

From Eqs. (2)–(4) one easily obtains

$$\frac{1}{a} = \frac{\int \bar{\chi}(2)A(2)\psi(2)d\tau_2 + i \int \bar{\chi}(3)A(3)K_+(3, 2)A(2)\psi(2)d\tau_2 d\tau_3}{\int \bar{\chi}(2)A(2)f(2)d\tau_2 \times \int \bar{g}(2)A(2)\psi(2)d\tau_2} \quad (5)$$

The first-order variation of $1/a$, with respect to arbitrary independent variations of ψ and $\bar{\chi}$, vanishes.

In the particular case of a time-independent potential, starting from Eqs. (2) and (3) in which integration with respect to the time variable is performed, one obtains the variational principle for the scattering amplitude already used by Schwinger and his co-workers.⁴

It seems worth while to compare these results with the variational principle established by Schwinger⁵ for the "reaction operator K ." Following Schwinger's notation it is useful to indicate the world-points 1 and 2 by x' and x , respectively. One has the relation⁷

$$K_+(2, 1) = i\bar{S}(x-x') - \frac{1}{2}S^{(0)}(x-x'). \quad (6)$$

Solving Eqs. (2) and (3) by successive approximations and introducing the solutions in Eq. (4), one obtains an expression that can be compared with the analogous expansion of the reaction operator given in S III, Eq. (1.24).

One finds that a is the matrix element of the operator⁸ $S-1$ taken between the initial and final state of the electron. The expansions of the two operators $\frac{1}{2}(S-1)$ and K are identical, except that in the former the function $K_+(2, 1)$ given by Eq. (6) in term of functions $\bar{S}(x-x')$ and $S^{(0)}(x-x')$ appears, while in the latter only the function $i\bar{S}(x-x')$ is contained.

The fact that for the two operators the same variational principle holds follows from both functions $K_+(2, 1)$ and $\bar{S}(x-x')$ being four-dimensional Green functions for Dirac's free electron equation.

The details of these calculations will be published elsewhere.

- ¹ J. Schwinger, Phys. Rev. **72**, 742 (1947); W. Kohn, Phys. Rev. **74**, 1763 (1948); J. M. Blatt and J. D. Jackson, Phys. Rev. **76**, 18 (1949).
² R. P. Feynman, Phys. Rev. **76**, 749 (1949).
³ All symbols used are defined in Feynman's paper.
⁴ See reference 1, Kohn, Section III.
⁵ J. Schwinger, Phys. Rev. **74**, 1439 (1948); **75**, 651 (1949); **76**, 790 (1949); referred to as S I, S II, and S III.
⁶ See reference 5, S I, Eqs. (4.15) and (4.22).
⁷ The definitions of the functions $\bar{S}(x)$ and $S^{(0)}(x)$ are given in S II.
⁸ See also F. J. Dyson, Phys. Rev. **75**, 1736 (1949).

Mass Assignment of Natural Activity of Samarium

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Sm^{147} has now been definitely established as the source of the natural alpha-radiation from this element. This was done by direct counting of each of the samarium isotopes, recently separated by the Isotope Research and Production Division at Y-12.¹

Although previous reports had indicated that the alpha-active samarium isotope might be of mass 148² or 152,³ Dr. A. J. Dempster's latest conclusions were "that the alpha emitting isotope is almost certainly the isotope at mass 147."⁴

Alpha-counting may be used for the approximate determination of the Sm^{147} content of enriched samarium isotopes. A comparison

TABLE I. Counting rates of samarium samples.

Isotope collection	Natural Sm							
	144	147	148	149	150	152	154	
Counts/min.	24.1	10.9	130.8	9.3	8.3	3.5	2.9	0.53
Mass 147 content in percent (by mass spectrometer)	15.07*	7.7	81.6	6.1	5.1	2.0	1.6	0.36
Sm^{147} content in percent (from alpha-counts)	15.0	6.8	—	5.8	5.2	2.2	1.8	0.33

* Inghram, Mark G., David C. Hess, Jr., and Richard J. Hayden, Phys. Rev. **73**, 180 (1948).

of 81.6 percent Sm^{147} with the other separated isotopes is given in Table I. Ten-milligram samples of samarium oxide were used in these determinations. Closer correlation with results from the mass spectrometer will probably be possible with improvement in the technique of sample preparation.

The method of preparing samples was as follows. Ten milligrams of pure Sm_2O_3 were placed on a stainless steel disk and dissolved in about 0.1 ml of concentrated nitric acid. The solution was dried over a low hot plate. Its tendency to contract toward the center of the disk was counteracted by spreading with a small glass rod until streaks were left in the thickening solution. The nitrate was ignited to oxide over a Meker burner. The sample covered about 20 cm² of disk area.

All samples were counted for at least an hour in proportional counters having backgrounds of only 5 to 10 counts/hr., after earlier measurements by other counters with higher backgrounds had revealed the activity from Sm^{147} .

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¹ C. P. Keim, H. W. Savage, and Boyd Weaver, Y-640.

² T. R. Wilkins and A. J. Dempster, Phys. Rev. **54**, 315 (1938).

³ A. J. Dempster, Phys. Rev. **73**, 1125 (1948).

⁴ A. J. Dempster (quotation from a private communication, 1949).

Single Crystal Magnetostriction Constants of an Iron-Cobalt Alloy

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THE single crystal magnetostriction constants of iron-cobalt alloys have never been measured owing to the difficulty of obtaining large single crystals of a brittle material which undergoes a phase transformation, and the insensitivity of the usual measuring techniques which make them inapplicable to measurements on a small crystal. We have adapted the resistance strain gauge technique first employed by us for magnetostriction measurements on polycrystalline materials¹ to the measurement of magnetostriction in very small single crystals of iron-cobalt. The results reported below are for a crystal containing 30 percent cobalt very kindly loaned to us by Professor McKeehan of Yale University. The crystal is in the form of an oblate spheroid 3 mm in diameter and approximately 0.3 mm thick. For crystals of this size, the form effect can be neglected to a first approximation.² The orientation of the crystal was determined with x-rays by back reflection using white radiation from a tungsten target.³ The plane of the sample is found to be approximately a (411) plane.

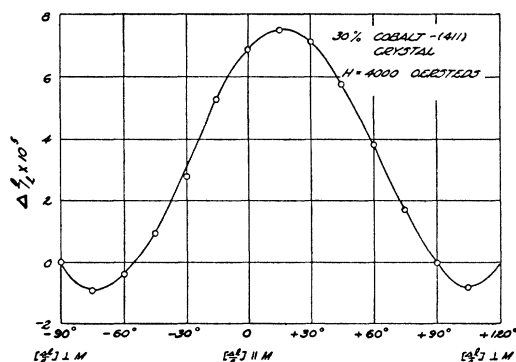


FIG. 1. $\Delta l/l$ in direction of gauge vs. angle between gauge and M .