NUCLEON-NUCLEON CROSS-SECTIONS AT HIGH ENERGIES

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USING the Alikhanian-Alikhanov magnetic spectrometer, the authors of Refs. 1 and 2 determined the cross section σ_a for the inelastic interaction between protons of average energy from 0.9 to 34 Bev and lead or carbon nuclei. From these data, on the basis of the optical model,[3] it is possible to determine the transverse cross-section $\bar{\sigma}$ of the nucleon-nucleon interactions at the above energies, and also to choose the most logical form of the distribution of the nucleons in the nucleus, first using the results of electromagnetic measurements and then determining the scale parameter from the resultant experimental cross-sections.

Hofstadter[4] used the scattering of high energy electrons by nuclei to establish that, for medium and heavy nuclei, the distribution of the protons can be represented by the so-called homogeneous smoothed distribution of the type

$$\rho(r) = \rho_0 \left\{ \exp\left[\frac{r-c}{z}\right] + 1 \right\}^{-1}, \qquad (1)$$

where $c = 1.08\,A^{1/3} \times 10^{-13}$ cm, $z = 0.53 \times 10^{-13}$ cm, ρ_0 is the density at $r = 0$, and A is the atomic weight. It was shown in Ref. 5 that, accurate to 3%, the radial distributions of the protons and neutrons are identical. On this basis one can assume that the distribution of the nucleons in the nucleus coincides with that of the protons (1), determined by experiments on electron scattering.

The measurements by Kocharian, Begzhanov, and Saakian[1,2] have that advantage, from the point of view of determining the nuclear dimensions, that they give the inelastic cross-section σ_a directly, dispensing with the entire formalism of the optical model.

Following Fernbach, Serber, and Taylor,[3] we calculate σ_a using the semi-classical target-parameter method. As it passes through the nucleus, the proton wave decays exponentially, with an absorption coefficient $K(r) = \rho(r)\bar{\sigma}$. The size and shape of the nucleus are determined by the density distribution $\rho(r)$. The total absorption is expressed by the integral with respect to the coordinate s along the proton trajectory. The cross section σ_a equals here the interaction probability, integrated over the impact parameter b. Taking it into account that $r^2 = b^2 + s^2$, we have

$$\sigma_a = 2\pi \int_0^\infty \left\{ 1 - \exp\left[-2 \int_0^\infty K(\sqrt{b^2 + s^2}) ds \right] \right\} b\,db. \qquad (2)$$

Numerical calculation of this integral for various values of the parameter c yields σ_a as a function of $\bar{\sigma}$ for the homogeneous smoothed distribution (1).

Calculation of the transverse cross section for the inelastic interaction between protons and carbon or lead nuclei, using the smoothed model of the nucleus (1), shows that the experimental cross sections for either lead [$\sigma_a = (1740 \pm 90)$ millibarns] or graphite [$\sigma_a = (210 \pm 15)$ millibarns] coincide with the calculated values at $\bar{\sigma} = (32 \pm 3)$ millibarns. The errors indicated are statistical.[6]

The best agreement between the calculated and the experimental cross sections is obtained for $c = (1.13 \pm 0.04) \times 10^{-13} A^{1/2}$ cm. It is assumed here that the fall-off thickness for the nucleon density is the same as for the protons density.[4] Consequently, if assuming the smoothed model of the nucleus, the nuclear radius R determined in this manner agrees with the results of the electromagnetic measurements. At the same time, whether the homogeneous or the Gaussian model is used, it is impossible to select the same value of r_0 in the expression $R = r_0 A^{1/3} \times 10^{-13}$ cm for the investigated nuclei.

The value of $\bar{\sigma}$ indicated above corresponds to the total effective cross section for nucleon-nucleon interactions, at least up to energies of 34 Bev. The section $\bar{\sigma} = (21 \pm 4)$ millibarns[7] corresponds to the mean value for the production of particles (or mesons) in elementary interactions with energies ~ 50 Bev. According to Williams,[8] the nucleon-nucleon cross-section increases with energy and $\bar{\sigma} \sim 120$ millibarns at ~ 30 Bev. The mistake in this work was noted later on by the author himself.[7]

Our results are in good agreement with the experiments on the determination of nucleon-nucleon cross sections at energies up to 5.3 Bev (Ref. 9) and on nucleon-nuclide cross sections. It follows therefore that, in general, the fundamental properties of the interaction processes, at least up to 34 Bev, do not differ from the interaction in the energy range attainable with modern accelerators.

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MEASUREMENTS OF THE SPIN-LATTICE RELAXATION TIMES OF Cr^{3+} *IN CORUNDUM*

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KNOWLEDGE of the spin-lattice relaxation times in ferromagnetic compounds has assumed particular significance in connection with recently developed investigations on the production of low-noise molecular amplifiers using ferromagnetics.

We measured the spin-lattice relaxation time for the Cr^{3+} ion in the lattice of corundum $Al_2O_3 - Cr_2O_3$ for the $3/2 \rightarrow 1/2$ electron transition (Ref. 1).

The measurements were carried out at 9370 Mc at two temperatures ($T = 300°K$ and $T = 77°K$), and the saturation effect in ferromagnetic resonant absorption was observed for the case when the constant field was parallel to the symmetry axis of the crystal.

The values obtained for the spin-lattice relaxation time, $T_1 = 1.4 \times 10^{-7}$ sec for $T = 300°K$ and $T_1 = 7 \times 10^{-4}$ sec for $T = 77°K$, make it possible to conclude that the basic mechanism of the relaxation in this temperature ranges consists of "Raman effect" processes, which lead to a temperature dependence of the spin-lattice relaxation time in the form $T_1 \sim T^{-7}$ (Ref. 2).

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CONCERNING THE HYPERON-NUCLEON INTERACTION

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1. What little is known of the character of the forces between hyperons and nucleons is learned by analysis of hyperfragments or of the interactions between hyperons and nuclei.[1,2]

Parity nonconservation in hyperon decay can be used to study the interaction between hyperons and free nucleons, and also to investigate hypernuclei.

The direct method of establishing the spin-orbit dependence of the $Y - N$ forces can be the observation of the up-and-down asymmetry of the decay products relative to the scattering plane. The fact that the hyperons produced in $p - N$ and $K - N$ interactions are polarized is apparently evidence in favor of the presence of a (LS) dependence of the forces, but for direct proof the up-and-down asymmetry must be observed in the decay of hyperons that are polarized in elastic $Y - N$ scattering.

A study of the up-and-down assymetry with respect to the plane of hypernucleus production can be used to study the structure of the hypernucleus and for a direct determination of the spin of the hyperfragment. Proof that the spins of the baryons are compensated in ${}_\Lambda He^4$ would be the absence of such an asymmetry, which would be observed in ${}_\Lambda H^3$ at the same time.

2. Let us consider certain consequences of the unitarity and symmetry of the S matrix for $Y - N$ interactions. At Λ^0-particle energies below 150 Mev, only elastic scattering is possible in $\Lambda - N$