TABLE I. Thresholds for photo-nuclear reactions.

| Parent isotope | Activity detected | Observed threshold (Mev) | | Other work* (Mev) |
|---|---|---|---|---|
| $I^{127}$ | 13 d. $\beta^-$ | 9.45 ±0.20 | | |
| $Pr^{141}$ | 3.5 min. $\beta^+$ | 9.8 ±0.3 | | 9.40 ±0.1 |
| $As^{75}$ | 16 d. $\beta^-$, $\beta^+$ | 10.3 ±0.2 | | |
| $Zr^{90}$ | 4.5 m. $e^-$ | 12.1 ±0.1 | Average 12.0 ±0.2 | 12.48 ±0.15 |
| | 78 h. $\beta^+$ | 11.9 ±0.3 | | |
| $Ni^{58}$ | 36 h. $\beta^+$ | 11.7 ±0.2 | | |

* Hanson, Duffield, Knight, Diven, and Palevsky, Phys. Rev. **76**, 578 (1949).

The results are shown in Table I. Zirconium$^{90}$ decays either by 78-hour positron emission, or by 4.5-minute internal conversion or *K*-capture. The apparent threshold for the photo-disintegration of $Zr^{90}$, as determined by observation of the 78-hour period, was slightly less than that determined by observation of the 4.5-minute period. If the 4.5-minute period represents the decay by isomeric transition into the 78-hour isotope, one would expect the threshold observed by means of the 78-hour period to be somewhat less than that observed by the 4.5-minute period. However, since the errors quoted for the thresholds overlap, it is probably more logical to take 12.0±0.2 Mev as a mean value for the gamma-*n* threshold of $Zr^{90}$.

The authors would like to express their appreciation to Mr. Robert D. England for his very considerable help in keeping the betatron and the associated circuits running during the course of this work.

* This document is based on work performed at the Los Alamos Scientific Laboratory of the University of California under Government contract W-7405-Eng. 36.

** Now doing graduate work at George Washington University, Washington, D. C.

[1] J. Mattauch, *Nuclear Physics Tables* (Interscience Publishers, Inc., New York, 1946).

[2] McElhinney, Hanson, Becker, Duffield, and Diven, Phys. Rev. **75**, 542 (1949).

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# True Magnitude of the Geomagnetic Secular Variation

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IN order to analyze the geomagnetic secular variation in physical terms one extrapolates the surface field so as to obtain the field at the boundary of the earth's core[1] (this boundary, designated here by *C*, is almost halfway down to the earth's center). It follows from potential theory that the secular field at *C* is uniquely determined by the corresponding surface field under the highly plausible assumption that there are no sources of this field in the intervening layer. The extrapolation is usually carried out by means of a spherical harmonic analysis, but at *C* the series converges too slowly to be of much use. Vestine's[2] detailed maps of the secular variation show that the phenomena may be graphically described by a number of moderately rounded "hills", some positive, some negative, where the lines of constant rate of change of the field or potential are the contour lines of the hills. There are some 10 to 11 hills and dales on the whole earth at the present time.[3]

It is possible to achieve projection upon *C* of an individual "hill" having a circular boundary; for this purpose we employ solutions of the potential equation which vanish at the surface of a cone of half-angle $\vartheta_0$. They are

$$\psi = r^{-n-1} P_n^m(\cos\vartheta) e^{im\varphi},$$

where $n$ is non-integral, defined by $P_n^m(\cos\vartheta_0)=0$. The surface harmonics form an orthogonal set over the circular section of the sphere cut out by the cone. For not too large values of $\vartheta_0$ (up to about 55°), $P_n^m$ is well approximated by the Bessel function, $J_m[n^{\frac{1}{2}}(n+1)^{\frac{1}{2}}\vartheta]$. In practice the leading term of this series is by far the most useful, as for the higher terms $n$ is so large that $r^{-n-1}$ varies too rapidly to be significant, given the limited accuracy of the data. It follows from the orthogonality that the magnitude of the leading term furnishes, at any level below the surface, a lower limit for the r.m.s. value of the potential or field over the circular area. Numerical tests show that the observed hills, on averaging over the deviations from roundness, are well approximated by the lowest term in $J_0$.

For preliminary computations we have used Vestine's[2] maps of the variation of the vertical field component. These were replaced by an assembly of 10 to 11 circular regions whose aggregated area about equals that of the earth. The size of each region and the difference of the field at the center and at the circumference were chosen to correspond to the actual features of the maps. The radii of the regions range from 23° to 50°; the first term of each expansion gives an r.m.s. value at *C*, ranging between about 0.15 and 1.5 gauss/century, for individual regions. The grand total r.m.s. value is near 0.7 gauss/century (estimated error, 20 percent). Now the mean lifetime of these centers of secular variation is somewhat less than a century; hence on integrating over the mean lifetime it may be concluded that the secular variation corresponds to a fluctuating field at *C* whose vertical component has an r.m.s. magnitude of at least 0.5 gauss. The r.m.s. value of the vertical component of the main dipole field at *C* is 1 gauss; hence the variable part of the field is certainly not small compared to the constant part at *C*. These results seem to favor the explanation of both parts of the field by a common hydromagnetic mechanism proposed by one of us[1] as compared with the assumption of a separate "fundamental" origin of the dipole component parallel to the earth's axis.

[1] W. M. Elsasser, Rev. Mod. Phys. **22**, 1 (1950).

[2] E. H. Vestine, Carnegie Institution of Washington Publications, Nos. 578 and 580 (1948).

[3] See some of Vestine's maps reproduced in reference 1.

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# A Determination of the Dipole Moment and Molecular Structure of Fluorosilane

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WE have measured and identified the three rotational absorption lines arising from the $J=0\rightarrow1$ transitions of $Si^{28}H_3F$, $Si^{29}H_3F$, and $Si^{30}H_3F$. The spectrum consisted of a single absorption line for each molecular species and so is in harmony with present ideas that the $Si^{28}$ and $Si^{30}$ spins are zero and that $Si^{29}$ spin is 1/2. It is possible that these spins might be incorrect if the nuclei had very small quadrupole coupling constants which resulted in an unresolvable hyperfine structure. The measured and derived constants are listed in Table I.

In principle one could determine unambiguously the three structural parameters of such a symmetric top molecule since moments of inertia have been measured for structures corre-

TABLE I. Molecular constants for $SiH_3F$ (transition $J=0\rightarrow1$).

| Species | $\nu_0$(mc/sec.) | $I_B\times10^{40}$ (g-cm$^2$) | $B_0$ (mc/sec.) |
|---|---|---|---|
| $Si^{28}H_3F$ | 28,655.80 ±0.1 | 58.555 | 14327.9 |
| $Si^{29}H_3F$ | 28,393.4 ±0.2 | 59.096 | 14196.7 |
| $Si^{30}H_3F$ | 28,145.2 ±0.2 | 59.617 | 14072.6 |

sponding to the three different isotopic masses of Si. However, the uncertainties in the absolute values of the isotopic masses do not permit the evaluation of accurate values of the molecular configuration from these three nearly parallel equations relating the structural parameters with the moments of inertia. In order to avoid the parallelism it is necessary that one of the three moments of inertia be measured for a structure resulting from an isotope variation in another atom; in either the fluorine or the hydrogen atoms in this case.

Assuming an angle of $111° \pm 1°$ for the HSiH angle, as is indicated from measurements on other monohalogen silanes, we compute $d_{\mathrm{SiF}} = 1.593 \pm 0.002\mathrm{A}$ and $d_{\mathrm{SiH}} = 1.503 \pm 0.036\mathrm{A}$ from the measurements on $\mathrm{Si^{28}H_3F}$ and $\mathrm{Si^{30}H_3F}$. These values were then checked with the measurements on $\mathrm{Si^{29}H_3F}$ and found to be consistent. The $d_{\mathrm{SiF}}$ is thus about 0.04A longer than the corresponding distance (1.555A) found in $\mathrm{SiHF_3}$.[1] This is consistent with the shortening (about 0.06A) of the CF bond in $\mathrm{CHF_3}$ over that found in $\mathrm{CH_3F}$.[2] Our value of 1.593A for $d_{\mathrm{SiF}}$ is considerably shorter than the sum of Pauling's covalent radii (1.81A). That this observed bond shortening is likely to be due to resonance with an ionic structure is born out by the sum corrected according to the Schomaker-Stevenson rule, *viz.*,

$$d_{\mathrm{SiF}} = r_{\mathrm{Si}} + r_{\mathrm{F}} - 0.09\,|X_{\mathrm{Si}} - X_{\mathrm{F}}| = 1.61\mathrm{A},$$

where the quantity in bars is the electronegativity difference of the silicon and fluorine.

From measurements of the Stark effect of the $\mathrm{Si^{28}H_3F}$ line, we compute the dipole moment to be $1.268 \pm 0.013D$.

The authors gratefully acknowledge the assistance of Dr. Paul Zemany of this laboratory who checked the purity of the gas sample on the mass spectrometer.

[1] John Sheridan and Walter Gordy (private communication).

[2] Gilliam, Edwards, and Gordy, Phys. Rev. **75**, 1014 (1949).

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## Temperature Variation of Decay Times of Scintillation Phosphors

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A DECREASE in the decay times of gamma-scintillations with decrease in temperature of organic phosphors has been found by Kelley and Goodrich[1] of Oak Ridge and also by this Laboratory. Measurements made at this Laboratory of the variation of organic phosphor times with temperature using a shorted line technique give the following results: anthracene at 290°K—$3.2 \times 10^{-8}$ sec.; anthracene at 80°K—$1.4 \times 10^{-8}$ sec.; anthracene at 4°K—$6 \times 10^{-9}$ sec., which was within the resolving time of the photo-multiplier. That this behavior is probably characteristic of the molecules rather than the lattice is shown by the fact that mixtures of anthracene in naphthalene yielded approximately the same variation with temperature. These preliminary measurements are believed to have an over-all accuracy of better than 20 percent and are based on pulse shapes having the form $e^{-t/\tau}$. More accurate determinations of temperature variation are now in progress.

[1] G. G. Kelley and M. Goodrich, Phys. Rev. **77**, 138 (1950).

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## Interpretation of Underground Cosmic-Ray Data

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February 20, 1950

IN a recent note of the same title,[1] the author misrepresented the conclusions of Barnothy and Forro, and implied that the results of Miesowicz *et al.*[2] opposed the existence of the penetrating, non-ionizing component hypothesized by Barnothy and Forro. Actually, the soft, isotropic, non-ionizing radiation studied by Miesowicz *et al.* had been detected and investigated many years ago by Barnothy and Forro,[3] who originally suggested that it was largely composed of gamma-rays of radioactive origin, in agreement with the recent conclusions of Miesowicz. The *penetrating* non-ionizing radiation, suggested by Barnothy and Forro as necessary to interpret their absorption curves, is supposed to be of a quite different character, and on the question of the reality of this radiation the work of Miesowicz *et al.* apparently presents no information.

[1] K. Greisen, Phys. Rev. **76**, 1718 (1949).

[2] Miesowicz, Jurkiewicz, and Massalski, Phys. Rev. **77**, 380 (1950).

[3] J. Barnothy and M. Forro, Phys. Rev. **55**, 870 (1939).

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## $N_2O$ Bands in the Solar Spectrum*

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NITROUS oxide in the earth's atmosphere was first detected spectroscopically by Adel[1] through observation of the $\nu_1$ fundamental at $7.8\mu$. Subsequent confirming observations of other $N_2O$ bands at $3.9\mu$, $4.1\mu$, $4.5\mu$, and $8.6\mu$ were made by Migeotte[2] at Ohio State University and by Shaw, Sutherland, and Wormell[3] at Cambridge University.

The laboratory observations of Plyler and Barker[4] suggest that additional weaker bands of $N_2O$ may appear in the solar spectrum in the spectral region below $3.6\mu$ accessible to the high dispersion spectrometers and Cashman PbS cells[5] of the McMath-Hulbert Observatory at Lake Angelus and at the Mount Wilson Observatory. The expected bands, $2\nu_2 + \nu_3$ at $2.97\mu$, $2\nu_3$ at $2.26\mu$, and $2\nu_1 + \nu_3$ at $2.13\mu$, have all been found in the solar spectrum. The $2.97\mu$ and $2.26\mu$ bands are badly blended, the former with a band of $H_2O$ and the latter with lines of $CH_4$ and $H_2O$. The bands at $2.13\mu$ and $2.26\mu$ are absent on tracings made with the noonday sun but appear quite plainly at solar altitudes less than about 10°. Comparison of telluric and laboratory intensities suggests an atmospheric abundance for $N_2O$ equivalent to that in a layer 4 mm thick at NTP.

Study of the solar tracing of the $2.13\mu$-band has revealed that each line is asymmetrically widened on the long wave-length side, indicating the presence of a weaker overlapping band of the same spacing. The asymmetry of the lines has been confirmed by a laboratory tracing made with a carbon arc as a source and an absorption cell containing 25 cm of $N_2O$ at atmospheric pressure. The laboratory tracing shows two additional very weak bands of $N_2O$, not recorded by Plyler and Barker, at $2.16\mu$ and at $2.28\mu$. The latter band is overlapped by the negative branch of the $2.26\mu$-band. The band at $2.16\mu$ is very probably caused by the transition from the ground state to $\nu_1 + 2\nu_2 + \nu_3$, for which the calculated position is $4633.9\ \mathrm{cm}^{-1}$. It has not yet been determined whether the faint bands overlapping those at $2.13\mu$ and $2.26\mu$ are isotopic or perhaps originate from an excited vibrational state.

The $2.16\mu$-band has been found in the solar spectrum on a sunset tracing made by Mr. Dale Vrabec at the Mount Wilson Observatory on September 25, 1949. The path length involved was of the order of 50 air masses.

We wish to thank Dr. I. S. Bowen for making available the Snow Solar Telescope under a guest investigator arrangement between the Mount Wilson and Palomar Observatories and the McMath-Hulbert Observatory. We also acknowledge with gratitude the continued assistance by McGregor Fund of Detroit.

* Supported in part by Contract N6onr-232-V with the ONR.

[1] A. Adel, Astrophys. J. **90**, 627 (1939).

[2] M. Migeotte, *The Atmospheres of the Earth and Planets* (University of Chicago Press, Chicago, 1949), p. 284.

[3] Shaw, Sutherland, and Wormell, Phys. Rev. **74**, 978 (1948).

[4] E. K. Plyler and E. F. Barker, Phys. Rev. **38**, 1827 (1931).

[5] Robert R. McMath and Orren C. Mohler, J. Opt. Soc. Am. **39**, 903 (1949).