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RESEARCH IN HIGH ENERGY PHYSICS AND RELATED TOPICS.

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LONDON W.C.1.

Personnel.

Professor J. Hamilton, Dr. W. N. Cottingham, Dr. T. D. Spearman, Dr. A.Donnachie, Dr. L. Egardt, Messrs D. Atkinson, P. Menotti, G. C. Oades, L. J. Vick, J. Cook, P. D. Kapadia.

The main effort has been the application of disperson relation techniques to pion-nucleon and nucleon-nucleon interactions. Considerable work has also been done on the leptonic decays of hyperons.

Pion-Nucleon Scattering.

(Professor Hamilton, Dr. Spearman, Dr. Donnachie, Messrs Atkinson, Menotti , Oades & Vick).

The method used was the application of the Mandelstam representation to the study of partial wave pion-nucleon scattering amplitudes. This representation makes it possible to analyse the data on low energy pion-nucleon scattering in terms of the 'forces' which produce the scattering. Further it is possible to separate the forces into a long range and a short range part in a reasonably unique way. This is achieved by fitting the partial wave dispersion relations to the data in the crossed (unphysical) region as well as in the physical region.

This separation of the forces into long and short range parts is very important. For example in S - wave pion - nucleon scattering the long range part is due to pion-pion interactions. Pion-pion interactions play a role because the nucleon is not a point. Indeed as Hofstadter has shown the charge distribution of the nucleon is not concentrated at its centre but extends out to a distance of about 10 - 13 cm. This distributed charge can only be carried by the cloud of (vertual) pions, which the nucleon is continuously emitting and re-absorbing. When a pion is incident on the nucleon it interacts with the pion cloud surrounding the nucleon as well as with the central part (or core) of the nucleon.

S-wave π -N Scattering.

Our method makes it possible to separate out the contribution of these pion - pion interactions to the observed S - wave pion - nucleon scattering. Next we deduce the pion-pion interactions themselves, and two important results appear

(i) two pions in the isotopic spin T = 0 state have a strong mutual attraction at low energies. We find a scattering length of about 1.3 natural units. It is also reasonably easy to show that this agrees fairly well with what other information is available about pion-pion interactions in this state.

(ii) two pions in the T = 1 isotopic state are known to have a resonance about 750 Mev. This also fits our data well, and we can give a fairly satisfactory link up between (a) Hofstadter's form factor data (b) low energy pion-nucleon scattering (c) the 750 Mev pion-pion resonance.

p-wave π - N Scattering

Next the same method is applied to the low energy data on p-wave pion-nucleon scattering. This is in good agreement with the pion-pion interactions which we deduced from the s-wave pion-nucleon scattering data. That provides strong confirmation of the validity and consistency of the methods we have used.

Finally from this p-wave work we gain considerable insight into the causes of the p-wave pion-nucleon scattering. For example the ($\frac{3}{2}$ $\frac{3}{2}$) resonance is caused by the Born term plus the T = 0 pion-pion attraction (formerly it was not known that the latter played a part here).

This work has been reported fully in Technical Note No 5, and is being published in Physical Review (Nov. 15th, 1962). Copies of a paper describing an earlier stage of the work (J. Hamilton, T. D. Spearman and W. S. Woolcock, Annals of Physics 17, 1 (1962)) are forwarded with this report.

Spearman's Method.

T. D. Spearman has used a different dispersion relation to analyse s - wave pion-nucleon scattering. This dispersion relation refers to the imaginary part of the scattering amplitude, and again the pion-pion effects can be separated out. This method is independent of the partial wave method discussed above, but the results agree.

This work has been reported in Technical Note No. 9.

Atkinson's Method.

D. Atkinson has carried out an analysis of pion-nucleon scattering using another different method. He examines forward and backward pion-nucleon scattering and deduces the pion-pion interactions. His results are in agreement with those described above, and in addition he obtains some information about the pion-pion interactions in the T = 0, J = 2 (i.e. angular momentum 2) state.

This work has been reported in technical Note No. 6 and will appear soon in Physical Review (Nov. 15th, 1962).

Other Work on Pion-Nucleon Scattering (Professor Hamilton and Dr. Donnachie). An attempt is being made to use the unitary condition to determine the short range interactions in pion-nucleon scattering, from general theoretical considerations. This work was progressing satisfactorily at the end of the period in review, and it is now being pursued further.

Nucleon - Nucleon Interactions (Dr. Cottingham and Mr. Kapadia)

This is an attemptto deduce the inter-nucleon potential from first principles using dispersion relations and putting in the T = 1 pion-pion interaction. Fairly satisfactory agreement with the phenomenological potentials of Breit et al was obtained. Now the method is being refined and improved. This problem is both complicated and difficult, but it appears that for the first time a proper understanding of the nucleon-nucleon interaction is approaching.

The first part of this work is in the process of being published, but no reprints are yet available.

Hyperon Decay (Dr. L. Egardt)

Egardt has examined various aspects of the leptonic decay of hyperons. His work is complementary to experimental work on the leptonic decays which is going on in this laboratory.

First he found the proton-Electron angular distribution in Λ decay under different assumptions for the work interaction. This work has been submitted as Technical Notes No. 7 and No.10. Next he found analogous expressions for the proton spectrum. This has been submitted as Technical Note No.9.

Considerable experimental data on Λ leptonic decay is now coming along and Egardt's calculations should be valuable for sorting out possible types of weak interaction (e.g., current-current, scalar, or axial-couplings).

J.Hamilton.

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