symbol and charge states	Antiparticle name
fermions (spin ½)	leptons (light particles)		neutrino	ν_e	0	stable	$\bar{\nu}_e$	antineutrino
			neutretto	ν_μ	< 3.5	stable	$\bar{\nu}_\mu$	antineutretto
			electron	e^-	0.51	stable	e^+	positron
			muon (mu minus)	μ^-	105.66	2.2×10^{-6}	μ^+	muon (mu plus)
only one fermion can exist in a particular state at any given time	baryons (heavy particles)	nucleons	proton	p (=N^+)	938.2	stable	$\bar{p}$ (−)	antiproton
			neutron	n (=N^0)	939.5	1×10^{-3}	$\bar{n}$ (0)	antineutron
		hyperons	lambda	Λ (0)	1115.4	2.5×10^{-10}	$\bar{\Lambda}$ (0)	antilambda
			sigma plus	Σ^+	1189.4	8×10^{-11}	$\bar{\Sigma}^-$	antisigma
			sigma zero	Σ^0	1191.5	$\ll 1 \times 10^{-11}$	$\bar{\Sigma}^0$	
			sigma minus	Σ^-	1196.0	1.6×10^{-10}	$\bar{\Sigma}^+$	
			xi zero	Ξ^0	1315	3.9×10^{-10}	$\bar{\Xi}^0$	antixi
			xi minus	Ξ^-	1321	1.7×10^{-10}	$\bar{\Xi}^+$	
bosons (spin 0 or 1)			photon	γ	0	stable	γ	photon
two or more bosons can exist in the same state at the same time	mesons (intermediate particles)		pion pi zero	π^0	135.0	1.0×10^{-16}	π^0	pion
			pion plus or minus	π^+ or π^-	139.6	2.6×10^{-8}	π^- or π^+	
			kaon K plus	K^+	493.9	1.2×10^{-8}	K^-	antikaon
			kaon K zero	K^0 K_1^0	497.8	1.0×10^{-10}	$\bar{K}^0$	
				K_2^0		6.0×10^{-8}		