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Intermediate Structure of the Fast Neutron Scattering by Spherical Nuclei

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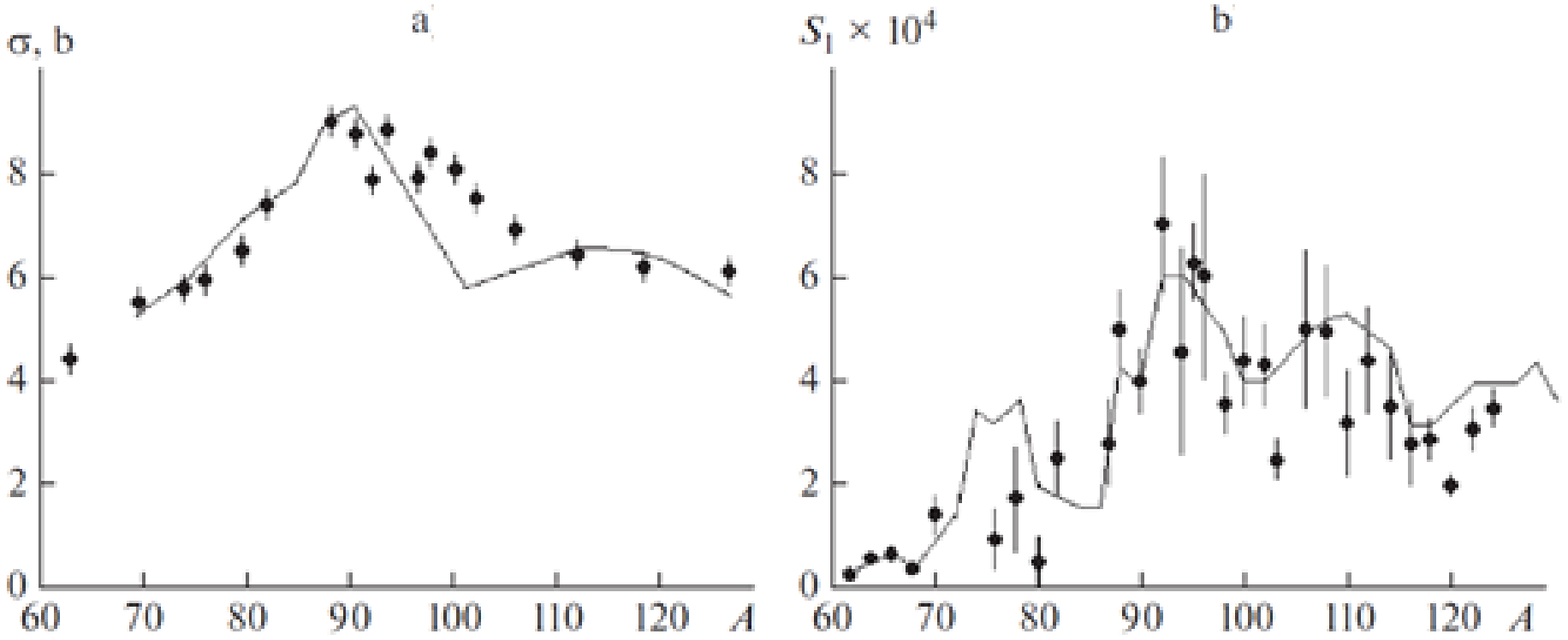
An energy and isotopic structure of the neutron cross sections and the *p*-strength functions

An energy and isotopic intermediate structure of the cross sections was revealed in an elastic and inelastic fast neutron scattering by even-even nuclei with mass numbers A≈60-130

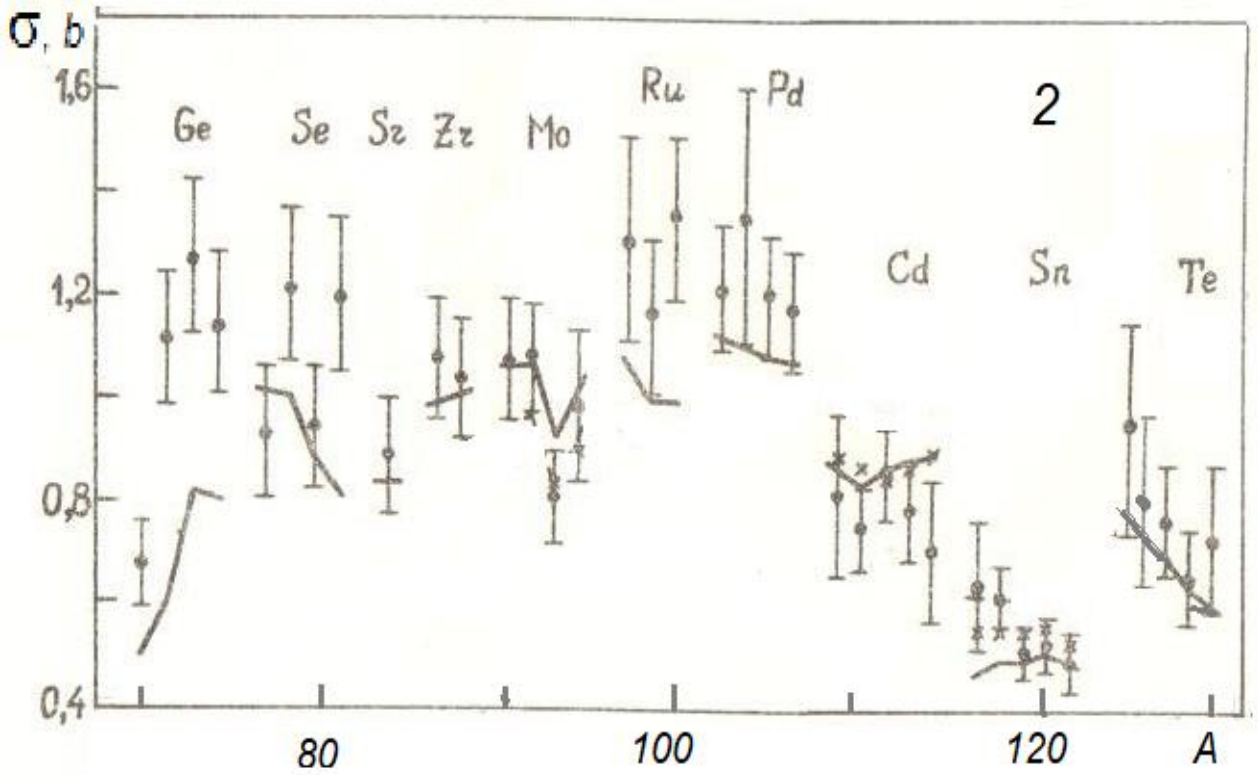
The average neutron cross sections and the strength functions of these nuclei is described within the two-phonon coupled-channel approach of a generalized optical model

The isotopic structure of the neutron total cross section and *p*-strength functions of middle nuclei



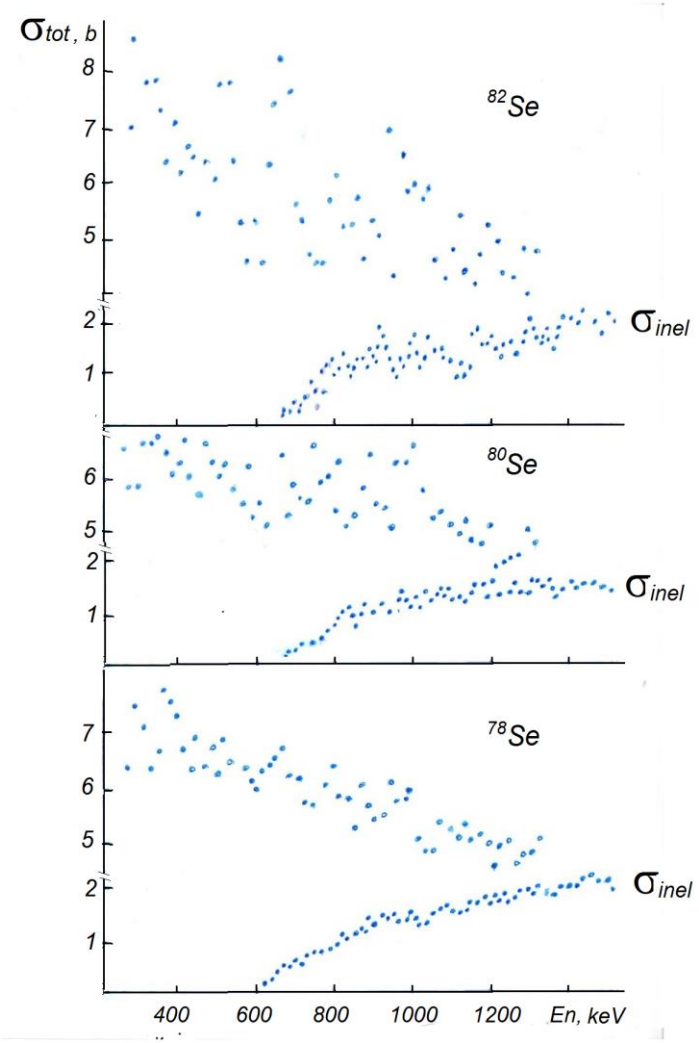
The generalized optical model description of the total cross sections (a) and *p*- strength function S_1 (b) in the near 3*p*-maximum of the neutron strength function

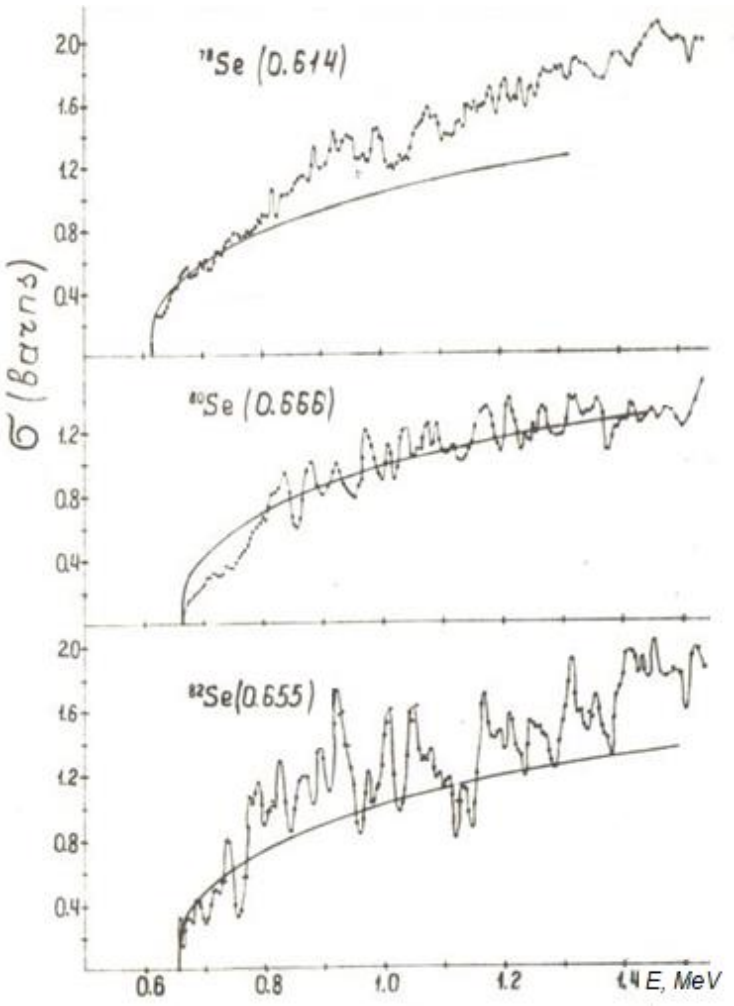
A cross section isotopic structure of fast neutron inelastic scattering by even-even nuclei



The data are presented at 300 keV energy above the excitation threshold of the single-phonon state 2+ of the nuclei. A cross section approximation is given optical model with 0^+-2^+-0^+-2^+-4^+ coupled circuit of vibration states.

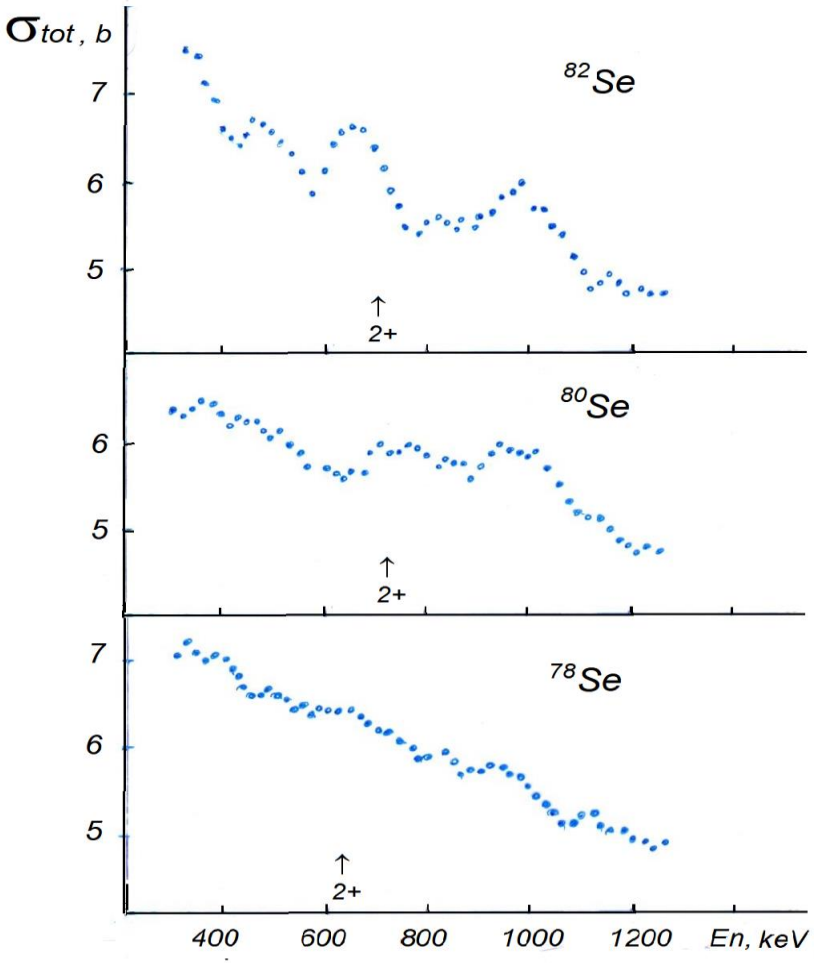
An energy structure of the experimental total and inelastic cross sections of the Se isotopes

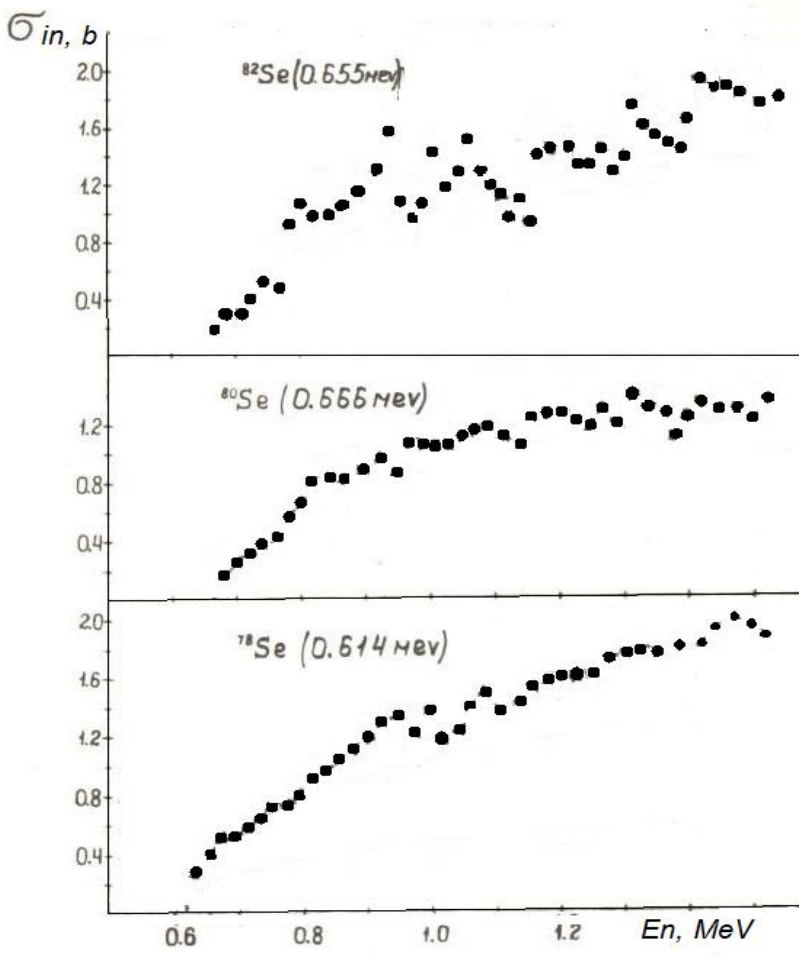




The cross sections measured with resolution ΔE =15 keV

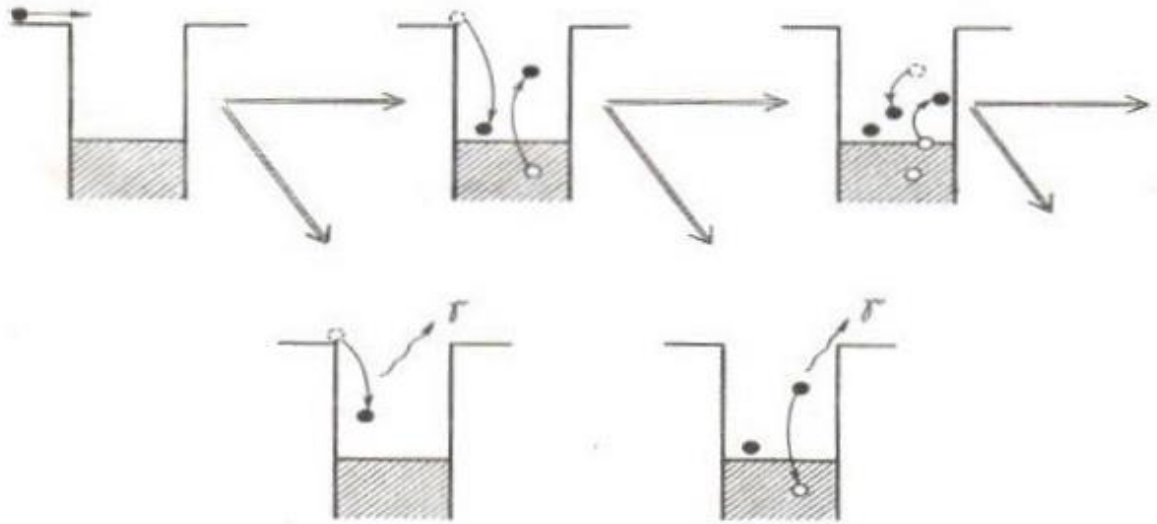
The intermediate energy structure of the average cross sections of the selenium isotopes





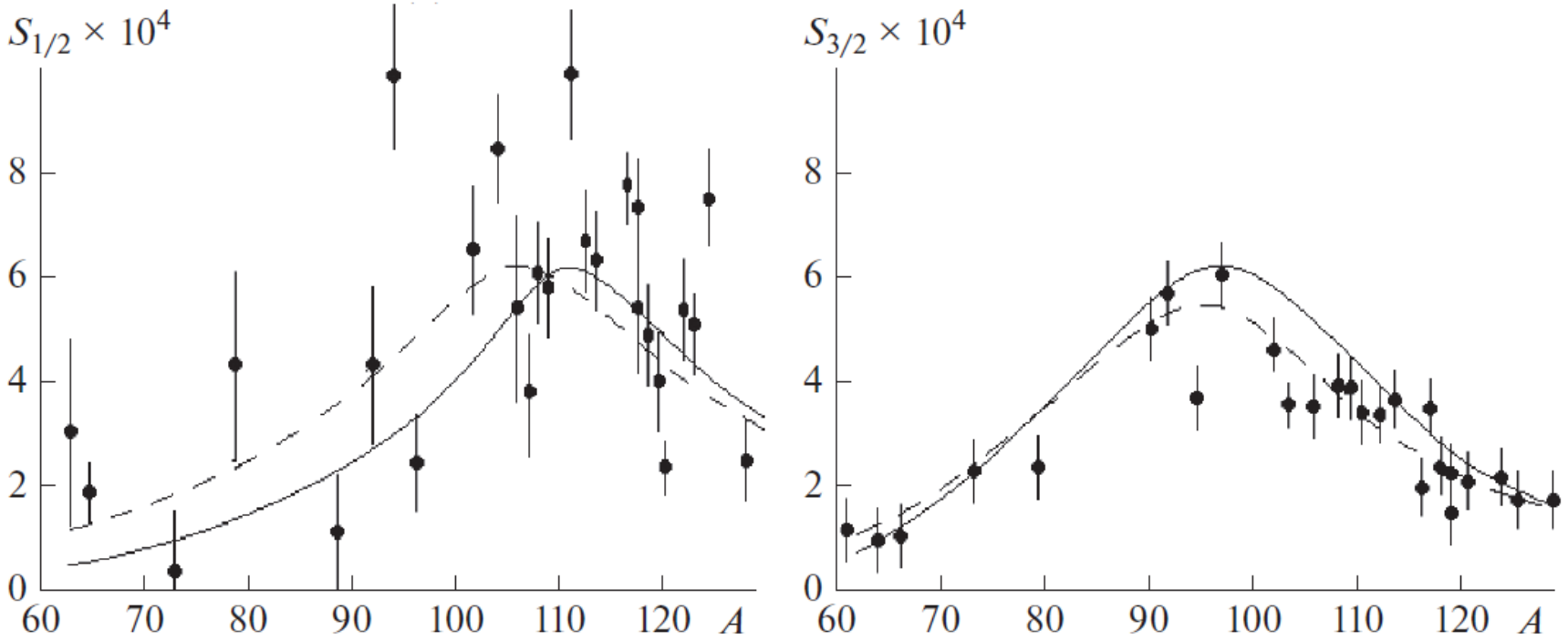
The averaging energy of the cross sections is ΔE =50 keV

The cross sections intermediate structure can be due to the coupling of the input channel with quasiparticle configurations of the particle-core system.



This is intensifies single-phonon coupling and produces intermediate resonance in the elastic and inelastic fast neutron scattering by nuclei

The isotopic structure of the $S_{1/2}$ and $S_{3/2}$ *p*- neutron strength functions of the spherical nuclei



Samosvat, G.S., *Fiz. Elem. Chastits At. Yadra*, 1986, v. 17, no. 4.

The $S_{1/2}$ and $S_{3/2}$ structure is caused by the spin-orbit splitting of the 3*p*-maximum of neutron strength function and a local fluctuation of the nuclear dynamic deformation

$S_{1/2}$ and $S_{3/2}$ *p*-neutron strength functions are described by the two-phonon coupled-channel optical model with vibrational collective states 0+–2+–0+–2+–4+ and spin–orbit potentials 8 MeV

The calculated values of *p*-strength functions are close to the approximated experimental values

The calculated distance between maxima $S_{1/2}$ and $S_{3/2}$ $\Delta A = 14$ (at $A_{1/2} = 111$ and $A_{3/2} = 97$) is close to the experimental value of the splitting of the 3*p*-maximum of strength function ($\Delta A = 12 \pm 4$)

The shift of the $S_{1/2}$ calculated maximum relative to the experimental position ($A \cong 107$) is caused by a local increase in the dynamic deformation of nuclei

$S_{1/2}$ and $S_{3/2}$ description was obtained using a multiphonon variant of the coupled channel model. Samoilov, V.V. and Urin, M.G., *Yad. Fiz.*, 1990, v. 52.

The great value of a calculated strength functions splitting (ΔA = 17) is explained by due to different dynamic deformation of the nucleus in excited states with different numbers of phonons.

The experimental spin–orbit splitting of the 3*p*-resonance was $\Delta A = 12 \pm 4$, more than twice that of bound single-particle states in the shell model (ΔA = 5–8).

This spin–orbit splitting of the *p*-neutron strength functions is determined also by local intensifies single-phonon coupling

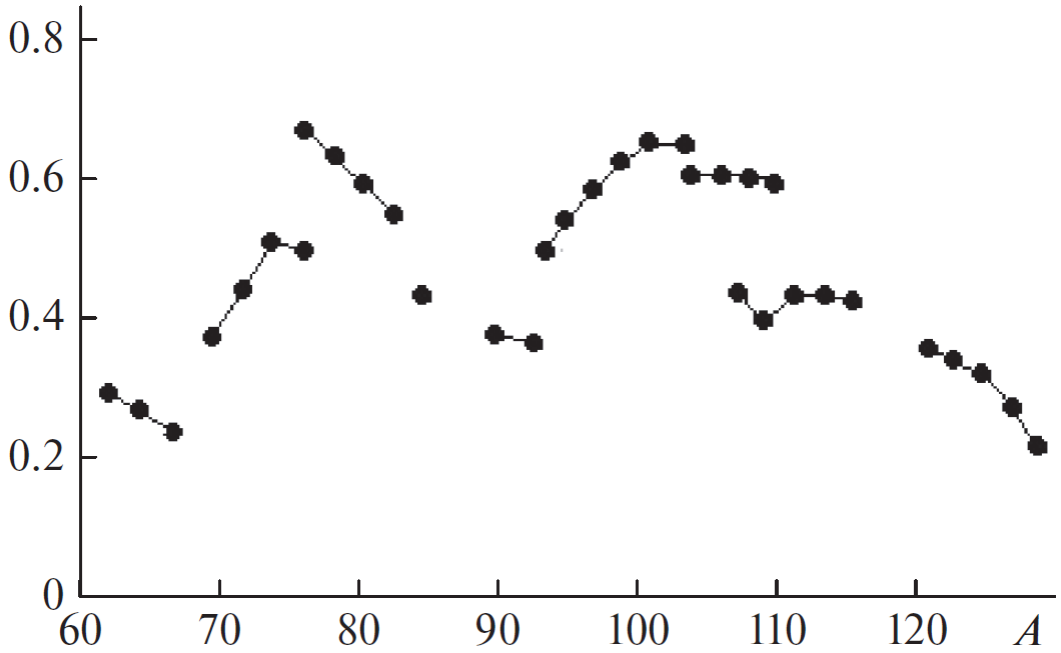
In 3*p* nuclear region the *p*- wave neutrons makes the main contribution to neutron–nuclear interaction at an energy of about 1 MeV.

Direct excitation of first 2+-phonon states occurs mainly through inelastic scattering channels with $J^{\pi} = 1/2^{-}$ and $J^{\pi} = 3/2^{-}$

The cross section of the direct reaction is close to fluctuation cross-section for the inelastic scattering of neutrons with an energy of ~1 MeV

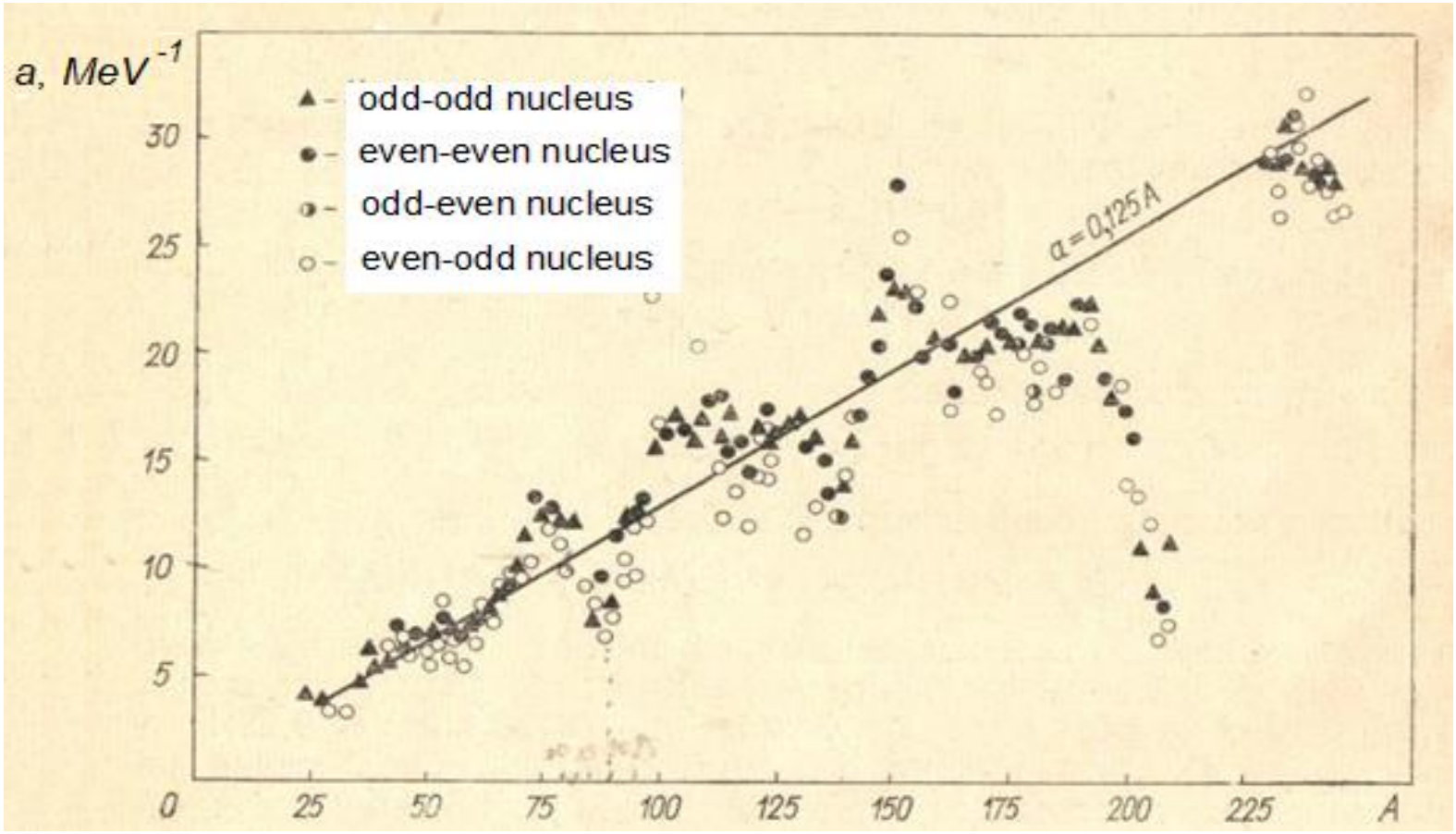
This is this is especially true for nuclei Ge, Se (*A*= 72-82) and Ru, Pd (*A*= 98-108) with large dynamic deformation (β_2=0.2-0.3), which intensifies single-phonon coupling and produces intermediate resonances

A ratio of a direct and fluctuation cross sections for fast neutron inelastic scattering at 1 MeV



Direct excitation of first 2+-phonon states is close to fluctuation for nuclei Ge, Se (A=72-82) and Ru, Pd (A= 98-108) with dynamic deformation of 0.2-0.3, which intensifies single-phonon coupling

The density parameter of the single-particle states of an atomic nucleus near the Fermi surface



The high density of the single-particle states for Ge, Se and Ru, Pd nuclei

The differential cross sections approximating of elastic neutron scattering was developed earlier that uniquely defines five parameters of resonans and potential *s*-and *p*-wave scattering: radii (R_0, R_1) and force functions (S_0, $S_{1/2}$, $S_{3/2}$)

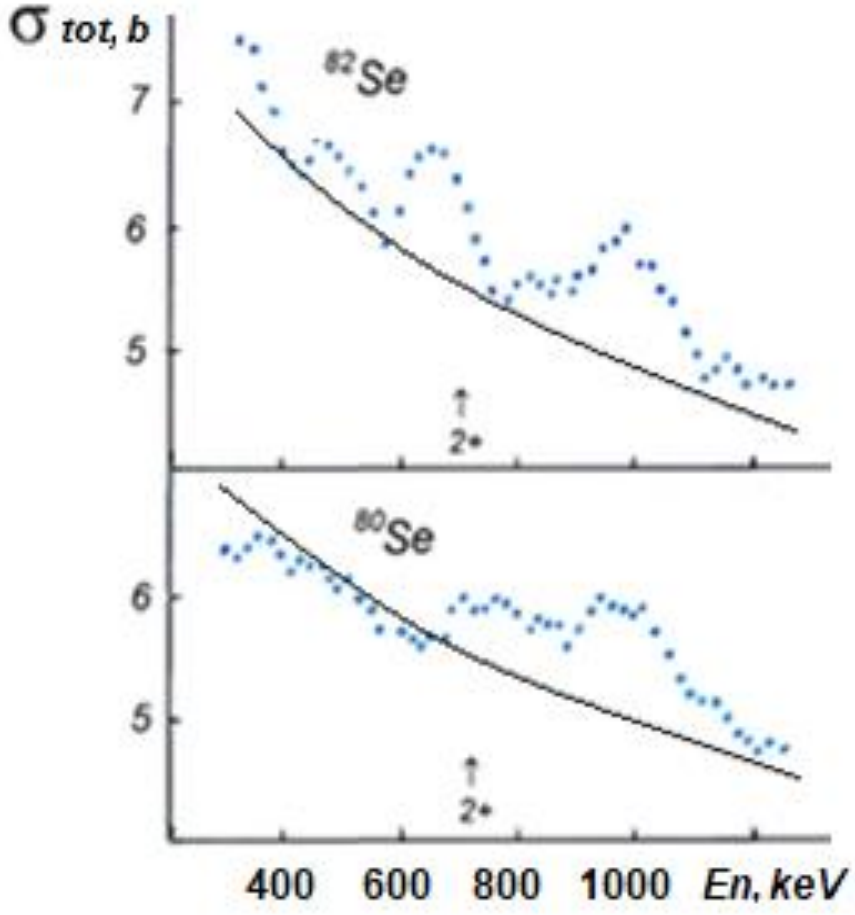
Samosvat, G.S., *Fiz. Elem. Chastits At. Yadra*, 1986.

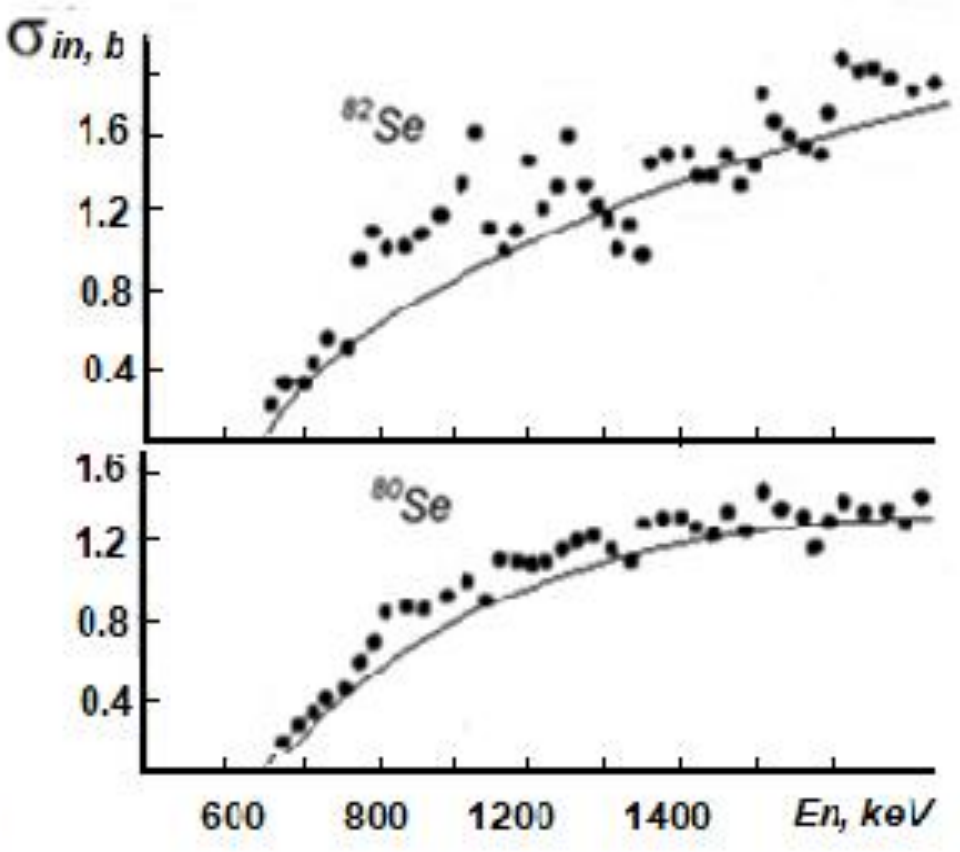
For parametrization of the cross sections in the approximation of isolated intermediate resonances, we used the average scattering matrix in the form.

$$< S_{c,c'} > = S^0_{c,c'} + e^{i(\delta_c + \delta_{c'})} [\delta_{cc'} + i \frac{\left(\Gamma^{\uparrow}_c \Gamma^{\uparrow}_{c'}\right)^{1/2} \Psi}{E_R - E - \frac{i}{2}\Gamma_R}$$

where $\Gamma_R = \Gamma^{\uparrow}_R + \Gamma^{\downarrow}_R$

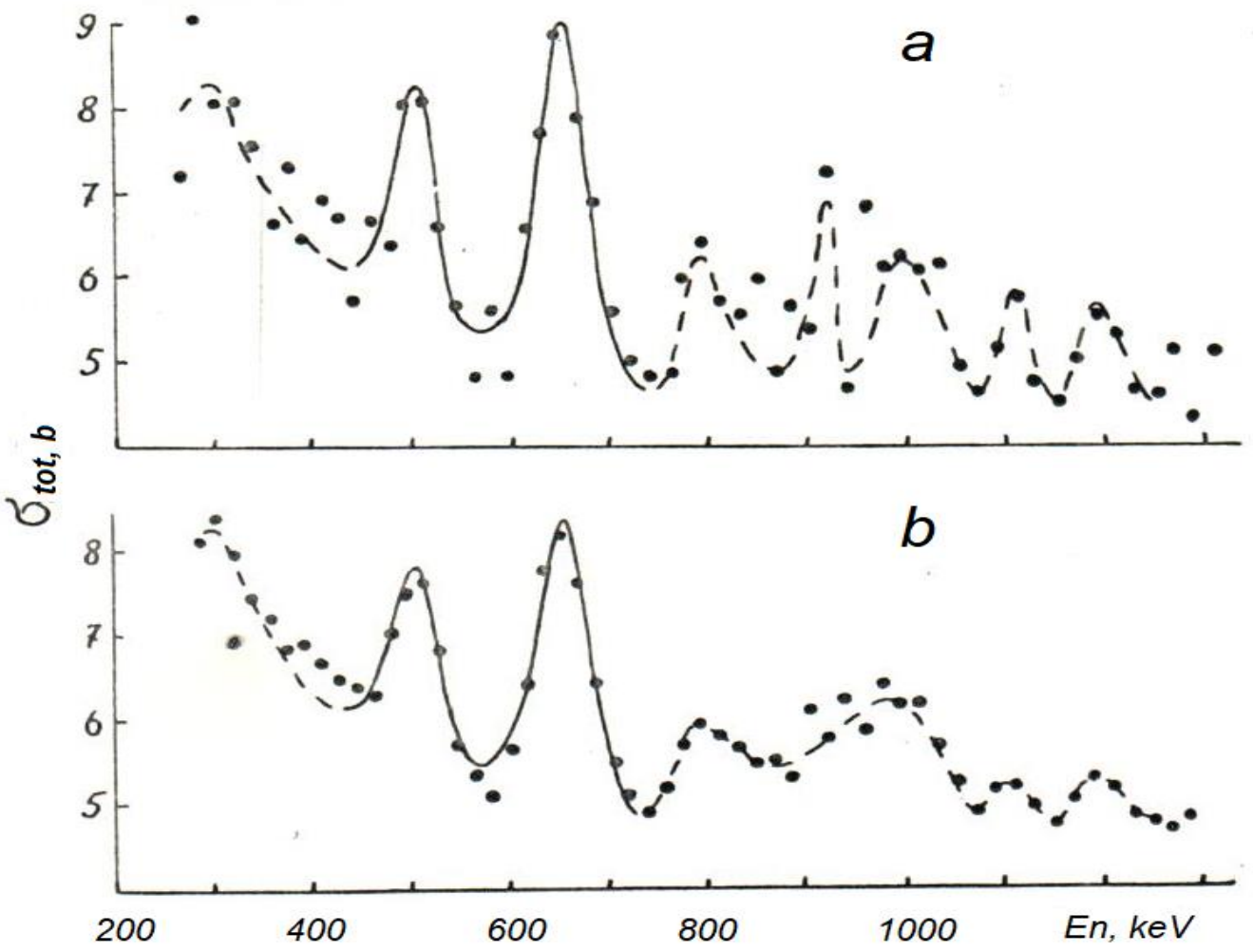
The intermediate resonance in the total and inelastic cross sections of the selenium isotops





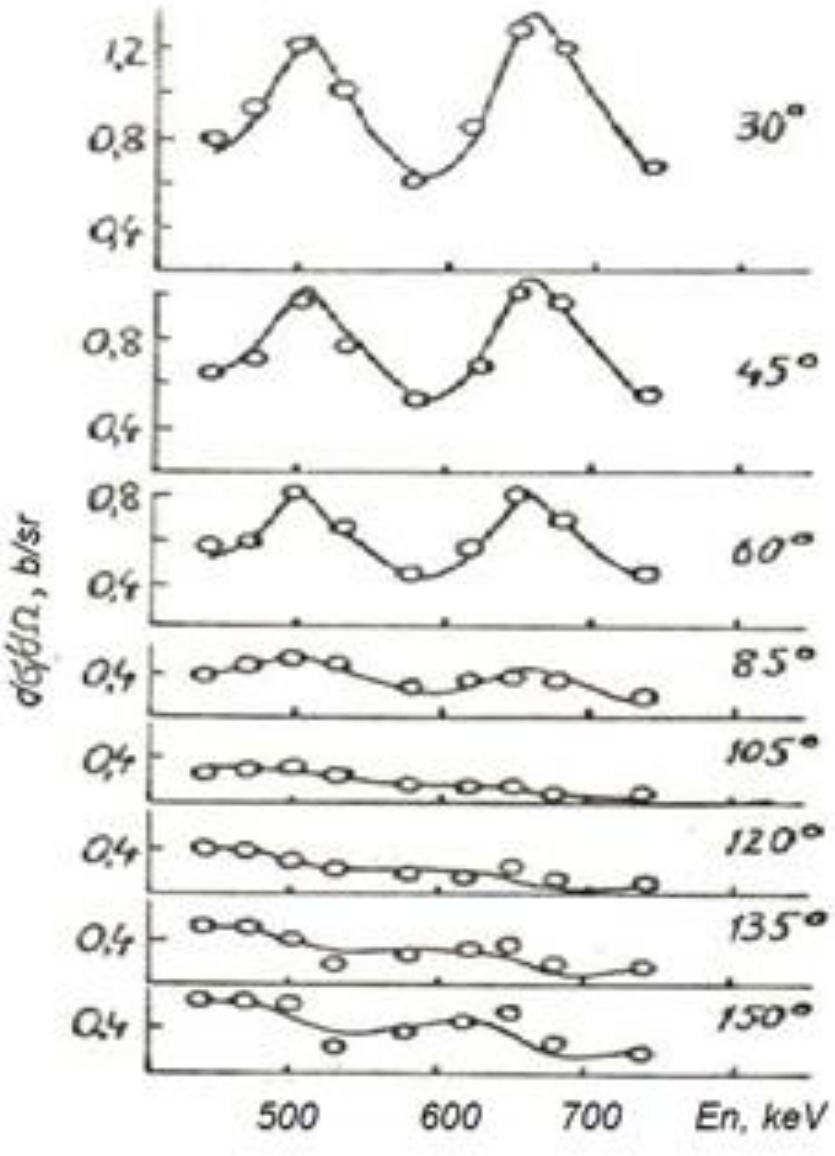
The intermediate resonance in Se cross sections observed at a fast neutron energy *E*= 0.8, 1.0, 1.25, 1.5 MeV

Approximation of the intermediate structure of the total cross sections selenium-82



The total cross sections approximation with ΔE=15 keV (a) and ΔE=50 keV (b) by a doorway state model.

Approximation of an energy structure in a angular distribution of the elastic cross sections of ^{82}Se



The averaged cross section analyzes for fast neutron elastic and inelastic scattering identified several intermediate resonances

№	cross sections	$E_{R,\ keV}$	$\Gamma_{R,\ keV}$	$\Gamma^{\uparrow}_{R,\ keV}$	$\Psi_{R,\ rad}$
1	total	310	140	20	-3
2	total, elastic	510	60	20	0.35
3	total, elastic	660	58	32	-0.15
4	total, elastic, inelastic	790	50	10	-1
5	total, elastic, inelastic	920	20	8	1
6	total, elastic, inelastic	1000	120	60	0.2
7	total, inelastic	1120	50	35	-1
8	total, inelastic	1180	90	70	-3
9	inelastic	1250	50		
10	inelastic	1500	100		

The contribution of intermediate resonances to the *p*-neutron strength function is about 50%.

THANK YOU!