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A New Mass Formula

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Continuing our work on quarteting in nuclear structure[1], we have investigated its role in nuclear masses. With a new mass formula incorporating SU4 symmetry, we find that the number of fitted parameters can be reduced while still improving the accuracy of the Weizsäcker formula. The usual two independent terms, viz., the symmetry energy and the pairing energy are replaced by a linear dependence on the lowest order Casimir operator C2 of the SU4 group. Its eigenvalues are

$$\begin{aligned} &\text{even - even}, && (T+2)^2 - 4, \\ &\text{odd - even}, && (T+2)^2 - 5/2, \\ &\text{odd - odd}, && (T+2)^2. \end{aligned}$$

We optimized the χ^2 for the following two expressions :

$$\text{Weizsäcker} : B(A,Z) = -a_v A + a_s A^{2/3} + a_K (4T^2) A^{\alpha} + a_p \delta(N,Z) A^{\beta}$$

$$\text{New (C2)} : B(A,Z) = -a_v A + a_s A^{2/3} + a_{C2}\, C2(A,Z) A^{\alpha}.$$

The Coulomb energy was taken as $0.72\, Z^2/A^{1/3}$ MeV, the shell correction was taken from Wing and Fong[2]; and they were not varied. The results are shown on the following table, for 1101 nuclides with $56 \leq A \leq 208$.

	Doubly open shell nuclei	Single open shell nuclei	All nuclides $56 \leq A \leq 208$
Weizsäcker	2090	1180	2380
New (C2)	1900	370	2150

R.M.S. MASS DEVIATIONS IN keV

The results obtained in all cases, with the fewer parameters of the new formula, are a strong indication of the overriding SU4 symmetry of the effective Hamiltonian governing the nuclear ground states[3].

In particular note the improvement for the case of single closed shell nuclei (2nd column). This demonstrates that the relation imposed by the SU4 symmetry between the T dependence and the even-odd differences in the C2 term is maintained in so-called pairing nuclei.

References : 1) M. Danos and V. Gillet, Z. Physik, 249 (1972) 294.
2) J. Wing and P. Fong, Phys. Rev. 136 (1964) B923.
3) P. Franzini and L.A. Radicatti, Phys. Lett. 6 (1963) 322.