Study of scattering of deuterons from 11B

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The purpose of the project:

➢ Experimental and theoretical study of the structure of the excited states, including the halo-state neutron-riched of 11B from the analysis of the scattering of charged particles.

Project objectives:

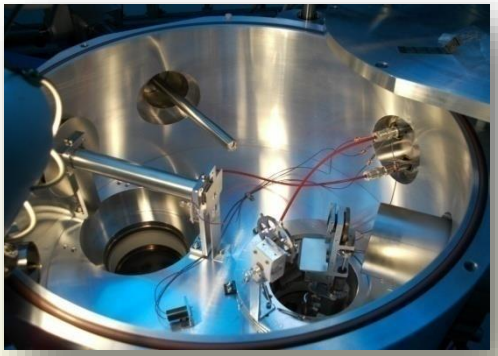
- ➢Measurement of differential cross sections for scattering of deuterons and alpha particles in the nuclear isotope 11B in a wide angular range.
- ➢An analysis of the differential cross sections for elastic scattering of deuterons and alpha particles by nuclei 11B in the optical model and coupled-channel method.
- ➢Evaluation of the contribution of the transfer of alpha-cluster in to cross section of alpha-particle scattering on nuclei of B11

Isochronous cyclotron U-150M.

In 1972 he transferred to the isochronous mode with controlled ion energy protons: 6-30 MeV deuterons: 12-25 MeV ions of helium-3: 18-62 MeV ions of helium-4: 25-50 MeV.

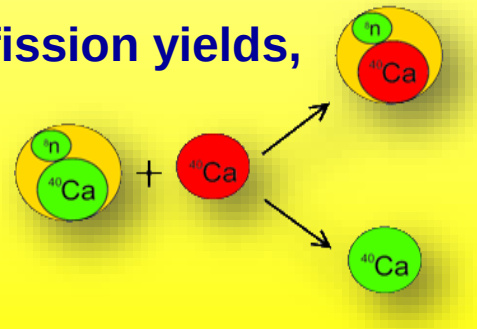
Heavy ion accelerator DC-60

With modes accelerating heavy ions with an energy of 0.3 MeV to 1.75 MeV per nucleon for nuclei of lithium to xenon



Nuclear physics

- Investigations of nuclear reactions mechanism and structure of light and middle nuclei in range of low and mean energies
- Investigations of exchange reactions and radiation capture for astrophysical applications and problem-solving in thermo-nuclear fusion and thermonuclear plasma diagnostics
- Investigations of inclusive cross-sections of nuclear reactions, related to establishment of nuclear-power facilities of new generation (ADS)
- Experimental data on transuranium elements fission yields, occurring in hybrid nuclear facilities



Search of neutron halo in ½⁺ excited state of ^{13}C and ^{9}Be

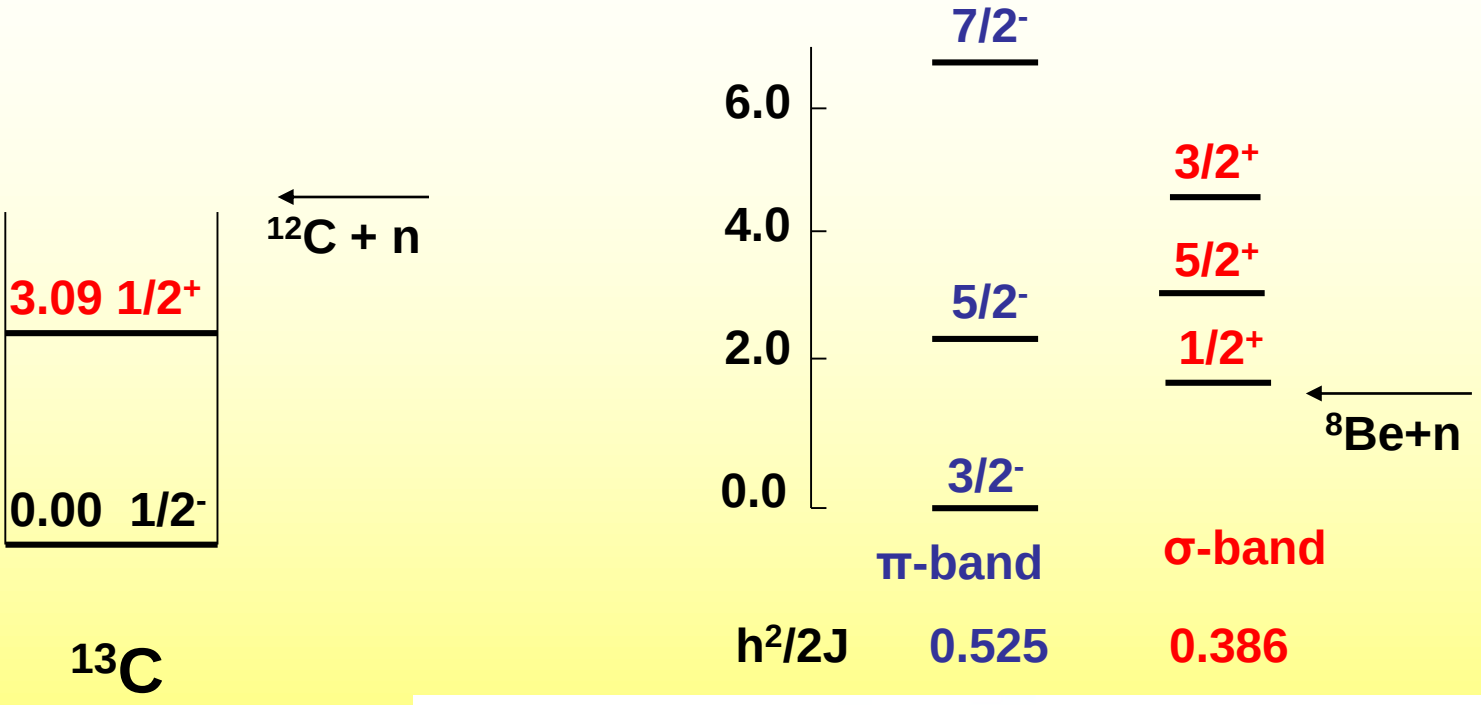
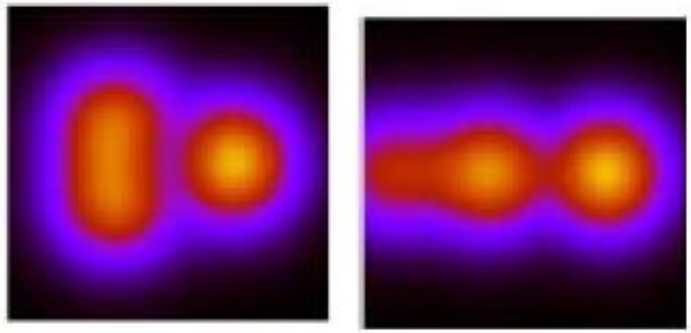


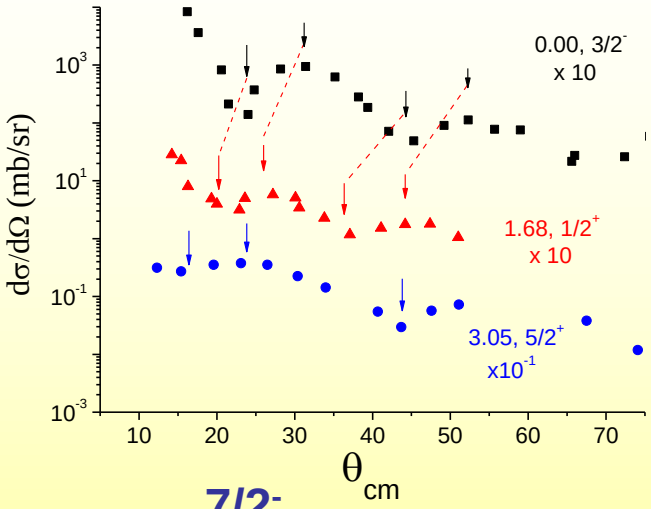
Fig. from T.Togashi et al., Int. J. Mod. Phys. E17 (08) 2081

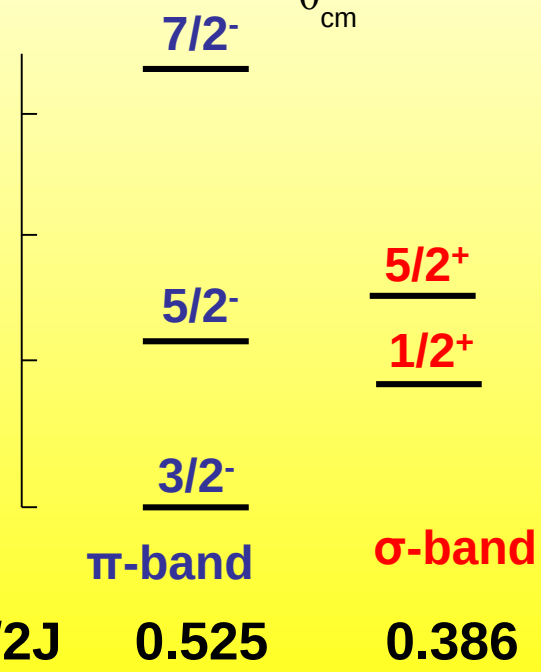


^{9}Be

^{9}Be + α, E_α=35.5 MeV

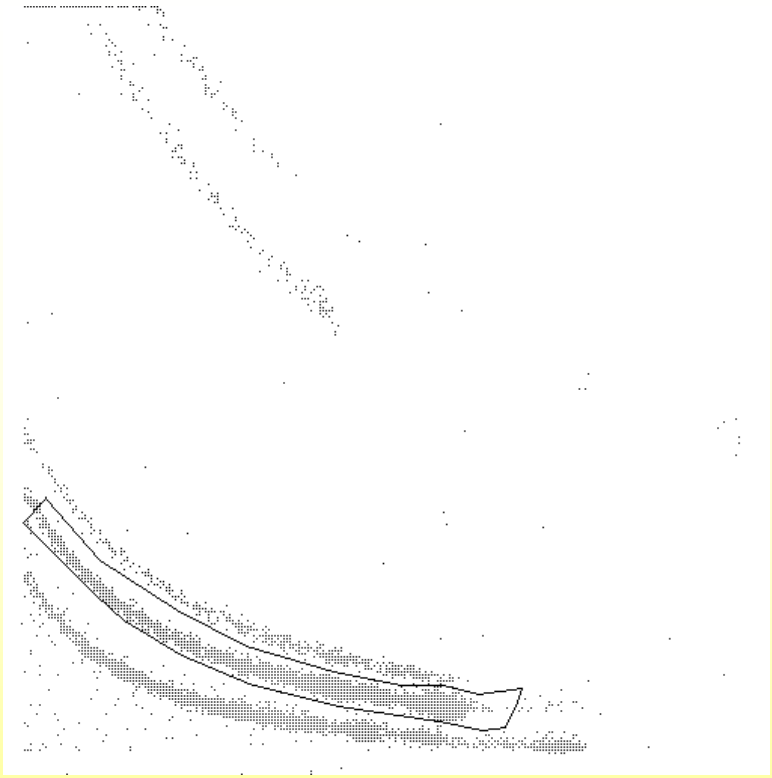
Data from R.J.Peterson



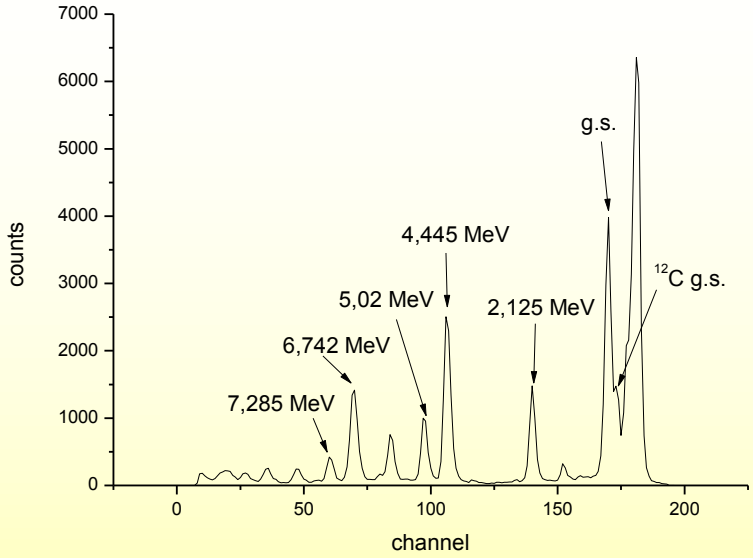


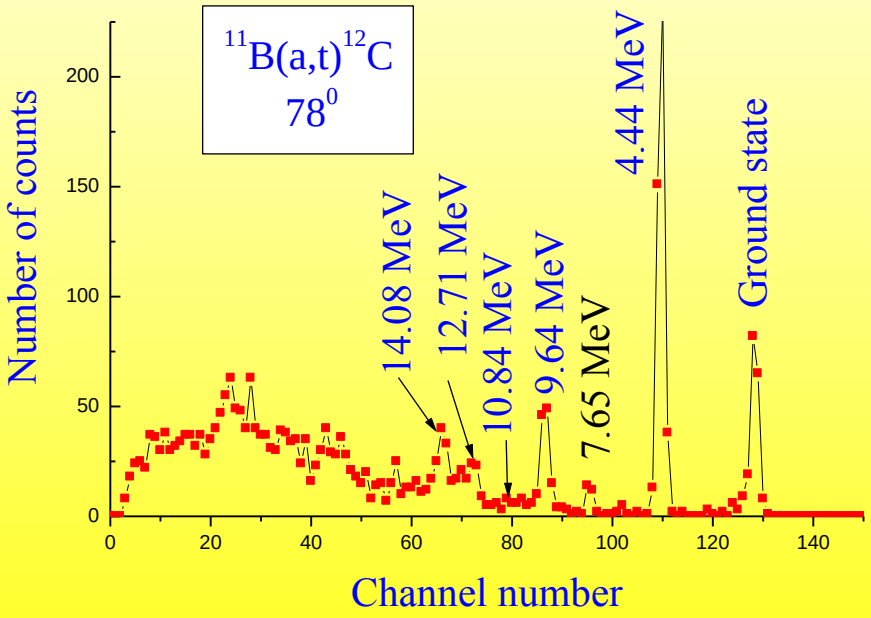
Neutron halo in ^{9}Be*

E, MeV, I^π	R_{dif}, fm	R_{rms}, fm
0.00, $3/2^-$	5.18 ± 0.03	2.37
1.68, $1/2^+$	6.38 ± 0.14	3.50 ± 0.15
2.43, $5/2^-$	5.25 ± 0.05	2.42 ± 0.07
3.05, $5/2^+$	> 6.3	> 3.1
6.38, $7/2^-$	5.27 ± 0.13	2.39 ± 0.14

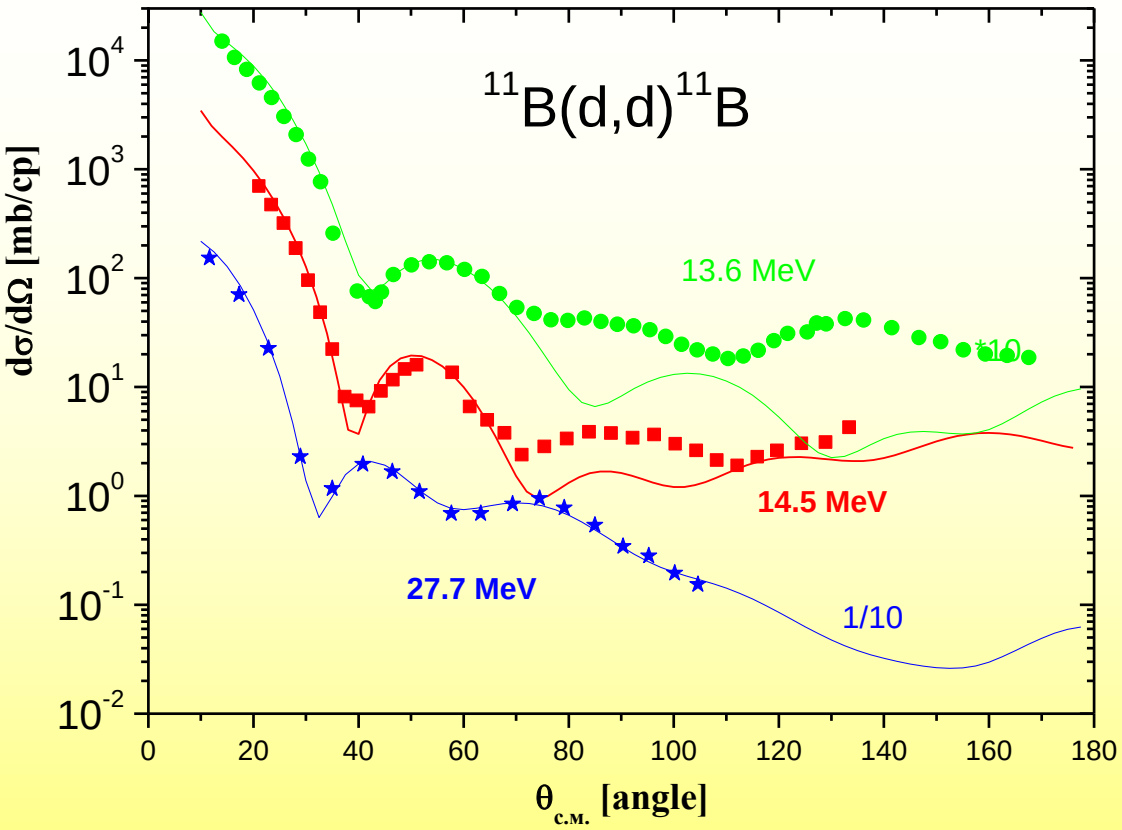


Typical Δ*E*-*E* -distribution of charged particles
Lower locuses - singly charged particles, the upper – double-charged..

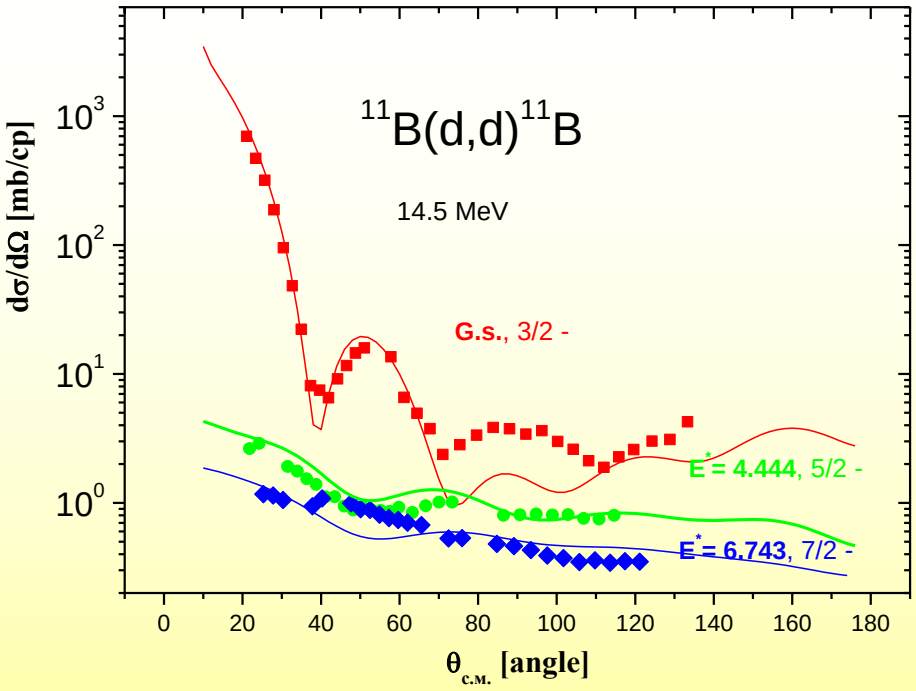




Exemplary energy spectra products of nuclear reactions

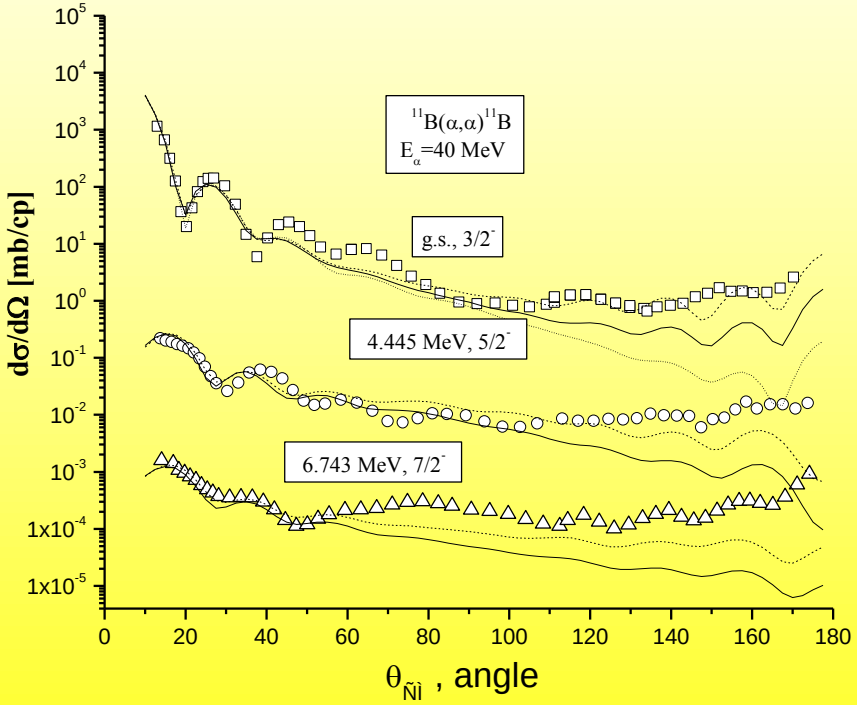


E MeV	Type	V MeV	r_v fm	A_v fm	W MeV	R_w fm	A_w fm	χ^2/N
13.6	A	80.70	1.17	0.993	33.94	1.322	0.516	32.33
14.5	B	86.8	1.17	0.993	7.040	1.322	0.945	30.17
27.7	C	83.13	1.17	0.844	16.251	1.322	0.813	27.7



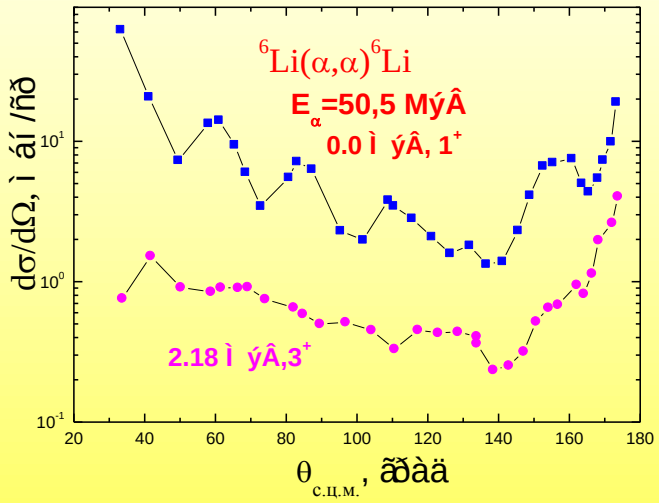
The symbols - an experiment; solid line - calculations for OM and the coupled channel method.
Calculations are made with inelastic deformation parameters:

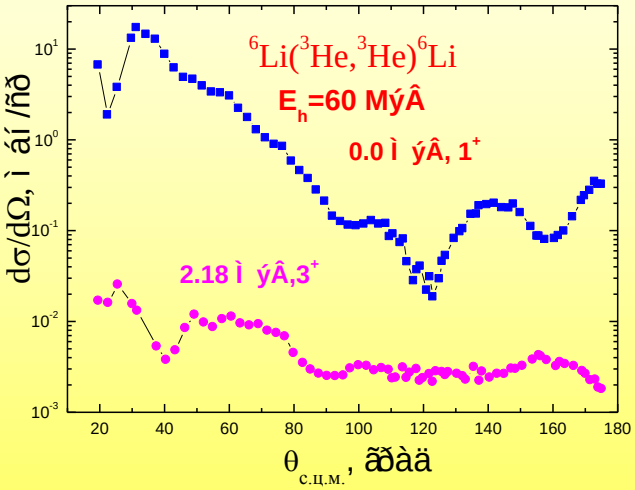
$\beta_2 = 0.4$; $\beta_4 = 0.1$



The problem of obtaining optical potentials from scattering data is greatly complicated by the fact that in many cases the behavior of the cross sections in addition to the potential effects of the mechanism of influence of nuclear structure, as well as the effects of coupled channels method.

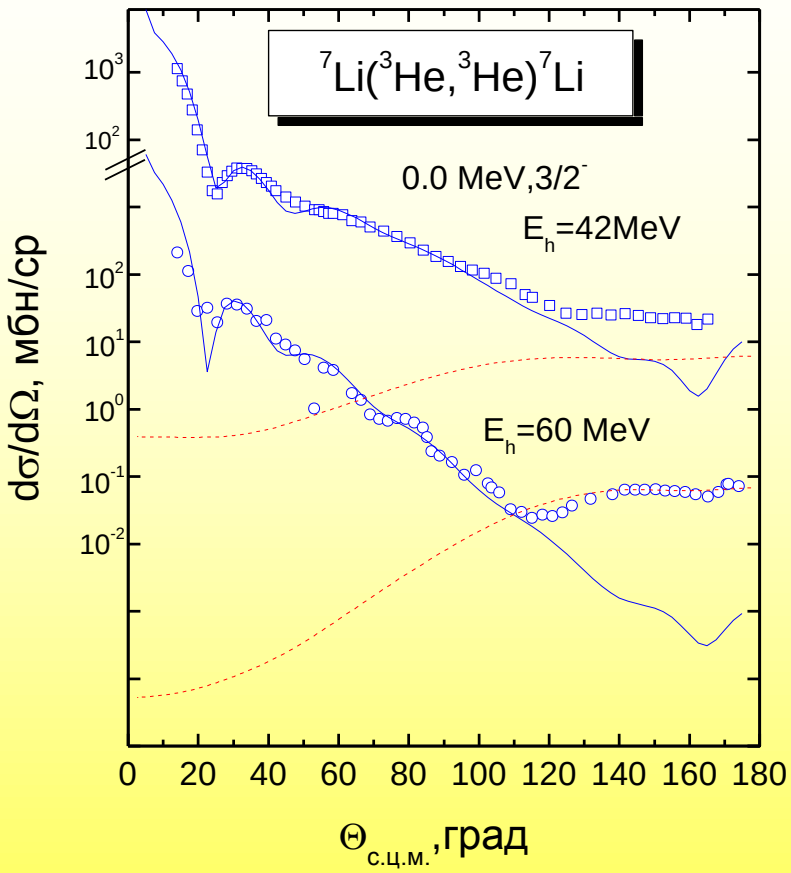
For example, in the case of interaction of helium nuclei with light nuclei with a pronounced cluster structure is observed anomalous scattering back, not inexplicable optical model.

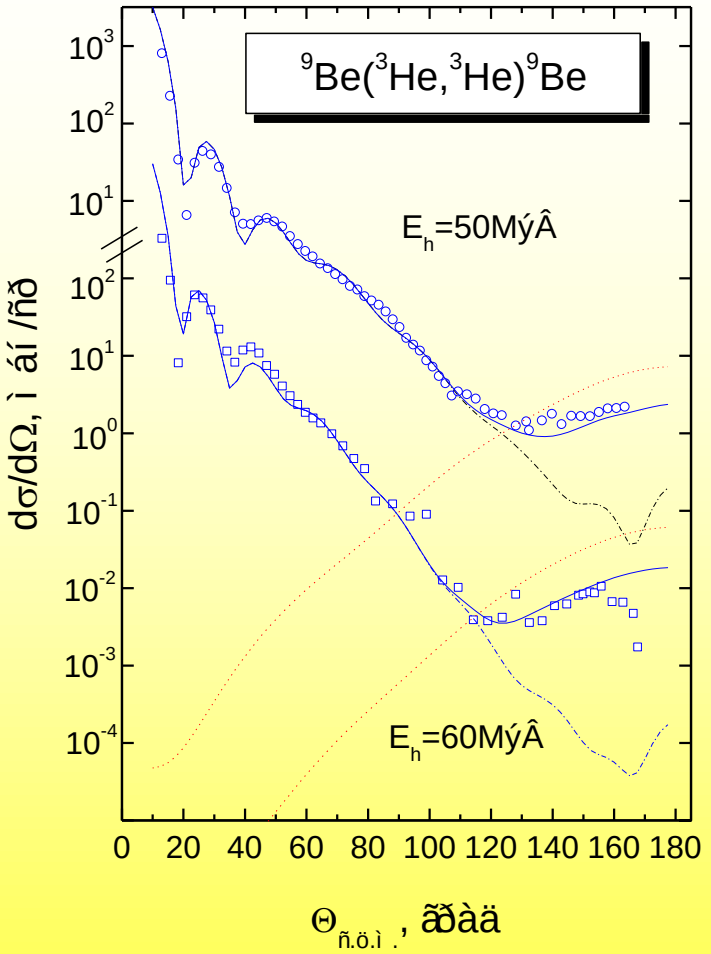




The experimental angular distribution of scattering processes alpha particles and ions 3He on nuclei 6Li

The differential cross sections for elastic scattering of ^{3}He ions on nuclei ^{7}Li and ^{9}Be





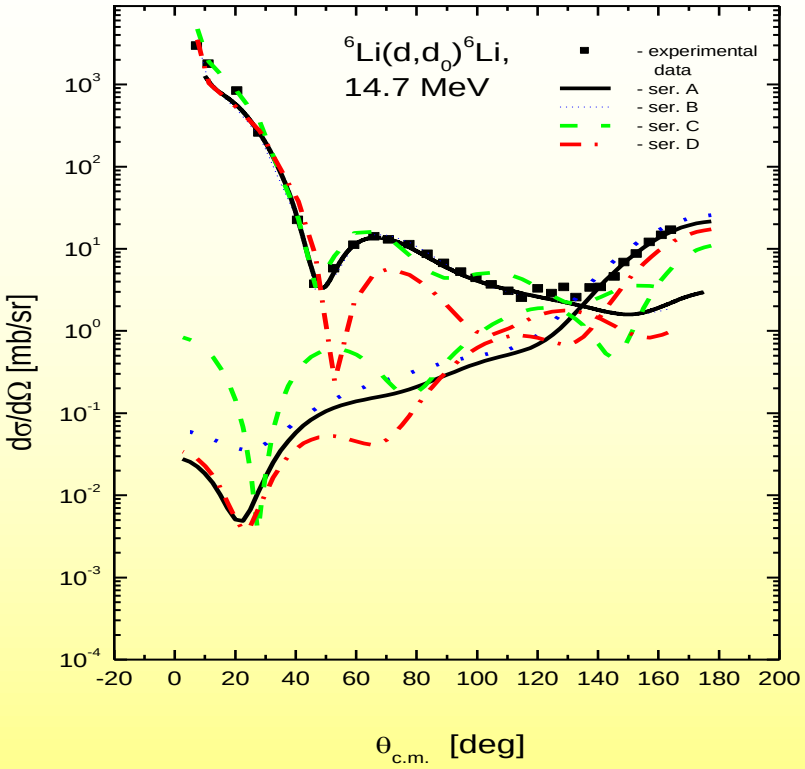
symbols - the experimental data and the dashed line calculation of the optical model with the potential V, dashed - the calculation of the cross sections of heavy disruption to the same potential, solid line - the sum of the two sections.

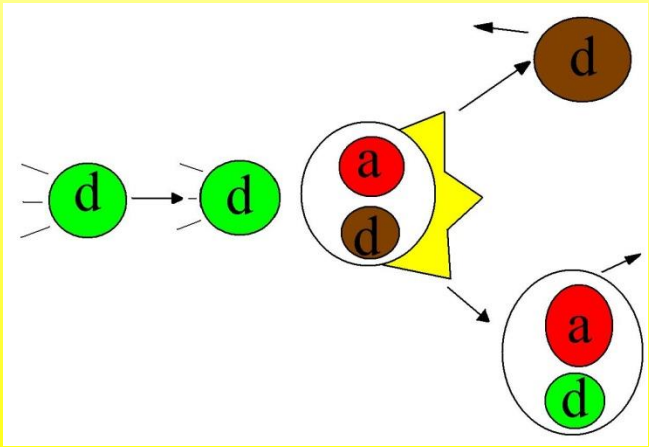
Spectroscopic factors derived from the analysis of experimental data on elastic and inelastic scattering of ^{3}He and alpha-particles on nuclei ^{6}Li, ^{7}Li and ^{9}Be

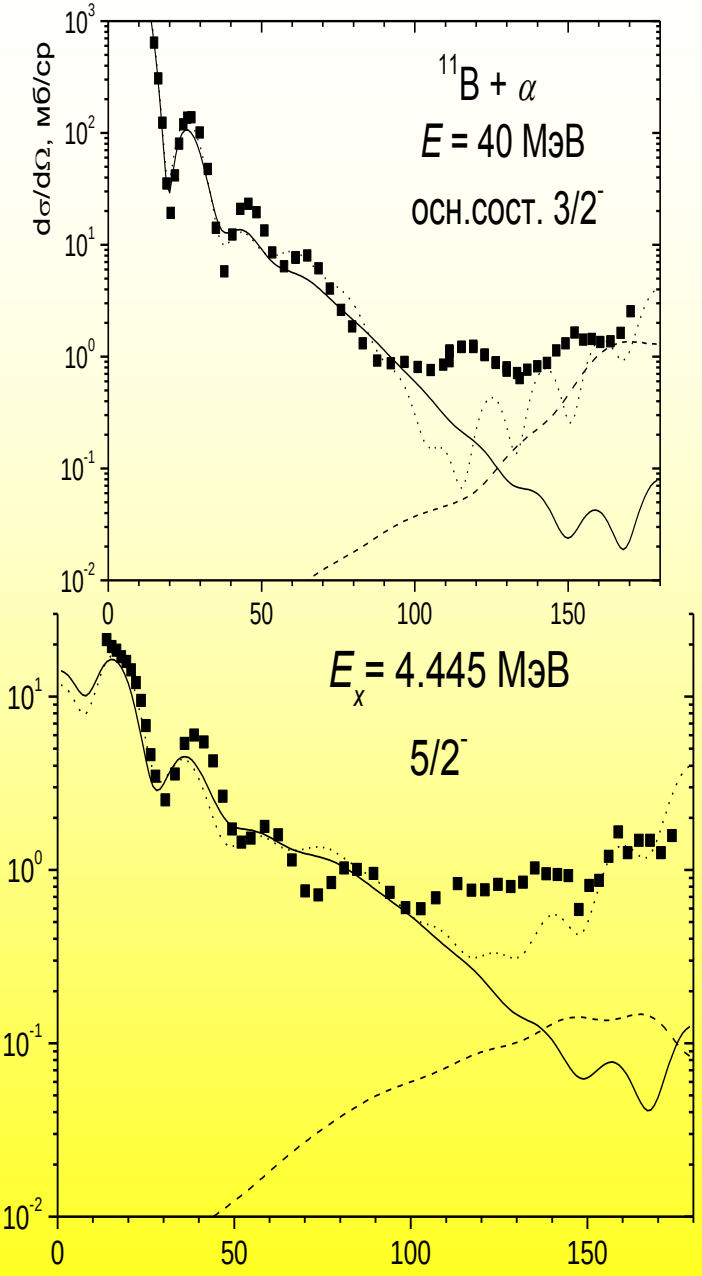
A	E_x, MeV	J^π	Configuration	S_{exp}	S_{theory}
^{6}Li	0	1^+	$2S(\alpha+d)$	1.39	0.93-1.07
^{7}Li	2.185	3^+	$2S(^{3}\mathrm{He}+t)$	0.5	0.5-0.9
^{9}Be	0	$3/2^-$	$2D(\alpha+d)$	0.5	1.0
	0.478	$1/2^-$	$1D(^{3}\mathrm{He}+t)$	1.14	1.0
	4.63	$7/2^-$	$2P(\alpha+t)$	1.03	1.19
	0	$3/2^-$	$2P(\alpha+t)$	0.26	1.0
	0	$3/2^-$	$(\alpha+t)$	0.28	1.0
	0	$3/2^-$	$2S(^{3}\mathrm{He}+^{4}\mathrm{H})$	0.26	0.81
			$3S(\alpha+^{5}\mathrm{He})$	1.0	0.236
			$2P(^{3}\mathrm{He}+^{6}\mathrm{He})$	0.22	

The contradictions of theoretical and experimental spectroscopic factors for the excited states may have different reasons - it is used by the internal inaccuracies of the wave functions of the nuclei of lithium, a possible contribution to the response of more complex processes, such as the transfer of multiple clusters or replacement mechanisms described triangular diagrams.

The contribution of transfer of clusters in the cross section of nuclear reactions

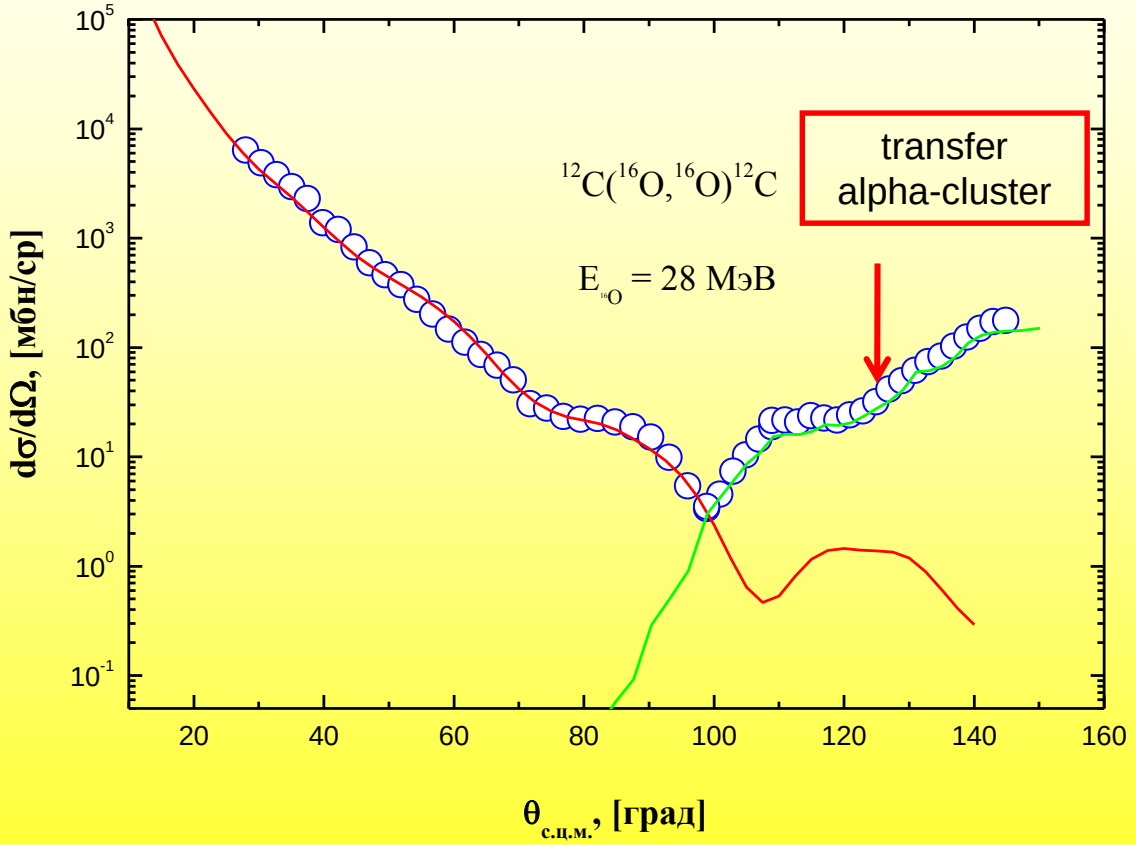


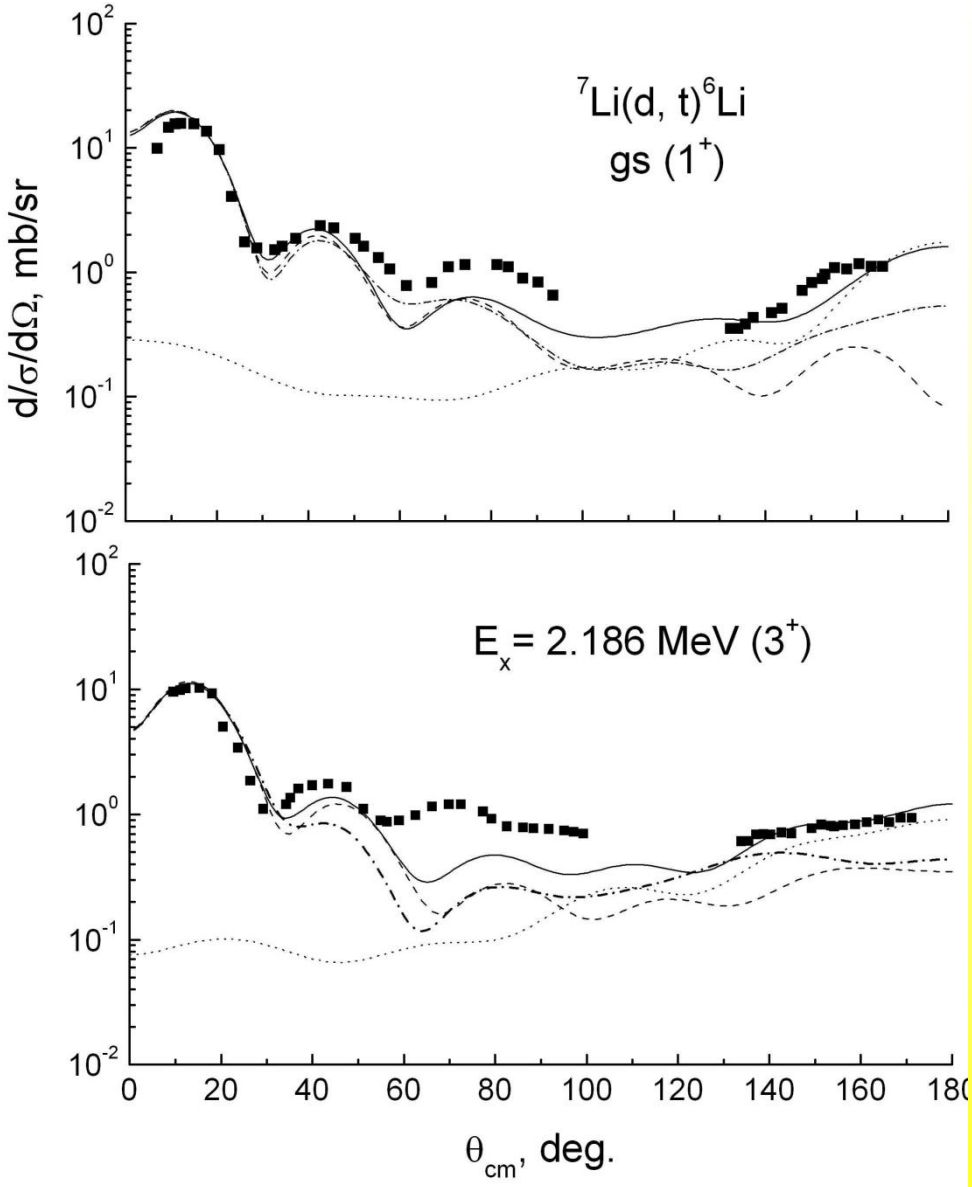




The experimental method of determining the cluster formations in nuclei in elastic interactions

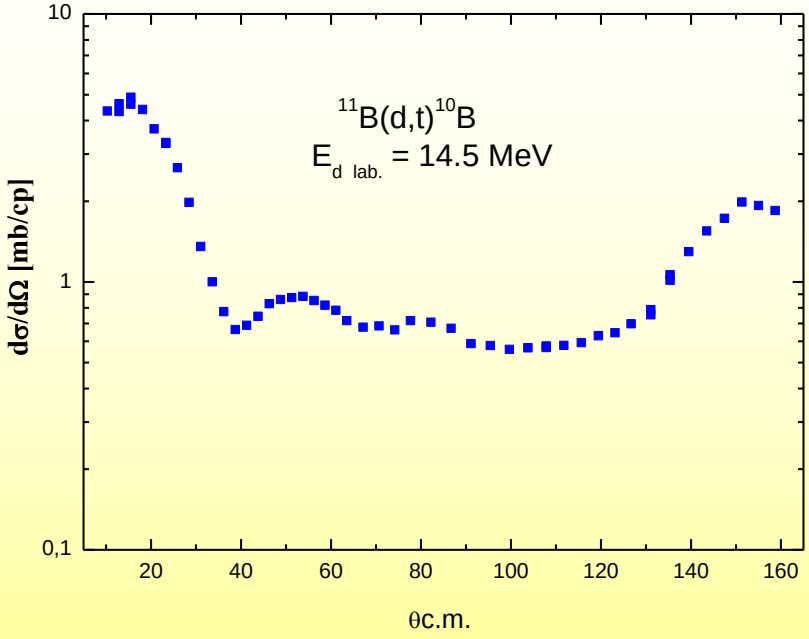
Abnormal rise section at large angles (more than 100^0) in the elastic scattering due to the transfer of alpha-cluster from the incident particle (16O) to the target nucleus (12C).

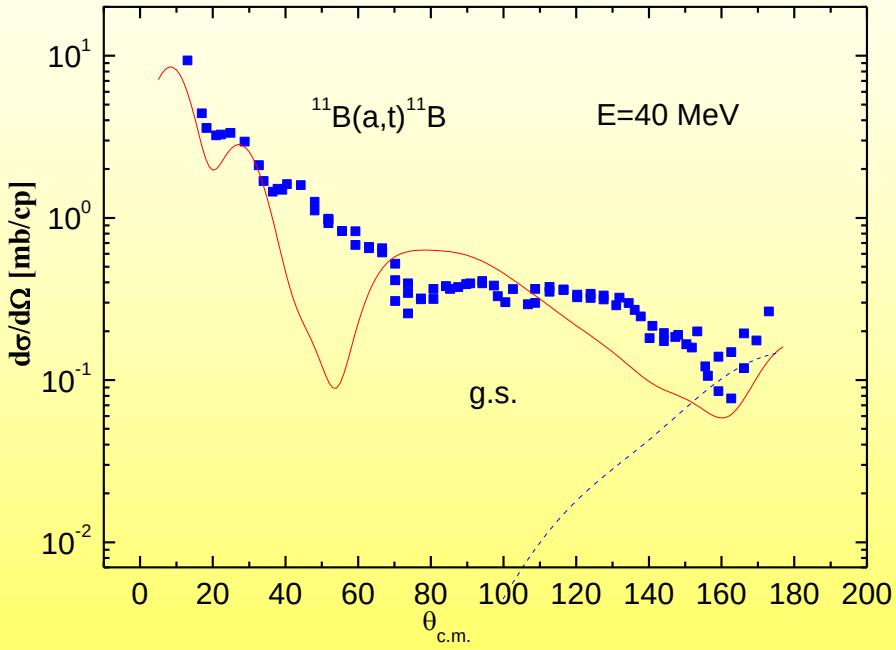




Angular distributions of tritons from the reaction ^{7}Li(*d*, *t*)^{6}Li, corresponding to transitions to the ground (1^+) and first excited (E_x = 2.186 MeV (3^+)) states of ^{6}Li nucleus. Squares - experimental points. Curves - calculations with OM 2: Solid curve - all couplings are taken into account, dashed curves - all couplings in the ^{7}Li(*d*, *t*)^{6}Li process but without the contribution of α-particle transfer, dotted curves - transfer mechanism with α-particles exchange in the ^{7}Li(*d*, ^{6}Li)*t* reaction. Dashed-dotted curve - calculation of the reaction ^{7}Li(*d*, *t*)^{6}Li without coupled channels processes (distorted waves with a finite radius of interaction).

The contribution of the transfer of t - cluster in the cross section of nuclear reactions of boron-11





Thank you for attention!