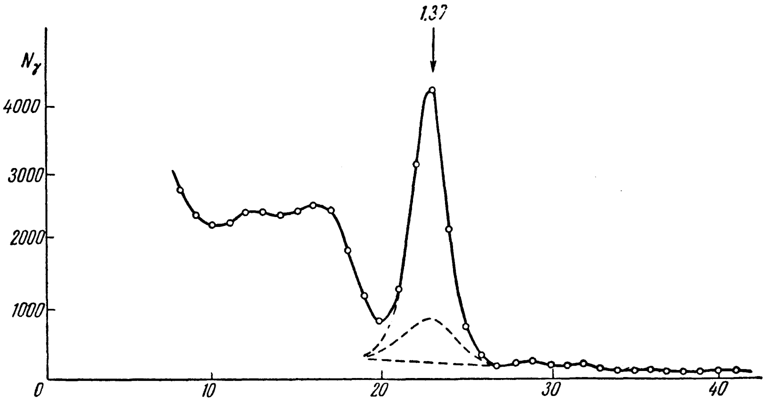

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FOCK'S CYCLIC SYMMETRY CONDITION AND YOUNG'S PATTERNS

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IN constructing the wave function of an n-electron system by Fock's method,[1] the following conditions are imposed on the coordinate wave function Ψ:
(1) antisymmetry in the first k arguments,
(2) antisymmetry in the remaining n-k arguments,
(3) the cyclic-symmetry condition

$$\cdot\ (1-\sum_{i=k+1}^{n} P_{ik})\Psi = 0 \tag{1}$$

(P_{ik} is the operator for transposition of the arguments i and k.) It is assumed that $k \le n-k$; then $s = n/2 - k$ is the total spin of the system.

It is known[2] that every function constructed from a Young pattern with two columns satisfies these conditions. In other words, it has been shown that the Young operator

$$Y_{n-k,k} = A(1,\ldots,k)\,A(k+1,\ldots,n)\prod_{m=1}^{k} S(m,k+m) \tag{2}$$

(where S and A are the operators for symmetrization and antisymmetrization with respect to their arguments), corresponding to the pattern with two columns shown in Fig. 1, satisfies the cyclic symmetry condition

$$(1-\sum_{i=k+1}^{n} P_{ik})\,Y_{n-k,k} = 0. \tag{3}$$

In the present note we want to show that this result is easily generalized to Young patterns of arbitrary shape, containing any number of columns.

Let us consider a Young pattern of the most general type (Fig. 2), having p columns of lengths $\lambda_1, \lambda_2, \ldots \lambda_p$, where

$$\lambda_1 \geqslant \lambda_2 \geqslant \ldots \geqslant \lambda_p > 0 \text{ and } \lambda_1+\lambda_2+\ldots+\lambda_p = n.$$

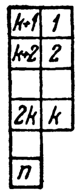

FIG. 1

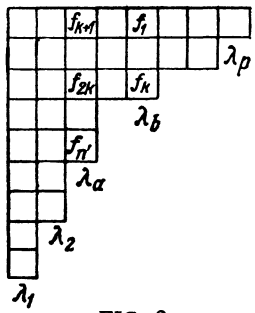

FIG. 2

In this case the Young operator consists of a symmetrization with respect to the arguments in the rows followed by antisymmetrization with respect to columns. We shall show that this operator satisfies the cyclic symmetry condition with respect to any pair of columns, say the columns a and b ($\lambda_a \ge \lambda_b$). For convenience of comparison with the case of two columns, we shall set $\lambda_b = k$ and $\lambda_a = n' - k$, and denote the arguments in the cells of these two columns by $f_1, f_2, \ldots f_k$ and $f_{k+1}, \ldots f_{n'}$, while the set of arguments in the other columns are denoted by g. The Young operator corresponding to our pattern can be written as

$$Y_{\lambda_1\lambda_2,\ldots,\lambda_p} = A'(g)\,A(f_1\ldots f_k) \times A(f_{k+1}\ldots f_{n'})\prod_{m=1}^{k} S(f_m, f_{k+m})\,S'(f,\ g). \quad (4)$$

$A'(g)$ is the product of the antisymmetrizers for all columns except a and b. We have extracted from the row symmetrizers factors containing the symmetrization with respect to the pairs of arguments in columns a and b, and have denoted the product of the remaining factors by $S'(f, g)$.

We want to show that

$$(1 - \sum_{i=k+1}^{n'} P_{f_i f_k})\,Y_{\lambda_1,\lambda_2,\ldots,\lambda_p} = 0. \quad (5)$$

But once the Young operator for the general case has been put in the form (4), relation (5) follows immediately from the already proven cyclic symmetry for the case of two columns, since the operator $(\ldots)$ in (5) commutes with the operator $A'(g)$.

A condition equivalent to (5), namely the impossibility of increasing the antisymmetry of a function which is antisymmetric with respect to groups of $\lambda_1, \lambda_2, \ldots \lambda_p$ arguments by adding to a larger group of arguments some argument from a shorter group (or a group of the same length) was the basis of Hund's[3] classification of the types of permutation symmetry of functions. Hund describes such a symmetry character as having the A-normal form $A(\lambda_1 + \lambda_2 + \ldots + \lambda_p)$. The case of $p = 4$ is of interest in treating the coordinate wave function of the nucleus when the forces are assumed to be independent of the spin and charge of the nucleons.[4]

Thus we have shown in the present note that a function symmetrized according to a general Young pattern has the A-normal form of Hund. The fact that Fock's condition is satisfied for Young patterns with two columns is an important special case of this result.

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MEASUREMENT OF THE HALF-LIFE OF THE NEUTRON

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THE present work, the purpose of which is to measure the neutron half-life with an accuracy considerably greater than that of previous experiments,[1-3] was undertaken by us in view of the special interest at present in the form of the β interaction.

The measurements were made in an apparatus shown in longitudinal section in Fig. 1. A well-collimated beam of neutrons from the RFT reactor (Physics and Engineering Reactor) passed through the evacuated chamber 1; decay protons appearing in the part of the beam opposite the diaphragm 2 passed through a field-free space to the grid 3 and were focused on the window of the proportional counter 5 by an electric field applied between grids 3 and 4. The strength of the electric field was considerably greater than the computed value for 100% focusing of the protons. The neutron half-life T, in minutes, is given by the formula $T = Jk\alpha \ln 2/n$, where J is the integral of the neutron density over the cross section of the beam, n is the number of decay protons recorded per minute, α is the transmission of the grids, and k is a coefficient whose value is determined only by the geometry of the apparatus and the distribution of the neutron density in the beam and is independent of the shape of the proton spectrum.

The neutron density was determined from activation of gold targets, making the appropriate corrections for the effect of resonance neutrons, and also from activation of targets of sodium, which follows a 1/v law. In both cases, the standardization was done by absolute β counting on gold.

The neutron density measured at the center of the beam was 2.17×10^3 neutrons/cm^3 in these experiments, while the integral of the neutron density over the cross section of the beam was $J = 7.68 \times 10^4 \pm 2\%$. The number of decay protons was determined from the difference of the counter readings with and without electric field. As a result of many series of measurements at the value of J cited above, we found the value $n = 30.0 \pm 0.4$ min^{-1}. The transmission α of the grids,