a discussion of the problem and valuable remarks.

[1] H. Weaver et al., Nature 208, 29 (1965).

[2] S. Weinreb et al., ibid., 208, 440 (1965).

[3] R. X. Mcgee, B. J. Robinson, F. F. Gargner, and J. G. Bolton, ibid. 208, 1193 (1965).

[4] A. H. Barrett and A. E. E. Rogers, ibid. 210, 188 (1966).

[5] A. E. E. Rogers et al., Phys. Rev. Lett. 17, 450 (1966).

[6] D. A. Varshalovich, JETP Letters 4, 180 (1966), transl. p. 124.

[7] R. V. Ambartsumyan, N. G. Basov, P. G. Kryukov, and V. S. Letokhov, JETP Letters 3, 261 (1966), transl. p. 167.

[8] S. A. Kaplan and S. B. Pikel'ner, Mezh vezdnaya sreda (Interstellar Medium), Fizmatgiz, 1963.

[9] R. V. Ambartsumyan, P. G. Kryukov, and V. S. Letokhov, JETP 51, 1669 (1966), Soviet Phys. JETP 24, in press.

1) A laser using feedback by scattering particles was proposed and constructed in [7].

INFLUENCE OF THE MEAN FIELD ON THE CHARACTER OF VARIATION OF THE NUCLEAR SHAPE

E. E. Berlovich
A. F. Ioffe Physico-technical Institute, USSR Academy of Sciences

Submitted 12 July 1966
ZhETF Pis'ma 4, No. 11, 481-484, 1 December 1966

The shape of the nuclei of the transition regions is determined by competition between numerous factors such as the properties of the self-consistent field and also pairing and quadrupole forces. An exact account of all these factors is a complicated problem [1]. Some peculiarities, however, can be qualitatively explained by starting from the properties of the levels of the self-consistent field. Thus, for example, the observed jumplike change of the nuclear shape from spherical to prolate in the region of 88 - 90 neutrons is apparently a manifestation of the realignment of the proton levels near the Fermi surface, due to the inclusion of descending Nilsson orbitals $1/2^-$ [550], $3/2^-$ [541], and $5/2^-$ [532] emerging from the $h_{11/2}$ node. All the neutron orbitals near N = 90 are descending and therefore addition of any pair of neutrons contributes to the shift of the minimum of the total energy toward larger deformations. However, the pairing forces (especially in the case of even-even nuclei) can offset this effect and the nucleus remains spherical until the number of neutrons reaches a critical value corresponding to a shift of the minimum such that the descending proton orbitals in question are included. Since the addition of the last pair of neutrons is simultaneously accompanied by a large increase in the number of the nucleons on the descending orbitals (2 neutrons and 6 protons), the resultant shift in the energy minimum should also be appreciable, and this indeed corresponds to a jumplike increase in the deformation.

It is possible that the three descending proton orbitals drop below the Fermi surface not simultaneously, but in two stages: when N = 88 the orbitals $1/2^-$ [550] and $3/2^-$ [541] drop below the Fermi surface, and are joined by the orbital $5/2^-$ [532] at N = 90. In this case the deformation of the even-even nuclei occurs not at N = 90, but already at N = 88. According to calculations by Baranger and Kumer [2], the Sm^{150} nucleus, hitherto assumed to be spherical, has a deformation $\delta = 0.16$. This coincides with the value calculated from the reduced probability of the Coulomb excitation of the first level 2^+. The second jump in deformation occurs at N = 90 (Sm^{152}), when the deformation reaches the value $\delta = 0.26$.

In [3] we analyzed the experimental data on the quadrupole moments of even-even deformed nuclei, and showed that the change in the internal quadrupole moment on going from an even-even nucleus to an odd one is determined essentially by the quantum characteristic of the particular orbit which is populated by the added nucleon; a descending orbital on the Nilsson diagram corresponds to an increase in the internal quadrupole moment, and asscending orbital to a decreasing moment, and a horizontal orbital to a constant moment. The average change of the internal quadrupole moment in the case of inclined orbitals of different slope is approximately 0.6 - 0.7 barn.

It follows therefore that when six nucleons are added on descending orbitals (2 neutrons and 4 protons) to the spherical nucleus Sm^{148}, the quadrupole moment should increase by approximately 3.5 - 4 barns. This agrees with the value $Q_0 = 3.5$ b for Sm^{150} ($\delta = 0.16$). The jump of the internal quadrupole moment on going from Sm^{150} to Sm^{152} ($Q_0 = 6.1$ b) corresponds to addition of four more nucleons (2 neutrons and 2 protons) on the descending orbitals. These estimates are patently only qualitative, but they show that the cause of the jumplike change in the shape of even-even nuclei when $N < 90$ (which, furthermore, occurs in two steps) is closely connected with the properties of the mean field.

In the transition region adjacent to the deformed nuclei of the rare-earth group, on the side of larger masses, both the proton and the neutron orbitals are ascending; therefore addition of nucleons from both groups can contribute only to a gradual decrease in the deformation. This agrees with the well known fact that the deformation decreases smoothly with increasing A for nuclei in this region. Thus, the character of the change in the nuclear shape reflects the properties of the mean field in this region of nuclei, too.

Finally, it is well known that near the limits of the new deformation region (Z = N = 50 - 82), the properties of the nuclei (for example, the energies of the levels 2^+ and 4^+ in even-even barium isotopes) change very smoothly [4].

Generalizing, we can state that the character of the change of the nuclear shape is determined to a considerable degree by the properties of the levels of the mean field.

According to considerations advanced by Belyaev [5], the change in the nuclear shape constitutes a first-order phase transition, meaning that the nuclear shape should change jumpwise. This means that no nuclear deformations that are too small should be realized. However, he gives no quantitative estimates of the "smallness" of the deformation. To answer the question whether small deformations are possible in nature it is therefore necessary to turn to the experimental data.

In principle, the nuclear shape always changes jumpwise when the number of nucleons changes. But this is due simply to the discreteness of nuclear matter, by virtue of which both the deformation energy E_{def} and the pairing energy E_{pair} always change by finite amounts. For a certain number of nucleons the difference $E_{def} - E_{pair}$ should reverse sign and change numerically by a finite amount, and this corresponds to a jumplike change in shape.

We note that in many cases the existence of relatively small deformations can be regarded as reliably established. Thus for the even-even nucleus Os^{190}, which has a well pronounced rotational level structure, the deformation parameter is $\delta = 0.15$. The deformations of the odd nuclei Ir^{191} and Ir^{193} are 0.14 and 0.12 respectively. In our opinion the deformations of the odd isotope of gold and of the odd isotopes of europium and promethium, which pertain to a different transition region, may be even smaller [6,7].

[1] M. Baranger and K. Kumar, Nucl. Phys. 62, 113 (1965).

[2] M. Baranger and K. Kumar, Paper at the 1965 Gordon Conference, USA (private communication by V. G. Solov'ev).

[3] E. E. Berlovich and Yu. A. Novikov, Izv. AN SSSR ser. fiz. 31, 1967 (in press).

[4] A. K. Kerman, Comptes Rendus du Congres Intern. de Phys. Nucl. 1, 184 (1964).

[5] S. T. Belyaev, Selected Topics in Nucl. Theory. Intern. Atom. Energy Agency, Vienna, 1963, p. 291.

[6] E. E. Berlovich, YaF, 1965 (in press).

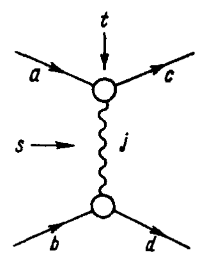
[7] E. E. Berlovich, Izv. AN SSSR ser. fiz. 29, 2177 (1965), transl. Bull. Acad. Sci. Phys. Ser. p. 2013.

FACTORIZATION OF AMPLITUDES AND PAIR PRODUCTION OF RESONANCES AT HIGH ENERGIES

A. B. Kaidalov
Institute of Theoretical and Experimental Physics

Submitted 12 September 1966
ZhETF Pis'ma 4, No. 11, 484-488, 1 December 1966

Particle collisions at high energies can now be described by means of several models in which amplitude factorization is possible. The reaction amplitudes are described by diagrams of the type shown in the figure, where j is the spin of the virtual particle and can be either integer (in the case of the peripheral model) or complex (in the case of Regge poles). We consider in this note a possible check on amplitude factorization in pair production of resonances with nonzero spins at high energies.



Let us consider the reaction $a + b \rightarrow c + d$ in which the masses and spins of the participating particles are arbitrary. The final state of the system of particles c and d is described by a polariza-