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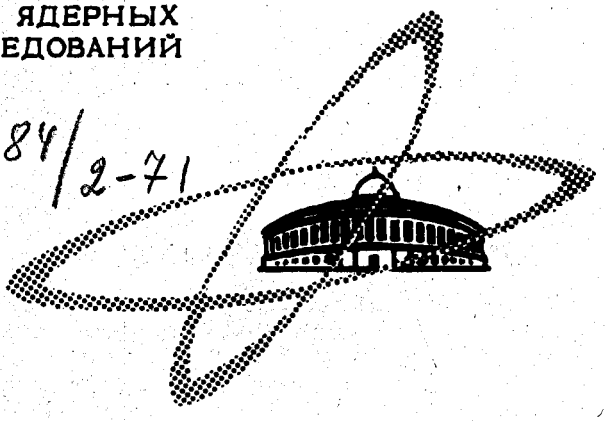

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EQUILIBRIUM PAIRING IN SOME SPHERICAL NUCLEI

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EQUILIBRIUM PAIRING IN SOME SPHERICAL NUCLEI

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The method of calculation of pairing energy gaps by minimizing the total energy of the nucleus under the condition of constant volume has been suggested in[1]. The only parameters which enter such calculation are the parameters of the single-particle potential. The method has been developed in[2] to include the spin-orbit splitting and applied to the neutron pairing in the isotopes of *Ni*, *Sn* and *Pb*. The results reproduce quite well the average pairing strength and the main tendencies observed experimentally. It appears that by a more realistic choice of the relative position of the single-particle levels in the Fermi surface region one can reproduce also the details of the experimental situation.

The most interesting regions for the equilibrium pairing calculation with the simple, Nilsson potential, are of course the deformed nuclei. For these nuclei the details of the subshell structure are averaged by the deformation, which also accounts for the main effect of the quadrupole component of the residual interaction. On the other hand, such effects as e.g. deformation dependence of the pairing energy gap, which can be studied by the energy minimum method without introducing new parameters, are important for the analysis of many phenomena in these nuclei.

However, before starting much more involved calculations for the deformed nuclei, an additional testing of the method on spherical nuclei is desirable. This concerns especially the proton pairing, which was not tested in[2]. For this purpose the proton and neutron pairing energy gaps were calculated for a number of nuclei with protons in the $1g_{9/2}$ and $1g_{7/2}$ subshells and neutrons in $1g_{7/2}$ and in the region of $1h_{11/2}$ $2f_{7/2}$ subshells. The calculation was performed with the Nilsson single-particle potential. The parameters of the potential were obtained by the extrapolation from the deformed regions, according to the extrapolation formula of[3]. This does not guarantee realistic single-particle relative energies for the nuclei considered. However, we choose the nuclei with several particles in the subshell of rather large degeneracy, for which the results of the calculation are not very sensitive to the changes of the single-particle parameters within reasonable limits. Also the Fermi energy is close to the energy of the open subshell in this case and the energy gaps can be compared directly with the odd-even mass differences.

The following energy expression was minimized with respect to the proton and neutron energy gaps Δ_p, Δ_n:

$$E = \hbar\omega(\Delta_p, \Delta_n) \sum_{\nu>0} \left\{ \frac{3}{4}\left(N_\nu + \frac{3}{2}\right) - \frac{5}{4}\kappa\left[2\,\ell\cdot s + \mu\left(\ell^2 - \langle \ell^2 \rangle\right)\right]_{\nu\nu} \right\} 2v_\nu^2 - \sum_{\nu>0} \Delta_\tau u_\nu v_\nu + \delta E_{RPA} \qquad (1)$$

Here N_ν is the oscillator quantum number of the state ν (ν includes the isospin index τ), κ and μ are the Nilsson model parameters, u and v are the pairing amplitudes in the BCS approximat-

ion, δE_{RPA} is the RPA correction to the BCS ground state energy, given explicitly in [4] and [2].

The condition of constant volume is fulfilled by keeping constant the mean square radius of the nucleus. This in turn is achieved by changing the oscillator frequency ω with Δ according to

$$\frac{\omega(\Delta_p, \Delta_n)}{\omega(\Delta_p = 0, \Delta_n = 0)} = \frac{\sum_{\nu>0} (N_\nu + \frac{3}{2}) 2 v_\nu^2}{\sum_{\substack{\text{occupied} \\ \text{states}}} (N_\nu + \frac{3}{2})} . \qquad (2)$$

The factor 5/4 in the $\ell \cdot s$ and ℓ^2 contributions to the energy (1) accounts approximately for the rearrangement in these terms. Its origin has been explained in [2].

The results are shown in Fig. 1. The triangels represent the calculated values of Δ_{eq}. Proton and neutron pairing energy gaps turn out to be independent. Due to the effect of the quadrupole force, which should be important in the region studied and which should influence the ground state energies, one can not expect spectacular agreement with the experimental odd-even mass differences, marked by the circles in Fig. 1. The spread of the experimental values for different isotopes in the case of the proton pairing and different isotones in the case of the neutron pairing may be considered as a measure of the magnitude of the quadrupole effects in the nuclei considered. As is seen from Fig. 1 they are of the order of the largest distances between the calculated and experimental points.

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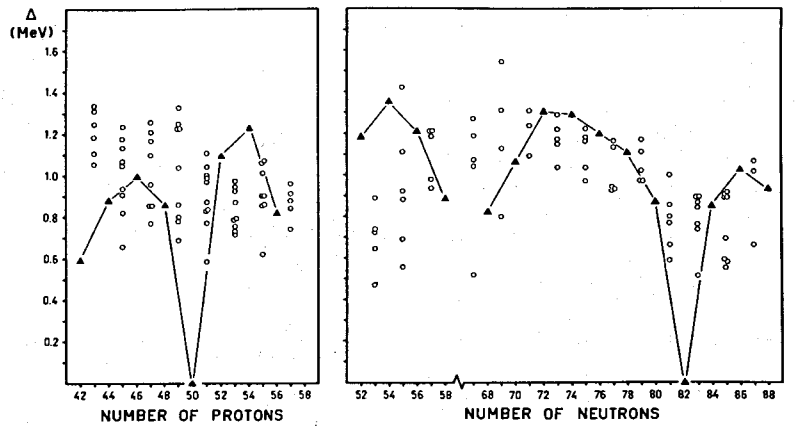

Fig. 1. The calculated values of Δ_{eq} (▲) are compared with the experimental odd-even mass differences (o), defined as $p_p = \frac{1}{2}[E(Z-1,N)+E(Z+1,N)]-E(Z,N)$, $p_n = \frac{1}{2}([E(Z,N-1)+E(Z,N+1)]-E(Z,N)$, where $E(Z,N)$ are the binding energies of /5/.