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Author
Sorensen, Bent.

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Bent Sørensen

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UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California 94720

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ISOSPIN STRUCTURE OF PAIRING VIBRATIONS

Bent Sørensen

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Isospin Structure of Pairing Vibrations.* Bent Sørensen.† Lawrence Radiation Laboratory, Berkeley.-- The possible existence of an isospin structure in collective pairing-type excitations is discussed in connection with the confrontation of experimental data and a reliable pairing force calculation[1] which neglects isospin structure. Evidence for the isospin structure suggested by Bohr[2] is found in C, Mg, Si, Ti, and Ni isotopes.

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*This work was performed under the auspices of the U. S. Atomic Energy Commission.

†On leave from the Niels Bohr Institute, University of Copenhagen, Denmark.

1. B. Sørensen, Nucl. Phys. A97, 1 (1966).

2. A. Bohr, Proc. of Int. Symp. on Nucl. Structure, Dubna 1968.

CONFERENCE ON NUCLEAR ISOSPIN

ISOSPIN STRUCTURE OF PAIRING VIBRATIONS*

Bent Sørensen†

Lawrence Radiation Laboratory, University of California
Berkeley, California

A calculation of pairing-type states in the neighborhood of closed neutron shells all over the periodic table has been performed by applying the boson expansion method (1) to a system of like particles interacting via a pairing force with constant matrix elements. The purpose of this calculation was to exhibit the limitations of such a model and possibly point to the nature of the additional structure which might be required in different regions of nuclei.

This model in general provided a surprisingly good agreement with experiments, not only for excited levels believed to be pairing states, but also for the ground state energies after a correction for Coulomb energy. The parameters of the calculation are i) the single-particle levels, which were adjusted from those extracted from one-particle stripping experiments by sum-rule methods, in order to roughly reproduce the excitation energies of non-collective pairing states in the even nuclei adjacent to the closed neutron shells, and ii) the pairing strength, chosen as $G = g\,A^{-1}(1-0.75(N-Z)A^{-1})$, where $g \approx 23$ depends somewhat on the number of configurations included. An explanation of the deviations which were found seems in all cases to require consideration of couplings to proton degrees of freedom. Two main sources of such couplings would be a) a quadrupole interaction, which adds to ground state correlations and produces jumps in the ground state energies when permanent deformation occurs, and which

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further produces low lying 0+ states which do couple with the pairing degrees of freedom, although in many cases not very much, and b) proton-neutron interaction which together with the pp and nn pairing interactions may have approximately the structure suggested by A. Bohr (2) of a T = 1 isospin pairing interaction

$$V_P = \frac{G}{4} \sum_{jj'} \left[(a^+_{j'} a^+_{j'})^{t=1}_{J=0} (\bar{a}_j \bar{a}_j)^{t=1}_{J=0} \right]^{T=0} \sqrt{3(2j+1)(2j'+1)} \quad (1)$$

plus a non-pairing type interaction, which splits the isospin multiplets. In case of a permanent pairing distortion this additional interaction may contain an iso-Coriolis force causing leading order energy shifts

$$\Delta E_T = AT(T+1) \quad (2)$$

A phenomenological model for isospin and quadrupole interactions between pairing modes has been considered by Damgaard (3). The experimental evidence to be presented here seems to suggest an isospin structure which can be approximated by Eq. (2), although some of the nuclei involved are non-superfluid (^{12}C, ^{28}Si, ^{50}Ti, ^{68}Ni).

The various statements made above are substantiated by Figs. 1-5, showing 0+ spectra of C, Mg, Si, Ti, and Ni isotopes. Possible evidence of similar structure is present in Ca. We plot the calculated pairing states by subtracting from the energies a term proportional to A, which makes the energies of the two even neighbors to each closed shell nucleus equal. Collective states are drawn with heavy lines. At each level are quoted (tp) cross sections from the ground state of the A-2 nucleus (arrow pointing right) and (pt) cross sections from the ground state of A+2 (arrow pointing left), normalized to the ground state transition. For each isotope the corresponding experimental evidence is placed to the right and in the middle we have added energy shifts following Eq. (2) to some of the theoretical pairing vibrational levels, and inserted the lowest quadrupole type 0+ state at twice the 2+ energy and with indication of the percentage of mixing with the ground state required for explaining the experimental sharing of strengths.

In ^{22}Mg and ^{42}Ti there is evidence of a strong increase in deformation. The calculated Ni spectra are combined results of starting the boson calculation either at the N = 28 or the N = 40 closed shell. The pure neutron pairing calculation starting from N = 40 fits all ground state energies except N = 28. In Fig. 5 the spectra of N = 28 to 32 uses the N = 28 basis.

References

(1) B. Sørensen, Nucl. Phys. A97, 1 (1966).
(2) A. Bohr, Proc. of Int. Symp. on Nucl. Structure, Dubna, 1968.
(3) J. Damgaard, private communication.

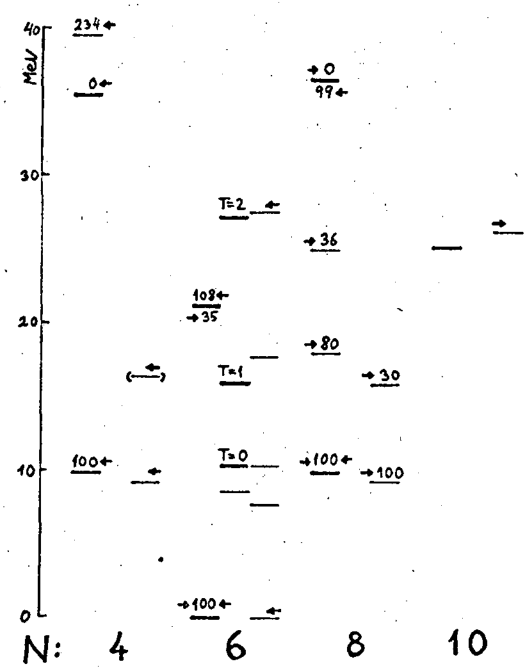

Fig. 1. C isotopes, G = 1.8.

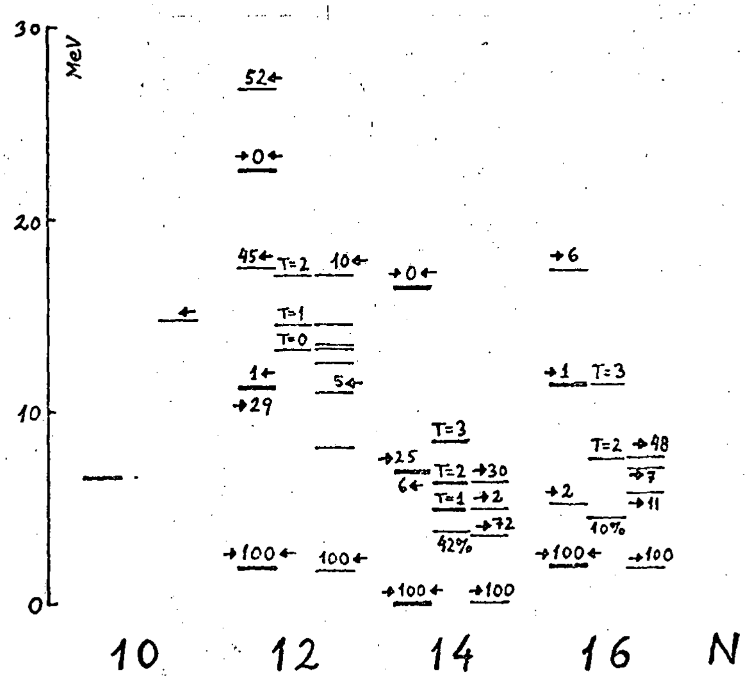

Fig. 2. Mg isotopes, G = 1.0.

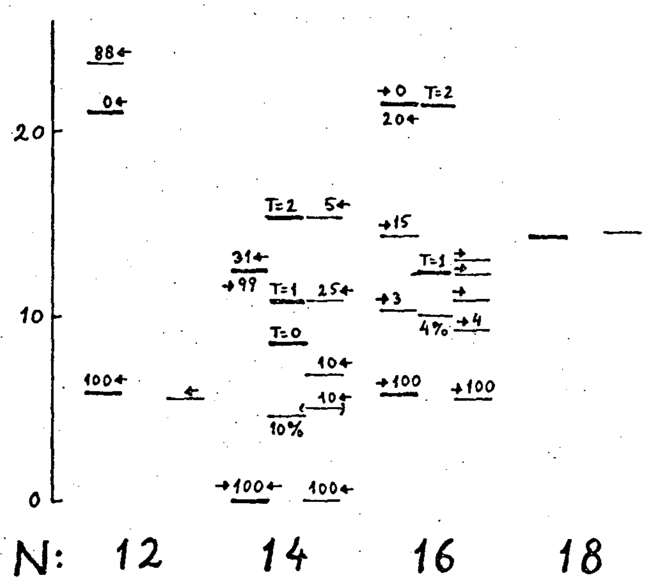

Fig. 3. Si isotopes, G = 0.9.

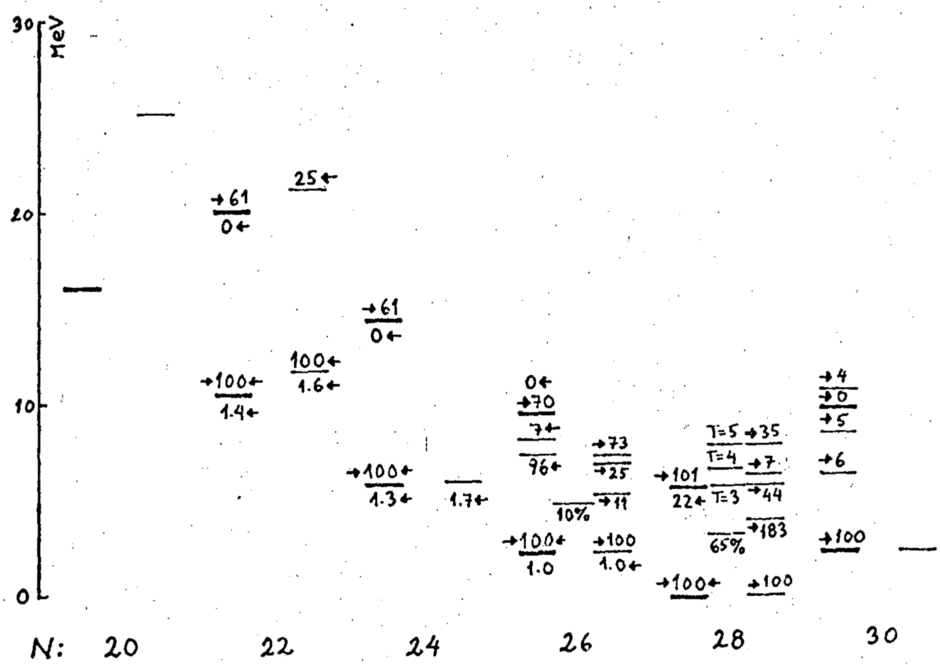

Fig. 4. Ti isotopes, G = 0.419.

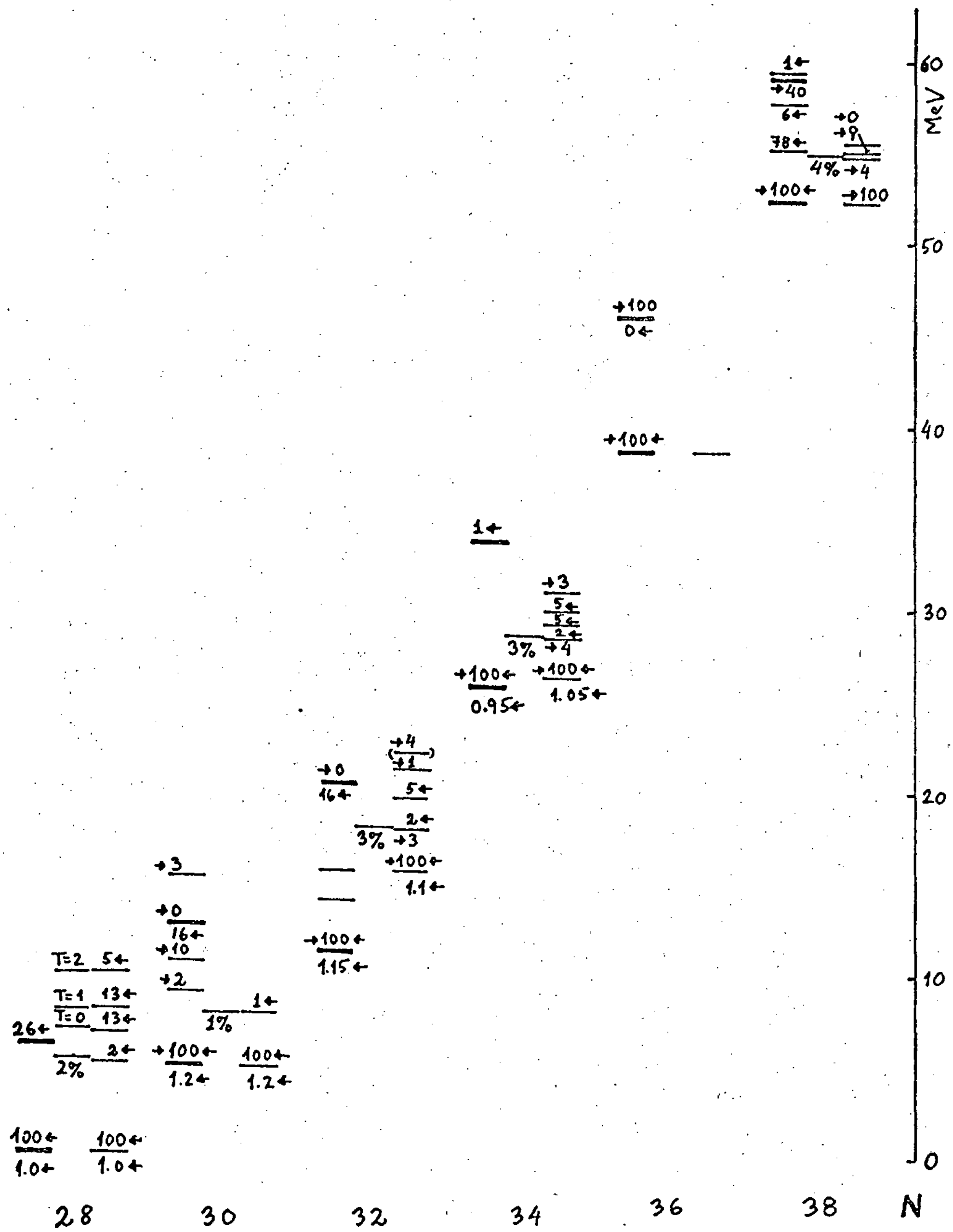

Fig. 5. Ni isotopes, G = 0.411 at N = 28, G = 0.293 at N = 40.

TECHNICAL INFORMATION DIVISION
LAWRENCE RADIATION LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720