comparison of the two effects should show whether, apart from the Coulomb repulsion, the proton-proton and the neutron–neutron interactions are the same at high energies. The recently published results of Stern and Bloom[2] on the scattering of 190-MeV. deuterons by protons (equivalent to the scattering of protons of approximately 95 MeV. by deuterons) are of great interest from this point of view. If their results are integrated over all angles, an elastic cross-section of roughly 24 millibarns is found. W. M. Powell[3], on the other hand, has observed an elastic neutron–deuteron cross-section of 48 millibarns at 90 MeV. neutron energy.

The experiment reported here was greatly assisted by the co-operation of Mr. A. O. Edmunds and the cyclotron crew. One of us (G. H. S.) is a member of the staff of the South African Council for Scientific and Industrial Research.

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## Raman and Infra-Red Spectra of Germanium Tetrafluoride

THE Raman spectrum of gaseous germanium tetrafluoride at 1·8 atm. has been investigated with mercury arc excitation, and two lines have been observed. One is excited by $\lambda$ 4358 and the other by $\lambda$ 4046 A., the measured $\Delta\nu$-values being 737·1 and 738·4 cm.$^{-1}$ respectively. This shift may with confidence be identified with the symmetrical breathing frequency of the tetrahedral $GeF_4$ molecule, to which we assign the value $\nu_1 = 738 \pm 2$ cm.$^{-1}$.

We have also observed the infra-red absorption spectrum of gaseous germanium tetrafluoride. This shows several bands, the most intense of which lies at 800 cm.$^{-1}$ and probably corresponds to $\nu_3$.

Further details of the spectra will be published later.

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## Runs in a Sequence of Observations

IN previous communications[1–4] one of us (P. V. K. I.) has discussed a number of distributions arising from $m$ observations belonging to $k$ groups arranged at random on a line. When all the observations are different, $m$ is equal to $k$, and for this case Kermack and McKendrick[5], and Levene and Wolfowitz[6] have considered the distribution of the number of runs 'up' and 'down'. A run 'up' or 'down' is a succession of observations in ascending or descending order. Kendall[7] has dealt with the same problem by considering the number of 'troughs' and 'peaks'. When $m$ is greater than $k$, the sequence of observations will have three kinds of runs, namely, ascending, descending and stationary. This note gives the difference equation satisfied by the probability generating function and the first two moments for the distribution of the total number of *junctions* for a sequence of $m$ observations with fixed probabilities $p_1, p_2 \ldots p_k$, a junction being the meeting point between two runs 'up', 'down' or stationary. It may be noted that the total number of runs is equal to the total number of junctions increased by unity.

The difference equation reduces to a $k \times k$ determinant as shown below:

$$\begin{vmatrix} \theta_1 & \psi_{10} & \psi_{11} & \psi_{12} & \cdot & \psi_{1,k-2} \\ \lambda_{20} & \theta_2 & \psi_{20} & \psi_{21} & \cdot & \psi_{2,k-3} \\ \lambda_{31} & \lambda_{30} & \theta_3 & \psi_{30} & \cdot & \psi_{3,k-4} \\ \lambda_{42} & \lambda_{41} & \lambda_{40} & \theta_4 & \cdot & \psi_{4,k-5} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \lambda_{k,k-2} & \lambda_{k,k-3} & \lambda_{k,k-4} & \lambda_{k,k-5} & \cdot & \theta_k \end{vmatrix} \varphi(m-2)=0$$

where $\theta_r = E^2 - p_r(p_r+q_rt)$; $\psi_{rs} = -p_r[p_{r+1} + p_{r+2} + \ldots + p_{r+s} + (1 - p_{r+1} - p_{r+2} - \ldots - p_{r+s})t]$ $\lambda_{rs} = -p_r[p_{r-1} + p_{r-2} + \ldots + p_{r-s} + (1 - p_{r-1} - p_{r-2} - \ldots - p_{r-s})t]$; $p_r + q_r = 1$; $E$ is the usual operator in finite difference and

$$\varphi(m) = p(m,0) + p(m,1)\,t + p(m,2)\,t^2 + \ldots,$$

$p(m,r)$ being the probability for $r$ junctions in $m$ observations.

The first two moments are:

$\mu'_1 = (n-2)\,\{4\Sigma p_rp_sp_t + 3\Sigma p_rp_s(p_r+p_s)\} = (n-2)\,P_1(3)$,

$\mu_2 = \mu'_1 + 2\,(n-3)\,\{10\Sigma p_rp_sp_tp_u + 8\Sigma p_rp_sp_t\,(p_r + p_s + p_t) + 6\Sigma p_r^2p_s^2 + 2\Sigma p_rp_s(p_r^2+p_s^2)\} + 2(n-4)\,\{54\Sigma p_rp_sp_tp_up_v + 34\Sigma p_rp_sp_tp_u(p_r+p_s+p_t+p_u) + 2\Sigma p_rp_sp_tp_u(p_s+p_t) + 22\Sigma p_rp_sp_t(p_rp_s+p_sp_t+p_rp_t) + \Sigma p_rp_sp_t(p_rp_s+p_sp_t) + 12\Sigma p_rp_sp_t(p_r^2+p_s^2+p_t^2) + 2\Sigma p_rp_sp_t(p_r^2+p_t^2) + 8\Sigma p_r^2p_s^2(p_r + p_s) + \Sigma p_rp_s(p_r^3 + p_s^3)\} - (5m - 16)\,[P_1(3)]^2$,

$$r > s > t > u > v.$$

The moments for the case when $n_1, n_2, \ldots n_k$ observations belong to $k$ different groups are obtained by substituting

$$\frac{n_r^{(\alpha)}\, n_s^{(\beta)}\, n_t^{(\gamma)} \ldots}{n^{(\alpha+\beta+\gamma\ldots)}} \text{ for } p_r^{\alpha}\, p_s^{\beta}\, p_t^{\gamma} \ldots$$

in the moments about the *origin* for fixed $p$'s.

The above moments have been obtained by extending the methods developed by one of us[3,4], by forming the frequencies for three, four and five observations for all possible combinations of equal and unequal observations.

It can be established from the difference equation that all the cumulants of the distribution are linear functions in $m$, and hence the distribution tends to the normal form as $m \to \infty$. Full details of this work will be published in the *Journal of the Indian Society of Agricultural Statistics*.

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