of three terms, all of which can be obtained from any one by cyclic permutation. If we restrict our attention to one of these terms V_{12}, we see that it depends only on the spins of the two nucleons 1, 2 whose world lines contain no pairs. The spin-orbit corrections involve only the spin of the third nucleon. The spin-orbit corrections of lowest order are contained in the expression

$$(2M)^{-2}[\boldsymbol{\sigma}_3\cdot(\nabla_{31}V_{12})\times\mathbf{p}_3+\boldsymbol{\sigma}_3\cdot(\nabla_{32}V_{12})\times\mathbf{p}_3]$$

and its cyclic permutations.

In the case of all diagrams, except (d) and (f), V is a function only of $|\mathbf{r}_i-\mathbf{r}_j|$. Then

$$\boldsymbol{\sigma}_i\cdot(\nabla_{ij}V)\times\mathbf{p}_i=\frac{1}{r_{ij}}\frac{dV}{dr_{ij}}\boldsymbol{\sigma}_i\cdot\mathbf{L}_i,$$

which shows the spin-orbit coupling explicitly.

The level splittings between states of $j=l-\frac{1}{2}$ and states of $j=l+\frac{1}{2}$ of a single nucleon outside a closed shell can be estimated,[6] and are of the order of 1 Mev or smaller, and of both signs.[7] This is an order of magnitude too small to fulfill the requirements of the shell model. Moreover, there seem to be no indications that consideration of many-nucleon forces involving more than three nucleons, or consideration of two- and three-nucleon forces of high order in the coupling constant, will supply the spin-orbit interaction postulated by the shell model. It should be pointed out that divergent diagrams have been consistently neglected in this investigation. Also, many spin-dependent terms which are not of the form of spin-orbit potentials have been discarded. These factors may possibly affect the level splitting significantly. For example, effects of the tensor force, corresponding to certain reducible diagrams and arising from second and higher orders in ordinary perturbation theory, may be responsible for the splitting.[8] The approximate equality of the splittings due to diagrams (a), (b), (d), (e), (f), and (g) raises the question of convergence[9] and casts doubt on the validity of the whole procedure.

It is a pleasure for the author to acknowledge his gratitude to Dr. F. Rohrlich for suggesting this problem, and for many interesting and stimulating discussions. His thanks are also due Dr. A. Klein for a copy of his unpublished manuscript, and for an interesting correspondence.

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[3] This author has independently calculated the uncorrected three-nucleon potentials arising from diagrams (d), (e), and (f) by the Tamm-Dancoff method. The results agree with those of Klein, reference 2.
[4] M. M. Lévy (private communication).
[5] We use units of $\hbar=c=1$.
[6] For the purpose of numerical estimates we choose $G^2/4\pi=10$.
[7] The level splitting vanishes for diagram (d) on account of its spin dependence.
[8] A. Feingold, Ph.D. thesis, Princeton University (unpublished).
[9] A. Klein, Bull. Am. Phys. Soc. **28**, No. 3, 36 (1953).

Radioactive Charging through a Dielectric Medium*

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A STUDY has been made of a process of electrostatic charging in which charged particles pass from a radioactive emitter through a dielectric to a collector. Particular attention has been given to the role played by the dielectric. The process of charging through a vacuum has been discussed in previous publications.[1-3]

If a layer of dielectric F (in Fig. 1) is sandwiched between an electrode S, emitting beta-rays, and an electrode P, acting as a collector, radiation from S will pass through F and charge P negatively, leaving S positive. A voltage will be developed across terminals T. Such a device may be represented by an equivalent circuit consisting of a constant current source of output i_0, representing the radioactive material, in parallel with the capacitance C of the device, and in parallel with its internal resistance and any other resistance which might be connected across terminals T. The initial rate of charge is i_0/C. The final equilibrium voltage is Ri_0. These relations have been verified experimentally. Sr90–Y90 sources of effectively 2 millicuries and 54 millicuries were used. The dielectric was polystyrene.

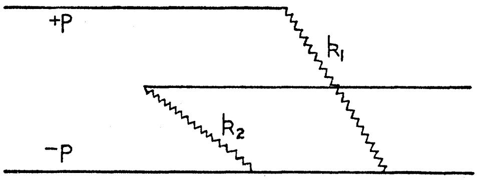

FIG. 1. Schematic diagram showing radioactive source S, dielectric separator F, and collector P.

Current-voltage characteristics, made with a 10^{-11} ampere charging current indicated that a maximum voltage of about 3700 could be reached. The internal resistance was found to correspond to a specific resistance for polystyrene of 7×10^{15} ohm-cm. Unbombarded values are given in the literature ranging from 10^{18} to 10^{22}. This decrease is attributed to bombardment-induced conductivity of the polystyrene. With a 2.5×10^{-10} ampere charging current the maximum voltage was determined to be about 6600, and the corresponding specific resistance 0.5×10^{15} ohm-cm, a decrease by a factor of 14 from the former value.

Measurements of the effect of varying the dielectric thickness showed an optimum thickness which yielded maximum charging rate. Charge soakage effects were observed, the charge rate and voltage developed being affected by previous radioactive charging. Backscattering of electrons was found to reduce the charging current. From this reduction backscattering coefficients were calculated as follows: 0.49 for lead, 0.31 for tin, 0.25 for silver, 0.17 for copper, 0.09 for aluminum, and 0.04 for carbon. These are in satisfactory agreement with values found by Trump and Van de Graaff.[4] A discussion of the experiments and their results will be published in detail at a later date.

The apparatus and techniques used in this study seem to offer a new and simple method of studying such effects as bombardment-induced conductivity, secondary emission, charge soakage, radiation absorption, and other effects of radiation on solids.

The work described here was suggested by the possibility of making a radioactive voltage or current source. Such a source could possess the advantages of long life, stability, and simplicity of construction. It is believed that it might find considerable application in the electronics field.

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Origin of the "Strong-Focusing" Principle*

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AFTER our proposal for strong-focusing accelerators[1,2] had been published, our attention was called to an unpublished manuscript by N. Christophilos, entitled "Focussing System for Ions and Electrons and Application in Magnetic Resonance Particle Accelerators." In this paper Christophilos proposes an accelerator which incorporates strong focusing, using a sinusoidal variation of the field gradient with azimuth rather than the stepwise variation considered by us. He points out, as did we, that