process, $He^+ + 2He \rightarrow He_2^+ + He$. Substitution of the interaction constants of Massey and Mohr[11] in the Thomson formula gives that the mean lifetime of a He^+ ion in helium at 25 mm Hg is only about 10^{-5} sec.[12] Since the age of the ions studied by Biondi and Brown ranged from 5×10^{-3} to $1\cdot1\times10^{-2}$ sec., it would seem probable that they were indeed He_2^+. In view of the importance of being certain of the nature of the recombination mechanism, it would be useful if this could be verified by means of a mass spectrograph.

The ambipolar diffusion measurements were conducted at lower pressures but the conditions were still such that He_2^+ might well predominate over He^+. Unfortunately the discrepancy between the results of Biondi and Brown and those of Tyndall and Powell[13] cannot be attributed to this, for Meyeratt[14] claims these latter probably also worked with molecular ions. It is difficult to predict the mobility of He_2^+ as certain collision reactions may introduce complications.

Finally I would like to thank Professor H. S. W. Massey for several helpful discussions.

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Microwave Spectra and Molecular Constants of Trifluorosilane Derivatives. SiF_3H, SiF_3CH_3, SiF_3Cl, and SiF_3Br *

JOHN SHERIDAN† AND WALTER GORDY
Department of Physics, Duke University, Durham, North Carolina
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$Si^{28}F_3H$ and $Si^{29}F_3H$. The rotational transitions $J=1\rightarrow2$ and $J=2\rightarrow3$ have been observed for $Si^{28}F_3H$. Precise measurements on the $J=1\rightarrow2$ transition yield: $\nu=28{,}831.90\pm0.10$ mc, $B_0=7207.98$ mc, and $I_B=116.39_4\times10^{-40}$ g cm^2 (with Planck's constant $=6.624_2\times10^{-27}$ erg sec.). With the assumptions, $d_{SiH}=1.55\pm0.05$A and $\angle FSiF=110°\pm1°$, the silicon-fluorine distance, $d_{SiF}=1.555\pm0.005$A, is obtained.

The $J=2\rightarrow3$ transition has been observed for $Si^{29}F_3H$. Failure to detect a hyperfine structure is evidence, but not proof,[1] that the nuclear spin of Si^{29} is $\frac{1}{2}$. Precision measurements are being made on the rotational frequency of this and other transitions. Also, it is expected that measurements can be made on $Si^{30}F_3H$, with Si^{30} in naturally occurring concentrations.

$Si^{28}F_3C^{12}H_3$. Observations of the $J=3\rightarrow4$ and $J=5\rightarrow6$ transitions[2] have been made for $Si^{28}F_3C^{12}H_3$. Precise measurements yield: $\nu=29{,}724.91\pm0.18$ mc for the $J=3\rightarrow4$ transition, $B_0=3715.62$ mc, and $I_B=225.79_4\times10^{-40}$ g cm^2 (with $h=6.624_2\times10^{-27}$ erg sec.). Assuming all angles to be tetrahedral and assuming $d_{SiF}=1.555$A and $d_{CH}=1.10$A, the SiC distance obtained is 1.88A.

$Si^{28}F_3Cl^{35}$ and $Si^{28}F_3Cl^{37}$. The pure rotational transitions, $J=6\rightarrow7$, $7\rightarrow8$, and $8\rightarrow9$, have been observed for $Si^{28}F_3Cl^{35}$ and the $J=7\rightarrow8$ for $Si^{28}F_3Cl^{37}$. A hyperfine structure, which has not yet been completely analyzed, was observed for each transition. The moments of inertia (I_B) are $338._6\times10^{-40}$ g cm^2 and $347._5\times10^{-40}$ g cm^2 for $Si^{28}F_3Cl^{35}$ and $Si^{28}F_3Cl^{37}$, respectively. If $\angle FSiCl$ is taken as 110°30′, as indicated by electron diffraction,[3] the preliminary values, $d_{SiF}=1.55_0$A and $d_{SiCl}=1.99_8$A, are obtained. The SiCl distance thus appears to be shorter than that[4] in SiH_3Cl by about 0.05A.

$Si^{28}F_3Br^{79}$ and $Si^{28}F_3Br^{81}$. The pure rotational transitions $J=15\rightarrow16$ and $16\rightarrow17$ have been observed for $Si^{28}F_3Br^{81}$ and the $J=16\rightarrow17$ for $Si^{28}F_3Br^{79}$. The hyperfine structure has not been completely analyzed. The moments of inertia are $541._4\times10^{-40}$ g cm^2 and $547._3\times10^{-40}$ g cm^2 for $Si^{28}F_3Br^{79}$ and $Si^{28}F_3Br^{81}$, respectively. If $\angle FSiBr$ is taken as 110°30′, as is $\angle FSiCl$ in SiF_3Cl, preliminary figures for the bond distances are obtained as follows: $d_{SiF}=1.55_0$A, $d_{SiBi}=2.15_9$A. The SiBr distance is thus probably some 0.05A shorter than that[5] (2.20$_9$A) in SiH_3Br.

Further work on these molecules is planned to complete the structure determinations and to determine the nuclear couplings and molecular dipole moments.

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† On leave from Department of Chemistry, University of Birmingham, England.
[1] From the relation between nuclear quadrupole moment and nuclear shell structure found by Gordy [Phys. Rev. **76**, 139 (1949)] one would not expect a large quadrupole moment for Si^{29}. Because of the symmetry of the tetrahedral bonds to Si, the quantity $(\partial^2V)/(\partial z^2)$ would be very small. Hence, if a hyperfine structure exists for $Si^{29}F_3H$, it might be unresolvable.
[2] Concurrently with our work, Minden, Mays, and Dailey (private communication) have made approximate measurements on the $J=2\rightarrow3$ and $3\rightarrow4$ transitions of SiF_3CH_3. They report several lines caused by molecules in excited vibrational states.
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Multiple Meson Processes and Nucleon Recoil

ALEX E. S. GREEN
University of Cincinnati, Cincinnati, Ohio
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AN investigation of the effects of multiple meson processes and nucleon recoil has been carried out with an adaptation of the functional formalism of Fock.[1] An iterative method was employed to deduce from the set of integro-differential equations the explicit interaction $U={}^2U+{}^4U+{}^6U+\cdots$, where

$$ {}^2U=-\int\{G_0^*(\mathbf{k})G_0(\mathbf{k})/\hbar\omega\}d\mathbf{k}, \tag{1}$$

$$ {}^4U=+\int\{G_0^*(\mathbf{k})[H_p, G_0(\mathbf{k})]/(\hbar\omega)^2\}d\mathbf{k}, \tag{2}$$

$$ {}^6U=-\int\{G_0^*(\mathbf{k})[H_p, [H_p, G_0(\mathbf{k})]]/(\hbar\omega)^3\}d\mathbf{k}, \tag{3}$$

$$ G_0(\mathbf{k})=\Sigma_u\, g(2\pi)^{-\frac{1}{2}}\beta_u c(\hbar/2\omega)^{\frac{1}{2}}\exp(-i\mathbf{k}\cdot\mathbf{x}_u). \tag{4}$$

H_p is the Hamiltonian for free nucleons and $\omega=c(\mathbf{k}\cdot\mathbf{k}+\kappa^2)^{\frac{1}{2}}$.

Equation (4) is for a neutral one-mass scalar field with scalar coupling. It may be modified for other types of fields and couplings. ${}^2U$ is the usual second-order interaction. Using this very same formalism but neglecting nucleon recoil, Tomonaga[2] obtained only ${}^2U$. In contrast with previous results by others ${}^4U$, ${}^6U$, ${}^8U$, etc. here are quadratic in the coupling constant. In deriving ${}^6U$ and ${}^8U$ certain questions as to the order of the operators involved in self-energy terms arose which we resolved in view of the symmetry requirements for bosons by assuming that expressions like $[G_{0u}(\mathbf{k}_2), [H_{pu}, G_{0u}(\mathbf{k}_1)]]\psi_0$ may be ignored. Apart from this unsettled point the work was straightforward. We believe it reasonable to anticipate that an indefinite extension of our method or a valid alternative perturbation method will lead to the following conclusions.

(a) The exact interaction is quadratic in the coupling constant.

(b) The results of any development employing power series in the coupling constant must be regarded with very great suspicion. The fact that in electrodynamics such a perturbation method