Letters to the Editor

POSSIBILITY OF USING NUCLEAR REACTIONS TO OBTAIN INFORMATION ABOUT THE $\pi\pi$ INTERACTION

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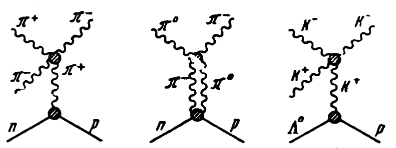
HIGH energy processes with small momentum transfers are now attracting much attention in nuclear physics. This interest is caused by the apparent possibility of a theoretical interpretation of these processes which yields some information on the $\pi\pi$, πK, and KK interactions. This information concerns the corresponding vertices in the Feynman graphs



etc.

We consider specifically the process of the creation of a π meson by a π meson. Chew and Low[1] have shown that for small momentum transfers the cross section for this process is related to the cross section for the $\pi\pi$ interaction ($\sigma_{\pi\pi}$) by the formula

$$d^2\sigma / dp^2\, d\omega^2 = (f^2 / 2\pi)\, p^2 (p^2 + 1)^{-2}\, \omega \sqrt{\omega^2/4 - 1}\; q^{-2}\sigma_{\pi\pi} + B(\omega p), \quad (1)$$

where f^2 is the meson-nucleon coupling constant, p is the momentum transferred to the nucleon, ω is the total energy of the mesons in their center-of-mass system, and q is the momentum of the incoming meson in the laboratory system. The quantities p, ω, and q are expressed in units of the meson mass. The term $B(\omega p)$ takes account of the contribution of the processes described by diagrams with three, five, etc. virtual mesons. There is reason to think — and this is indeed our assumption — that $B(\omega p)$ makes only a small contribution to the cross section in the region of small momentum transfers ($p \sim 1$ to 2) of interest to us. We can then integrate (1) over p and ω up to these values of p, and estimate the value of $\sigma_{\pi\pi}$ from the total cross section for the process of creation of one meson by another.

The interaction of the π meson with the nucleus can be regarded as the sum of the interactions with the separate nucleons of the nucleus. For light nuclei this reduces in most cases to the interaction with only one nucleon. The binding energy of the nucleon in the nucleus is much smaller than the binding energy of the π meson in the nucleon. We can therefore use (1) for the creation of a meson by a meson in the nucleus without making a large error. Since the nucleus almost always carries away (without splitting up) only a small momentum, the total cross section for nuclear reactions of the type

$$\pi + A \rightarrow \pi + \pi + B \quad (2)$$

contains information about the $\pi\pi$ interaction. Indeed, in the impulse approximation, (1) must be multiplied before integration by the quantity

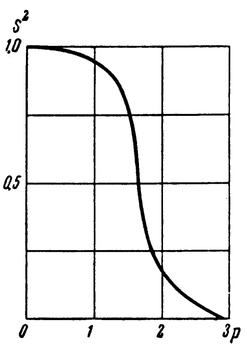
$$S^2 = \left\{\int_0^\infty \psi^*(r)\, e^{ipr}\, \psi(r)\, dr\right\}^2, \quad (3)$$

the probability that the nucleus with the ground state wave function $\psi(r)$ remains in the ground state when the momentum p is transferred to it. The function S^2 decreases sharply with increasing p. This can be verified by computing it under various assumptions for the wave function $\psi(r)$ or by estimating it directly from the experimental data on those processes (for example, on the elastic scattering of nucleons by nuclei[2]) in the description of which S^2 plays an important role. As we go from one nucleus to the next, S^2 changes in such a way that the admissible region of momenta p becomes smaller as the atomic number of the nucleus increases. In the region of light nuclei it is bounded by the value $p \sim 2$.

A convenient nuclear reaction in the region of light nuclei is

$$\pi^- + C^{12} \rightarrow \pi^- + \pi^- + N^{12}. \quad (4)$$

The initial nucleus C^{12} is contained in the material of the scintillators and in some liquids used in bubble chambers, so that the target and detector can be combined, which leads to a setup in which the 4π geometry is guaranteed. The presence of the β^+ active N^{12} nucleus with the β^+ end point energy 16.6 Mev and the life time 0.012 sec permits us to detect the reaction (4) and to separate it clearly from the background. For this purpose one can use discrimination by energy or amplitude analysis, registration of the decays in the absence of a pulse from the accelerator, or coincidence measurements of the two γ quanta from the annihilation of the β^+ in the target-detector. It is important that the N^{12} nucleus has no excited levels, and formula (3) is valid. The function S^2, as ob-



tained from the experimental data on the elastic scattering of nucleons by C^{12}, is shown in the figure.

In conclusion we express our deep gratitude to K. A. Ter-Martirosyan for valuable advice and constant assistance.

[1] G. F. Chew and F. E. Low, Phys. Rev. **113**, 1640 (1959).

[2] G. A. Leksin, On the Elastic Scattering of Nucleons by Nuclei, Preprint, Joint Inst. Nuc. Res., 1957.

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SINGLE CRYSTALS OF MAGNESIUM-MANGANESE FERRITES WITH A NARROW FERROMAGNETIC RESONANCE ABSORPTION CURVE

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A considerable interest has been noted recently in investigations of ferrites with narrow ferromagnetic resonance-absorption lines.[1-4] This interest is caused by the fact that the ferrite crystals can be used in nonlinear microwave apparatus. Particular attention is paid here to the investigation of single crystals of yttrium ferrite with garnet structure.[1-3] It appears to us, however, that not all the possibilities of the spinel class of ferrites have been disclosed in this respect.

Our experiments have shown that in some ferrite systems with spinel structure one can encounter compositions with single crystals that have a sufficiently narrow ferromagnetic resonance absorption line. We have measured the width of the line ΔH in single crystals of magnesium-manganese ferrites for different ratios of the manganese and magnesium oxides. The single crystals were grown by the Verneil method and machined into spheres 0.8 — 1 mm in diameter. The surfaces of the spheres were polished by running in with air on emery cloth with 20.15 μ and 10 μ grains. The measurements were made in a short-circuited waveguide section at 9470 Mcs. The width of the line was determined from the resonance curve at the 0.5 level. In the single crystals of magnesium-manganese ferrites which we investigated, ΔH = 12 to 18 oe (see Table I).

The narrowest absorption line at the surface finish employed by us (which obviously is not the ultimate one) was observed in a single crystal of the ferrite 8.4 MgO, 23.9 MnO, 67.5 Fe_2O_3. This sample had ΔH = 12 oe and $4\pi I_s$ = 2950 gauss.

Figure 1 (solid curve) shows the results of measurements of the anisotropy of the width of the line for the single crystal of 6.9 MgO, 37.3 MnO, 55.9 Fe_2O_3 in the (110) plane at room temperature. It is seen that ΔH reaches a minimum along [100] (axis of difficult magnetization) and a maximum in the direction [111] (axis of easy magnetization). The amplitude of the anisotropy ΔH at room temperature amounts to (3.5 to 0.5) oe. The dotted curve in Fig. 1 shows the anisotropy of the resonant field H_r.

The character of the anisotropy of ΔH, established in our experiments, corresponds to the phenomenological calculation of Skrotskiĭ and Kurba-

TABLE I. Width of resonant absorption line ΔH, saturation magnetization $4\pi I_s$, and electric resistivity ρ in magnesium-manganese ferrites

Composition in percent by weight (calculated)	ΔH, oe	$4\pi I_s$, gauss	ρ, Ω·cm
9.4 MgO; 16.5 MnO; 74.1 Fe_2O_3	18	3320	800
8.4 MgO; 23.9 MnO; 67.5 Fe_2O_3	12	2950	$1.6\cdot10^5$
8.0 MgO; 28.3 MnO; 63.7 Fe_2O_3	16	2740	10^6
6.9 MgO; 37.3 MnO; 55.9 Fe_2O_3	18	2480	$4.6\cdot10^6$