Two-particle disintegration processes in covariant approach

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OUTLINE

- Introduction
- Greens function formalism
- Total amplitude
- Vertex function properties
- Electro disintegration of light nuclei
- Results for different disintegration processes
- Conclusions and remarks

Investigation of nonlocal interactions in QED has quite long history:

$$A_\mu(x)J^\mu(x) \quad \text{Formfactor}\rightarrow \quad A_\mu(x)F\left(\frac{(x-x')^2}{l^2}\right)J^\mu(x')$$

D.I. Blochintsev (1957)

GOAL: To explore the incisive *medium energy* physics.

The aim is to develop our understanding of the *strong interaction* and to distribute the methods of standard QED into nonlocal (structural) particles.

Requirements to satisfy :

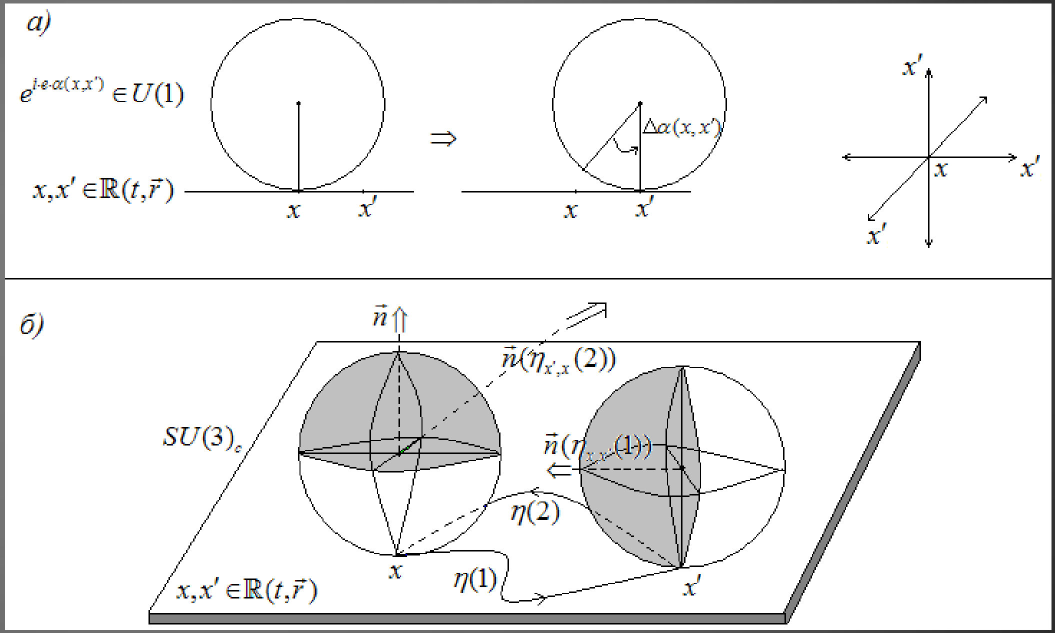
- *covariance*
- *local gauge invariance*
- *space-time homogeneity*

Observables are calculated for light nuclei (Deuteron, $^3\boldsymbol{He}$, $^4\boldsymbol{He}$), which could be assumed as an elementary particles in some sense (within the framework of the theory).

The following facts have been formulated and involved[1,2]:

- ***Inseparability*** property of the electric charge concept from the concept of mass
- ***Indifference*** property of electromagnetic forces

In order to describe these facts we involved to consideration a fiber generalized space $SU_3 \otimes U_1$ - Minkowski space and a unitary charge space.



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2. Kasatkin Yu. A., Klepikov V.F. Regular Part of the Conserving Structural Current is as Dynamic Measure Non-locality of the Coupled Fields // 3-d Int. Conf. “Current Problems in Nucl. Ph. and Atomic Energy” (*NPAE*-Kyiv2010), 7-12 June, 2010, Kyiv, P. 625-632

Charge part is formulated as the requirement of vanishing of the covariant derivative of the field function in the direction of the tangent space :

$$\frac{dx_\mu}{d\tau} D^\mu \psi_{ch}(x)|_{x=x(\tau)} = \frac{dx_\mu}{d\tau}(\partial^\mu - ieA^\mu)\psi_{ch}(x)|_{x=x(\tau)} = 0.$$

Solution of the equation, taking into account the initial condition $\psi_{ch}(a) = 1$ is given by :

$$\psi_{ch}(x) = Pe^{ie\int_a^x A^\nu(r)dr_\nu}.$$

The total wave function of a particle in generalized space :

$$\Psi(x;A) = \psi_{ch}(x)\psi(x) = Pe^{ie\int_a^x A^\nu(r)dr_\nu}\psi(x).$$

Substituting this function into the free electron field Lagrangian leads to the interaction Lagrangian:

$$\mathcal{L}_{local}(x;A=0)=\boldsymbol{\bar{\psi}(x)\left(i\gamma^{\mu}\partial_{\mu}-m\right)\psi(x)}\Rightarrow$$

$$\mathcal{L}_{local}(x;A)=\bar{\Psi}(x;A)\left(i\gamma^{\mu}\partial_{\mu}-m\right)\Psi(x;A)=$$

$$=\bar{\psi}(x)\overline{\left(Pe^{ie\int_a^x A^{\nu}(r)dr_{\nu}}\right)}\left(i\gamma^{\mu}\partial_{\mu}-m\right)Pe^{ie\int_a^x A^{\rho}(r)dr_{\rho}}\psi(x)=$$

$$=\bar{\psi}(x)e^{-ie\int_a^x A^{\nu}(r)dr_{\nu}}\left(i\gamma^{\mu}\partial_{\mu}-m\right)e^{ie\int_a^x A^{\rho}(r)dr_{\rho}}\psi(x)=$$

$$=\boldsymbol{\bar{\psi}(x)i\gamma^{\mu}\left(\partial_{\mu}+ieA_{\mu}(x)\right)\psi(x)-m\bar{\psi}(x)\psi(x)}.$$

Local gauge symmetry of the Lagrangian of free scalar field:

$$\mathcal{L}_{local}(x; A = 0) = \left[\boldsymbol{\partial}_{\mu}\boldsymbol{\phi}(\boldsymbol{x})\right]^{+}[\boldsymbol{\partial}^{\mu}\boldsymbol{\phi}(\boldsymbol{x})] - \mu^{2}\boldsymbol{\phi}^{+}(\boldsymbol{x})\boldsymbol{\phi}(\boldsymbol{x}) - \frac{\boldsymbol{\lambda}}{\boldsymbol{4}}(\boldsymbol{\phi}^{+}(\boldsymbol{x})\boldsymbol{\phi}(\boldsymbol{x}))^{2} \Rightarrow$$

$$\mathcal{L}_{local}(x; A) = \left[\boldsymbol{D}_{\mu}\boldsymbol{\phi}(\boldsymbol{x})\right]^{+}[\boldsymbol{D}^{\mu}\boldsymbol{\phi}(\boldsymbol{x})] - \mu^{2}\boldsymbol{\phi}^{+}(\boldsymbol{x})\boldsymbol{\phi}(\boldsymbol{x}) - \frac{\boldsymbol{\lambda}}{\boldsymbol{4}}(\boldsymbol{\phi}^{+}(\boldsymbol{x})\boldsymbol{\phi}(\boldsymbol{x}))^{2}$$

Nonlocal two-point Green's function:

$$D_{nonlocal}(x,y;A) = i < P\left(\phi(x) e^{ie\int_y^x A^\nu(r)dr_\nu}\phi^+(y)\right) >$$

Invariant with respect to local gauge transformations:

$$\phi(x) \to e^{-ie\alpha(x)}\phi(x),$$
$$\phi^+(y) \to e^{ie\alpha(y)}\phi^+(y),$$
$$A_\mu(r) \to A_\mu(r) + \partial_\mu\alpha(r).$$

Inclusion of the EM field is determined by the derivative of $A_\mu(x)$:

$$\frac{\delta D_{nonlocal}(x,y;A)}{\delta A_\mu(r)}\Big|_{A=0} A_\mu(r) \to (2\pi)^4 e\,\delta(q+p-p')\varepsilon_\mu \int_0^1 d\lambda \frac{\partial D(p+q\lambda)}{\partial(p+q\lambda)_\mu} =$$
$$=(2\pi)^4\,\delta(q+p-p')D(p+q)\{-e\varepsilon_\mu(p+p')^\mu\}D(p).$$

3-point GF consists of strongly-connected gauge-invariant nonlocal vertex part and has outer ends, that are 2-point Green's functions:

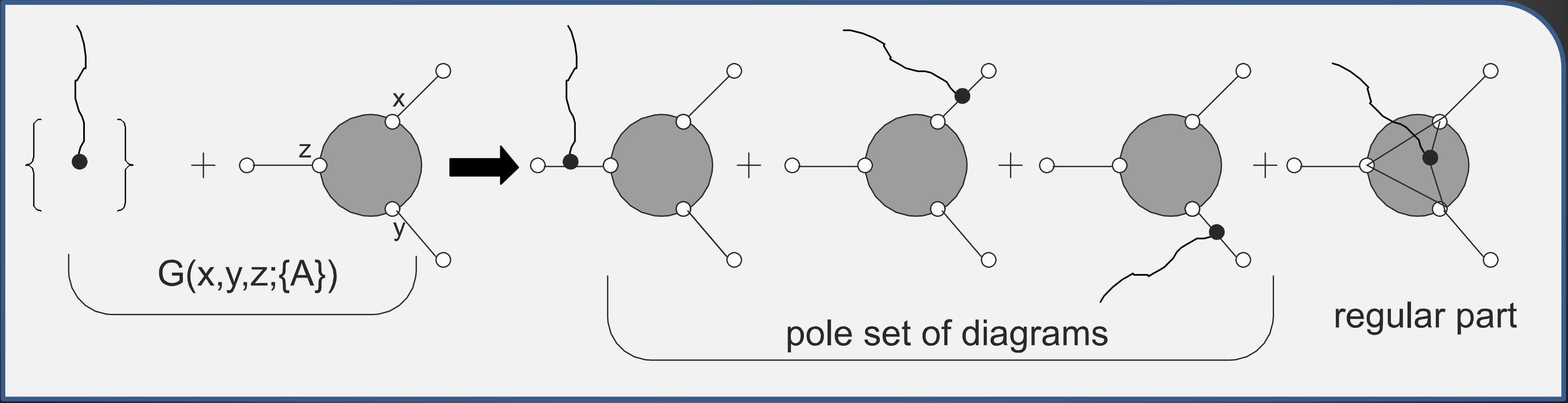
$$G(x, y, z; \{A\}) \equiv$$
$$< P\left(\phi(z) e^{ie_1 \int_x^z A^\nu(r) dr_\nu} \phi_1^+(x) e^{ie_2 \int_y^z A^\nu(r) dr_\nu} \phi_2^+(y)\right) >.$$

EM pasting in the momentum representation:

$$\frac{\delta G(x, y, z; \{A\})}{\delta A_\mu(r)}|_{A=0} \cdot A_\mu(r) \rightarrow$$
$$(2\pi)^4 \delta(q + p - p_1 - p_2) \varepsilon_\mu \times$$
$$\times \int_0^1 d\lambda \left\{ e_1 \frac{\partial G(p_1 - q\lambda; p_2)}{\partial (p_1 - q\lambda)_\mu} + e_2 \frac{\partial G(p_1; p_2 - q\lambda)}{\partial (p_2 - q\lambda)_\mu} \right\}.$$

The structure of the generalized gauge closed amplitude represents the sum of traditional pole series (left three diagrams), and inclusion of a photon into the vertex part causes the regular component (the remaining diagram).

A generalized set of diagrams:



Expression for total matrix element:

$$\mathrm{M} = e\varepsilon_{\mu} J^{\mu} \qquad J^{\mu} = J_{pol}{}^{\mu} + J_{reg}{}^{\mu}$$

$$J_{pol}{}^{\mu} = z_s G_s \frac{(d+d')^{\mu}}{s-m_d^2} + z_t G_t \frac{(p+p')^{\mu}}{t-m_p{}^2} + z_u G_u \frac{(n+n')^{\mu}}{u-m_n{}^2}$$

$$J_{reg}{}^{\mu} = \frac{k^{\mu}}{kq}(z_t G_t + z_u G_u - z_s G_s)$$

No singularity by (qk_s). The xpression is defined by the derivative of vertex function $\mathrm{G}(-\mathrm{k}_s^2)$ of strong interaction due to the charge conservation law $z_s = z_t + z_u$:

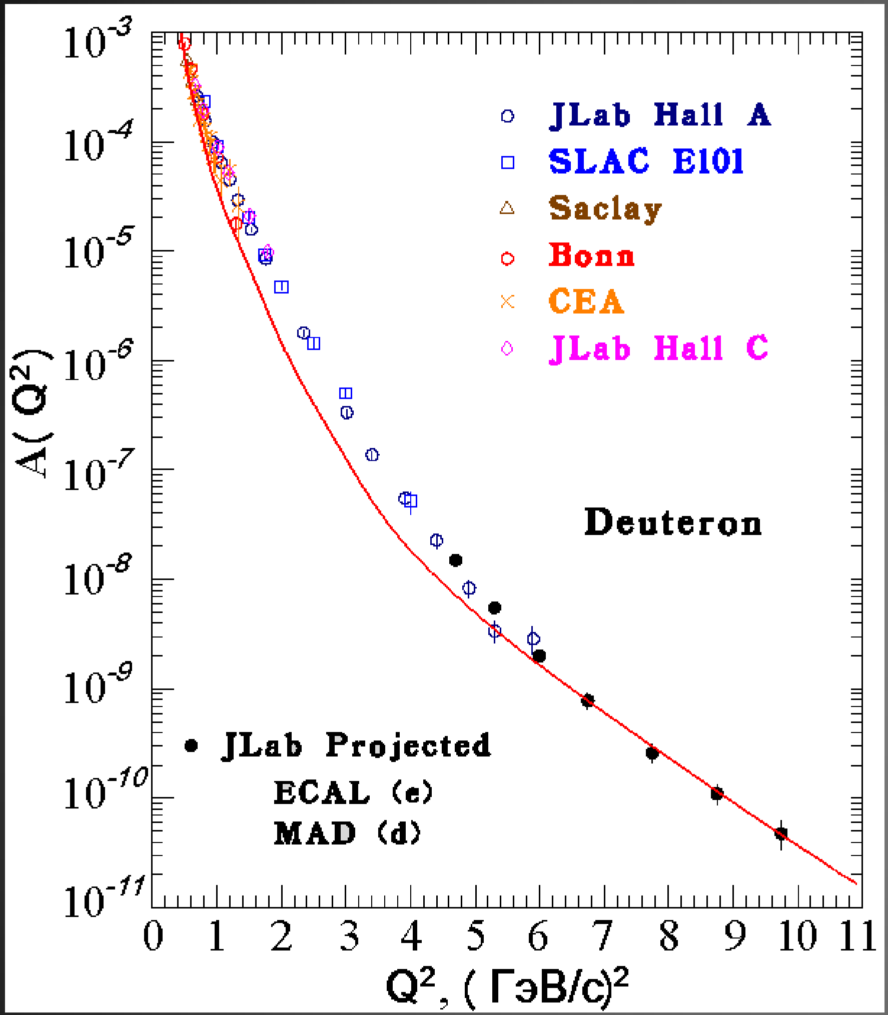
$$\lim_{k_s q \to 0} \frac{(z_t + z_u)G\,(-k_s{}^2) - z_t G\,(-k_s^2 + qk_s) - z_u G\,(-k_s^2 - qk_s)}{k_s q} = \lambda \frac{dG(x)}{dx}\bigg|_{x=-k_s{}^2}$$

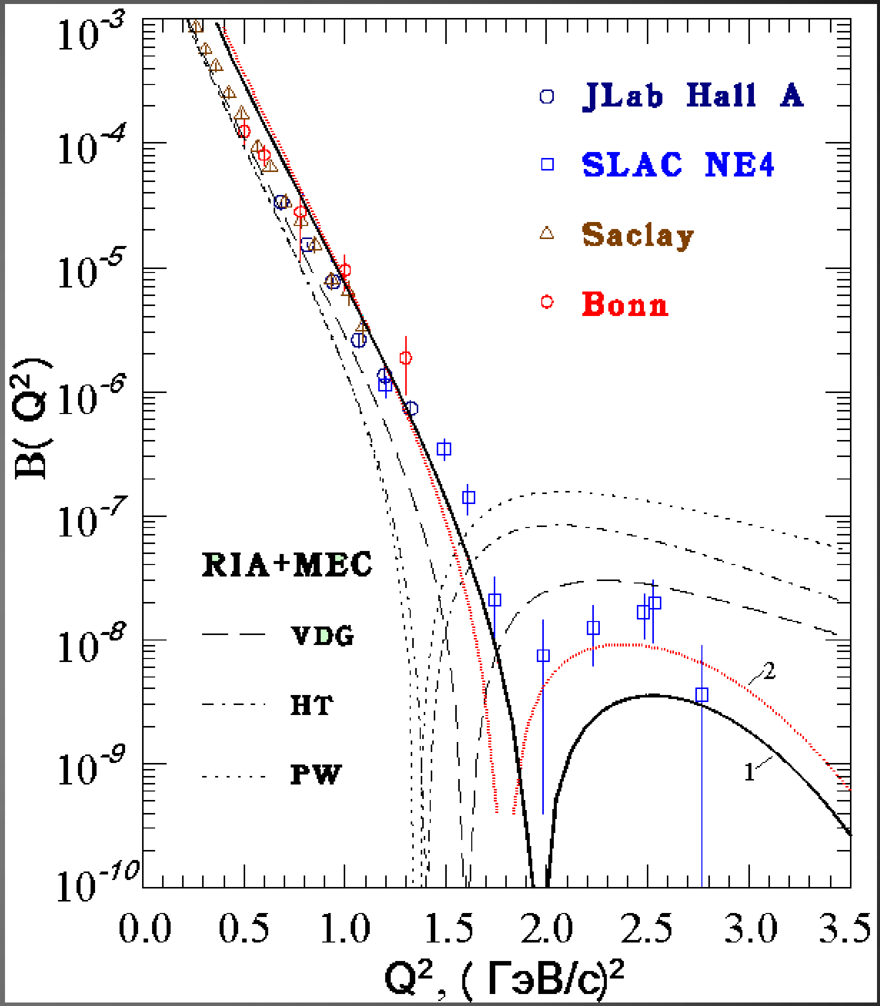
1. Vertex function *G* describes the virtual collapse and due to relativistic invariance depends on the square of the relative four-momentum.

2. Vertex functions $G^{(i)} \equiv G\left(-k_i^2\right),\ (i = s, t, u)$ depend of the appropriate arguments.

3. In the case $G^{(s)} = G^{(t)} = G^{(u)} = const$ we have:$M_\mu^{(c)} = 0$, and therefore the sum of pole diagrams is gauge-invariant.

G-function parameterization for Deuteron: *Vertex function properties*





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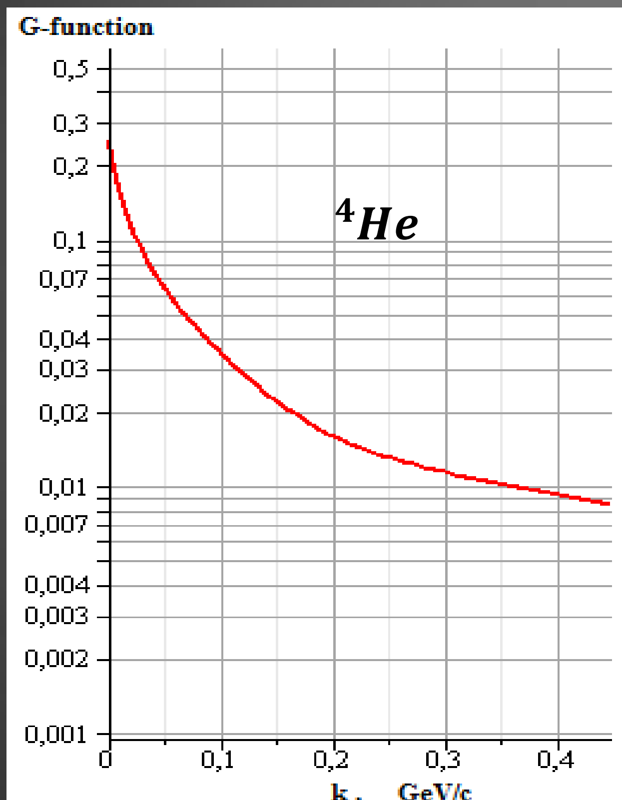
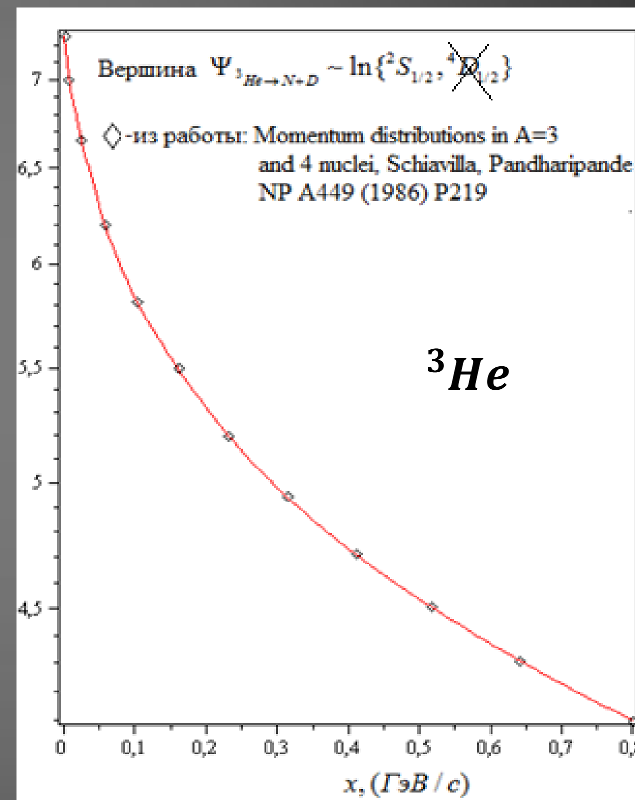
G-function parameterization for ^4He:



G-function parameterization for ^3He:



1. R. Schiavilla et.al. Momentum distributions in A=3 and 4 nuclei // Nucl. Phys.-1986.-Vol. A449.-P.219-242.

TABLE 9

d+p amplitudes in ^{3}He in fm$^{3/2}$

k [fm^{-1}]	Urbana+model VII		Argonne+model VII			
	variational		variational		Faddeev	
	$A^{00}_{dp}(1,-\frac{1}{2},\frac{1}{2})$	$A^{22}_{dp}(-1,-\frac{1}{2},\frac{1}{2})$	$A^{00}_{dp}(1,-\frac{1}{2},\frac{1}{2})$	$A^{22}_{dp}(-1,-\frac{1}{2},\frac{1}{2})$	$A^{00}_{dp}(1,-\frac{1}{2},\frac{1}{2})$	$A^{22}_{dp}(-1,-\frac{1}{2},\frac{1}{2})$
0	97.80 ± 0.07	0	93.08	0	97.2	0
0.16	85.99 ± 0.04	−0.461 ± 0.006	82.54	−0.375	85.43	−0.347
0.32	60.70 ± 0.08	−1.31 ± 0.02	59.55	−1.08	60.14	−1.00
0.48	38.2 ± 0.1	−1.79 ± 0.02	38.3	−1.53	37.6	−1.42
0.64	23.5 ± 0.1	−1.86 ± 0.02	24.0	−1.63	23.2	−1.53
0.80	14.4 ± 0.1	−1.74 ± 0.02	14.9	−1.54	14.2	−1.47
0.96	8.75 ± 0.08	−1.53 ± 0.02	9.17	−1.37	8.69	−1.32
1.12	5.37 ± 0.07	−1.30 ± 0.02	5.61	−1.17	5.28	−1.15
1.28	3.25 ± 0.06	−1.07 ± 0.01	3.33	−0.98	3.07	−0.98
1.44	1.96 ± 0.05	−0.87 ± 0.01	1.96	−0.80	1.73	−0.81
1.60	1.17 ± 0.05	−0.70 ± 0.01	1.12	−0.65	0.93	−0.66
1.76	0.64 ± 0.05	−0.56 ± 0.01	0.58	−0.53	0.41	−0.52
1.92	0.31 ± 0.04	−0.45 ± 0.01	0.26	−0.44	0.11	−0.41
2.08	0.10 ± 0.04	−0.37 ± 0.01	0.06	−0.36	−0.06	−0.33
2.24	−0.02 ± 0.01	−0.29 ± 0.01	−0.04	−0.30	−0.16	−0.28
2.40	−0.07 ± 0.03	−0.23 ± 0.01	−0.09	−0.25	−0.19	−0.23

The sampling errors for the variational and Faddeev Argonne amplitudes are similar to those for the Urbana amplitudes.

TABLE 10

Momentum distributions in ^{4}He in fm^3

k [fm^{-1}]	Urbana+model VII			Argonne+model VII		
	$N_p(k)$	$N_{tp}(k)$	$N_{dd}(k)$	$N_p(k)$	$N_{tp}(k)$	$N_{dd}(k)$
0	367.3 ± 0.5	341.5	143.8	491.7	477.8	197.4
0.08	359.6 ± 0.4	333.8	141.2	478.2	464.0	193.2
0.16	337.7 ± 0.4	312.0	133.8	440.4	425.1	181.3
0.24	304.4 ± 0.4	279.0	122.5	385.1	368.5	163.4
0.32	263.9 ± 0.5	239.4	108.6	321.0	303.7	141.7
0.40	220.7 ± 0.5	197.6	93.4	256.7	239.3	118.6
0.48	178.6 ± 0.5	157.5	78.2	198.0	181.5	96.2
0.56	140.4 ± 0.5	121.8	63.9	148.2	133.4	75.9
0.64	107.6 ± 0.6	91.7	51.1	108.3	95.5	58.3
0.72	80.8 ± 0.5	67.5	40.0	77.4	67.0	43.9
0.80	59.6 ± 0.5	48.7	30.8	54.3	46.2	32.4
0.88	43.2 ± 0.5	34.6	23.3	37.4	31.4	23.5
0.96	30.9 ± 0.4	24.1	17.4	25.4	21.1	16.8
1.04	21.8 ± 0.4	16.6	12.9	17.0	14.0	11.9
1.12	15.3 ± 0.4	11.2	9.37	11.3	9.2	8.29
1.20	10.7 ± 0.4	7.5	6.76	7.5	6.0	5.74
1.28	7.4 ± 0.4	4.9	4.84	4.9	3.9	3.94
1.36	5.2 ± 0.3	3.2	3.44	3.2	2.5	2.68
1.44	3.7 ± 0.3	2.0	2.42	2.0	1.6	1.82
1.52	2.6 ± 0.3	1.3	1.70	1.3	1.0	1.23
1.60	1.9 ± 0.3	0.76	1.19	0.8	0.60	0.83
1.68	1.4 ± 0.3	0.46	0.83	0.5	0.36	0.56
1.76	1.3 ± 0.3	0.26	0.57	0.4	0.21	0.37

The sampling errors for the Argonne results are similar to those for the Urbana results.

1. R. Schiavilla et.al. Momentum distributions in A=3 and 4 nuclei // Nucl. Phys.-1986.-Vol. A449.-P.219-242.

A transition from virtual to real photon considered in limit $q^2 \to 0$:

For *s*- channel:

$$\lim_{q^2\to 0} q_\mu (J^\mu_{sreg} + J^\mu_{spol}) = z_s G_s \lim_{q^2\to 0}\left(\frac{2q_\mu d^\mu + q^2}{m_d + 2dq + q^2 - m_d} - \frac{q_\mu k^\mu}{kq}\right)$$

$$= z_s G_s \lim_{q^2\to 0}\left(\frac{2q_\mu d^\mu}{2dq} - \frac{q_\mu k^\mu}{kq}\right) = 0$$

Similarly for *t*- and *u*-channels:

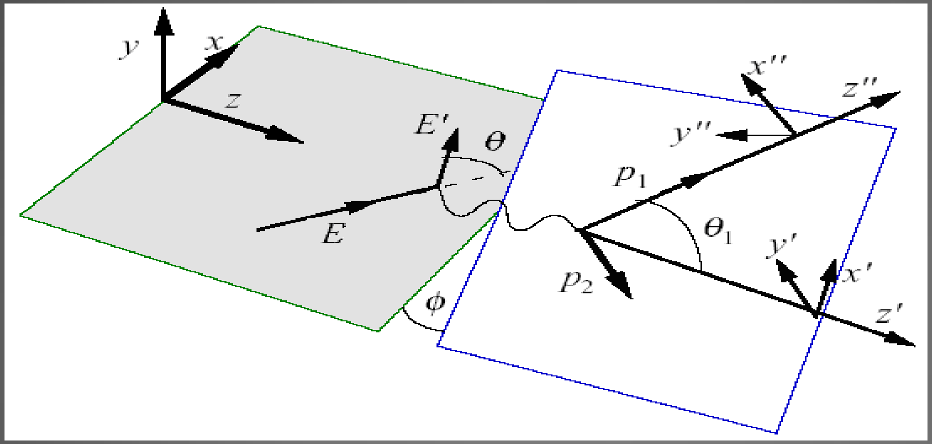
$$\lim_{q^2\to 0} q_\mu (J^\mu_{treg} + J^\mu_{tpol}) = 0;$$

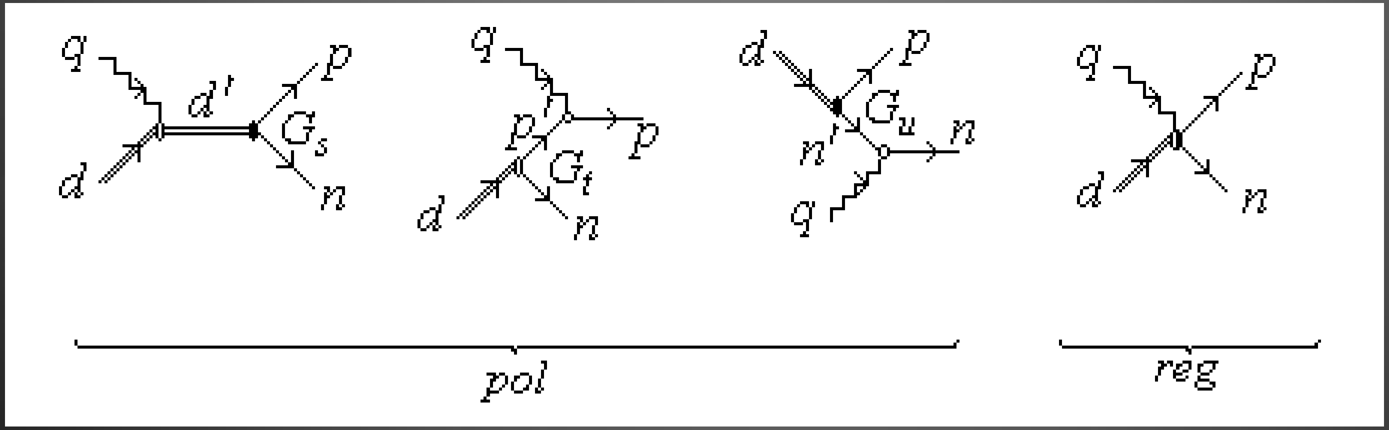
$$\lim_{q^2\to 0} q_\mu (J^\mu_{ureg} + J^\mu_{upol}) = 0;$$

Total current is conserved:

$$\lim_{q^2\to 0} (q_\mu J^\mu_{total}) = 0$$

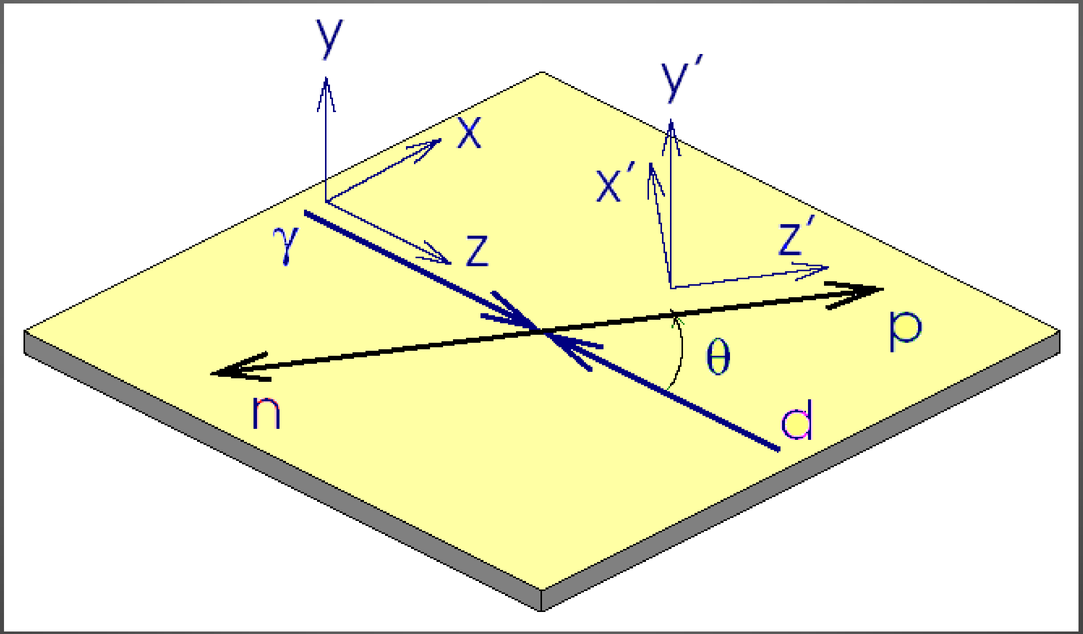
Diagrams of the process with virtual photons ($q^2 \neq 0$):





Therefore, we have the opportunity to investigate simultaneously electro and photodisintegration processes using described approach. But in contradiction to processes with real γ-quantum with $(q^2 = 0)$we deal with virtual γ-quantum with $(q^2 \neq 0)$. Further we are going to introduce results for different reactions with virtual photons.

To carry out further calculations on the basis of matrix element, we determine amplitudes of selected process. To write down the wave functions of initial photon and deuteron and formed nucleons (proton and neutron) we use *center of mass* frame:



$d(\gamma, p)n$:

Following previous results we are able to write down the matrix element:

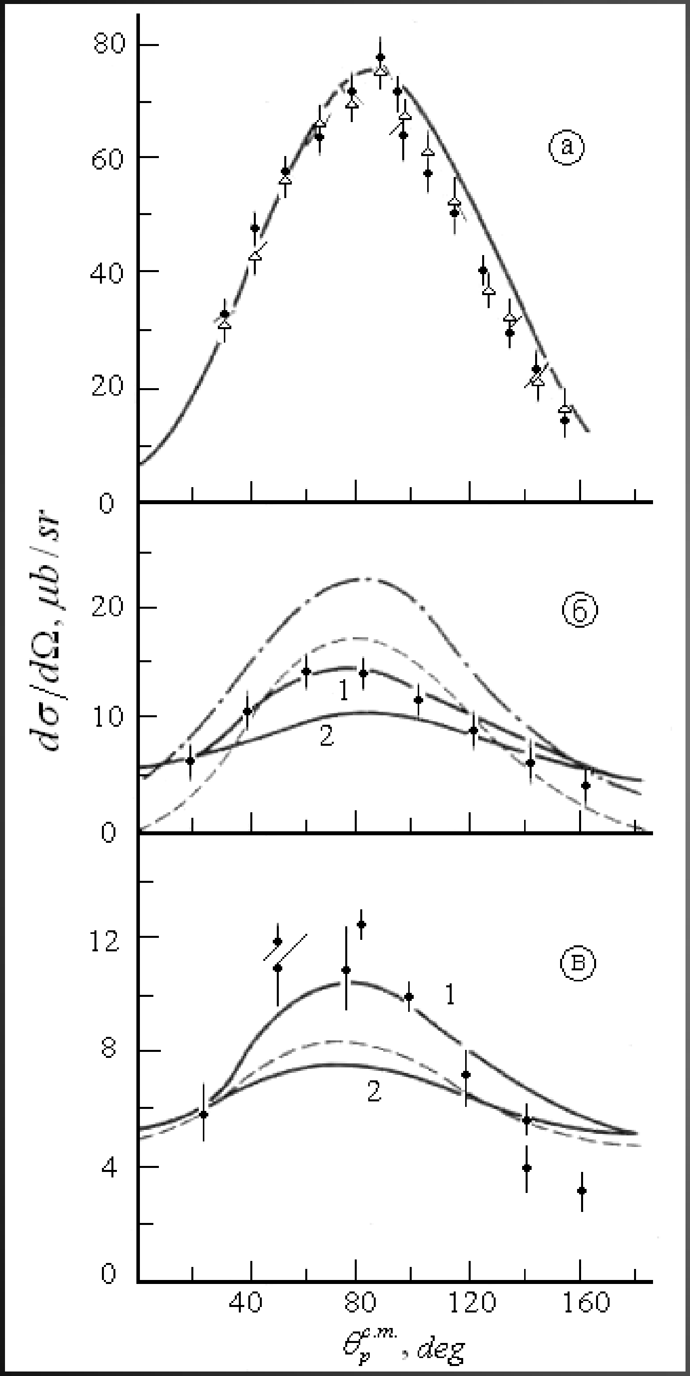
$$\mathcal{M}(\gamma + d \to p + n) = e\varepsilon^{\mu} U^{\nu} \bar{u}(p) T_{\mu\nu} C \bar{u}^{T}(n),$$

where:

$$T_{\mu\nu} = \sum_{i=s,t,u,c} T_{\mu\nu}^{(i)}$$

The following expression for differential cross-section of $d(\gamma, p)n$ was obtained:

$$\frac{d\sigma}{d\Omega}(W,\vartheta) = \frac{\overline{|M|^2}}{(8\pi W)^2} \frac{|\vec{p}|}{q_0} = \frac{e^2}{3(8\pi W)^2} \sum_{\lambda_d, \lambda_p, \lambda_n} \left| T_{\lambda_p, \lambda_n}^{1, \lambda_d} \right|^2$$



Angular distribution of protons at 18 (*a*), 60 (б), 70 (в) MeV respectively. Curves 1, 2 are represent different parameterizations. Dashed and Dashed-Doted curves represent nonrelativistic calculations.

$^4He(\gamma,p)T$, $^4He(\gamma,n)^3He$:

Results for different disintegration processes

The matrix element of these processes corresponding to a set of diagrams:

$$\mathcal{M} = e\varepsilon^{\mu}\bar{u}(p)\sum_{i=s,t,u,c} M_{\mu}^{(i)}\,v(T), \qquad v(t) = C\bar{u}^{T}(T),$$

Pole part:

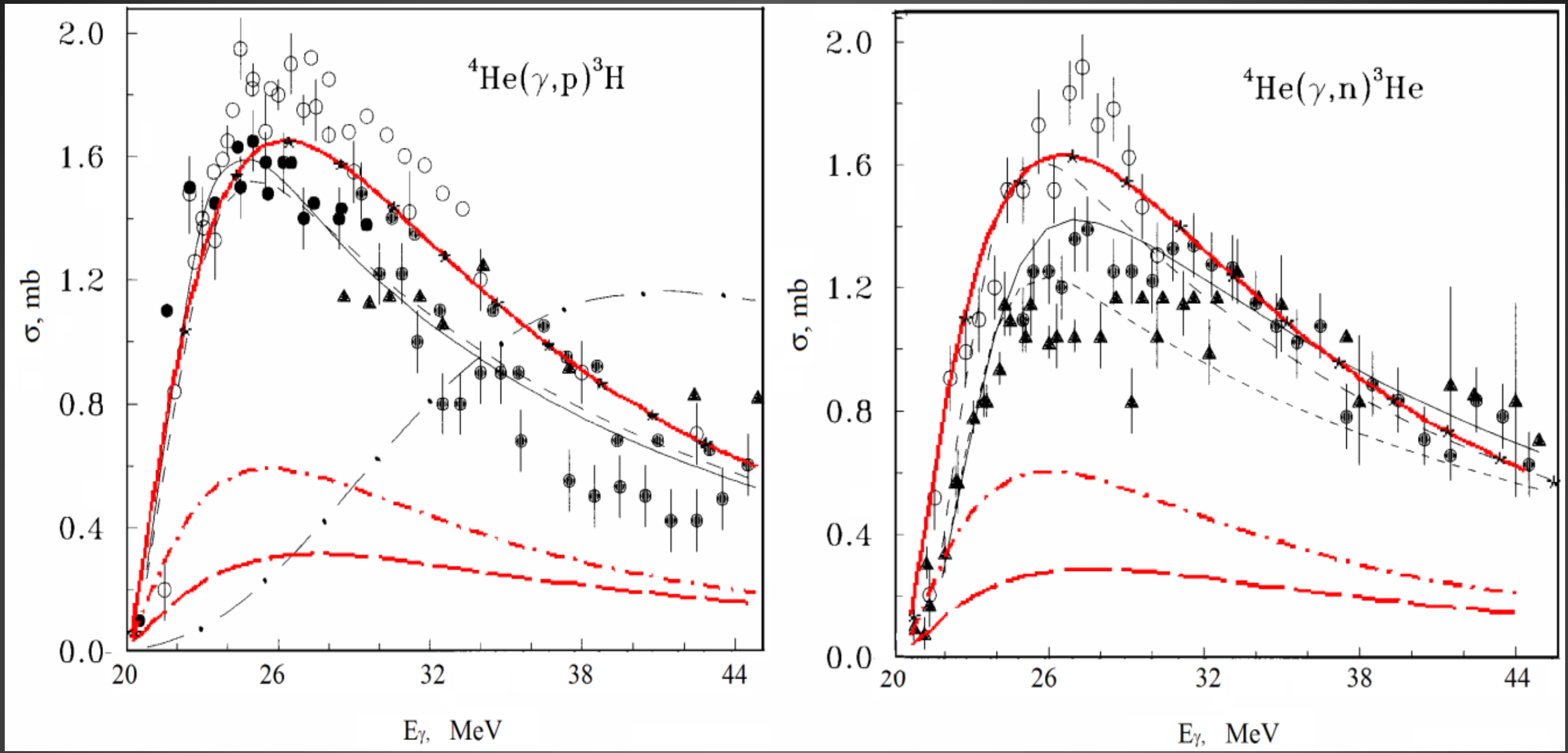
$$M_{\mu}^{(s)} = z_H \frac{\left(H+H^{/}\right)_{\mu}}{s-m_H^2} G^{(s)}\gamma_5,$$

$$M_{\mu}^{(t)} = j_{\mu}^{(t)} \frac{(\hat{p}^{/}+m)}{t-m^2} G^{(t)}\gamma_5,$$

$$M_{\mu}^{(u)} = G^{(t)}\gamma_5 \frac{(\hat{T}^{/}-m_T)}{u-m_T^2} j_{\mu}^{(u)},$$

Regular part:

$$M_{\mu}^{(c)} = \int_0^1 \frac{d\lambda}{\lambda}\frac{\partial}{\partial k_{\mu}}\{z_N G[-k_{st}^2(\lambda)] + z_T G[-k_{su}^2(\lambda)]\}\gamma_5$$



Dependence of total cross sections for reactions $^4He(\gamma, N)T$ from photon energy in range 20÷44 MeV [2]. Dash-dotted and dotted lines describe the accounting of pole diagrams and the regular one, respectively. Experimental data – [1].

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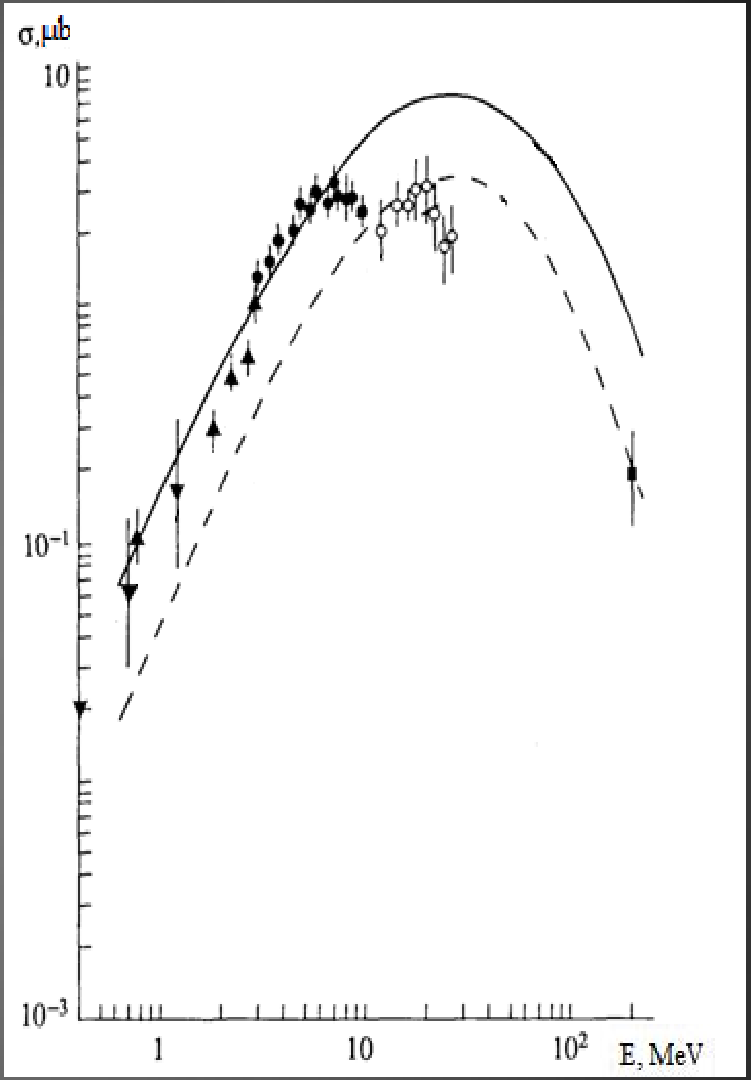
2. Kuznietsov P.E., Koshchii O.E. Ukr. J. Phys. 2014, Vol. 59, N 2, p.193-200.

Dependence of the total cross section for the process $^4He(\gamma,d)d$ from photon energy. Solid line - calculations with the full amplitude of the process, dashed - no contact diagram. Experimental data – [1].



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2. Kuznietsov P.E., Koshchii O.E. Ukr. J. Phys. 2014, Vol. 59, N 2, p.193-200

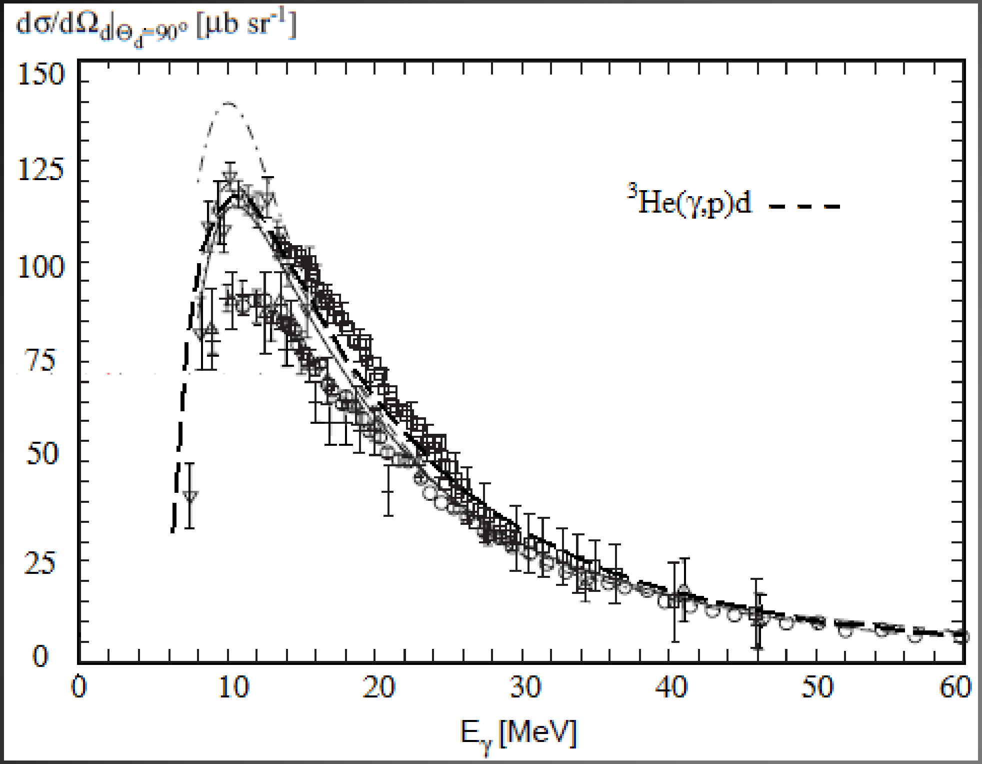
Matrix element of $^{3}He(\gamma,p)d$ and $^{3}H(\gamma,n)d$:

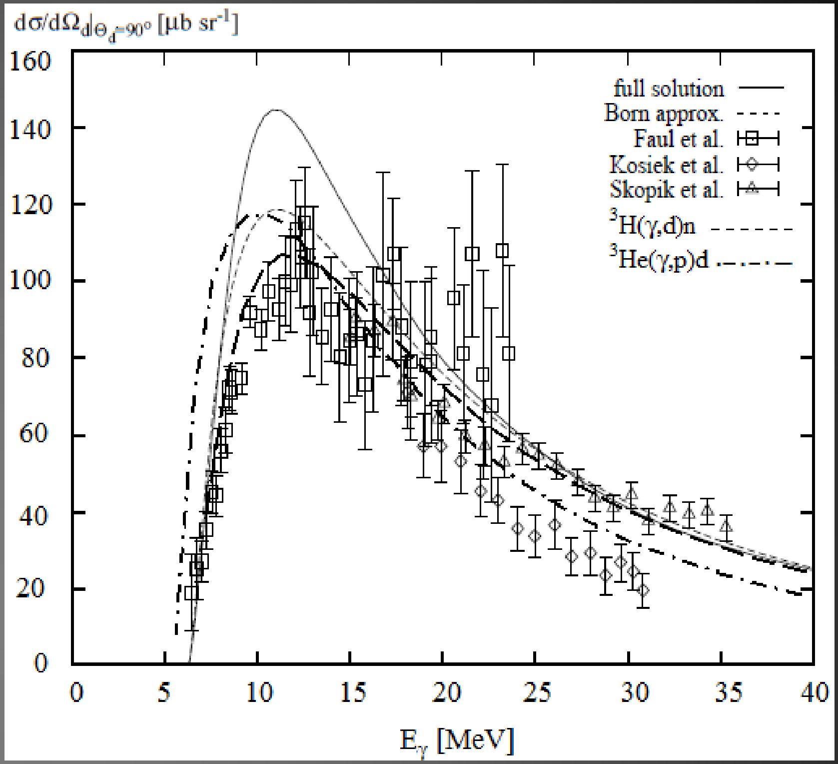
$$\mathfrak{M} = e\varepsilon^{\mu}\overline{u}(p)\Big(\sum_{i\in s,t,u,c} T^{(i)}_{\mu\nu}\Big)u(H)U^{*\nu}(d);$$

$$T^{(s)}_{\mu\nu} = A_{\nu}(-k_s^2)\gamma_5 \frac{\hat{\not{H}}' + m_H}{s - m_H^2} F^{(H)}_{\mu}; \qquad T^{(t)}_{\mu\nu} = F^{(p)}_{\mu} \frac{\hat{\not{p}}' + m_p}{t - m_p^2} A_{\nu}(-k_t^2)\gamma_5;$$

$$T^{(u)}_{\mu\nu} = A_{\alpha}(-k_u^2)\gamma_5 \frac{-g^{\alpha\beta} + \dfrac{d'^{\alpha} d'^{\beta}}{d'^{2}}}{u - m_d^2} F^{(d)}_{\mu\nu\beta};$$

$$T^{(c)}_{\mu\nu} = -\frac{k^{s}_{\mu}}{qk_s}[z_s A_{\nu}(-k_s^2) - z_t A_{\nu}(-k_t^2) - z_u A_{\nu}(-k_u^2)]\gamma_5;$$





Photon energy $(\theta = \pi/2)$ dependence of $^3He(\gamma, p)d$ differential cross-section from threshold up to 60 MeV. Dashed line represents our calculations. Experimental data [1]

Photon energy $(\theta = \pi/2)$ dependence of $^3H(\gamma, n)d$ differential cross-section from threshold up to 40 MeV. Dashed line represents our calculations. Experimental data [2,3]

Horizontal shift due to the difference of tritium and helium-3 binding energies. Vertical shift is due to difference of charges, magnetic moments and masses of particles

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1. Schadow W., Nohadani O., Sandhas W. Photonuclear reactions of three-nucleon systems. Preprint TRI-PP-00-29.
2. Schadow W., Sandhas W. Triton photodisintegration with realistic potentials. arXiv:nucl-th/9712018v1 5 Dec 1997.
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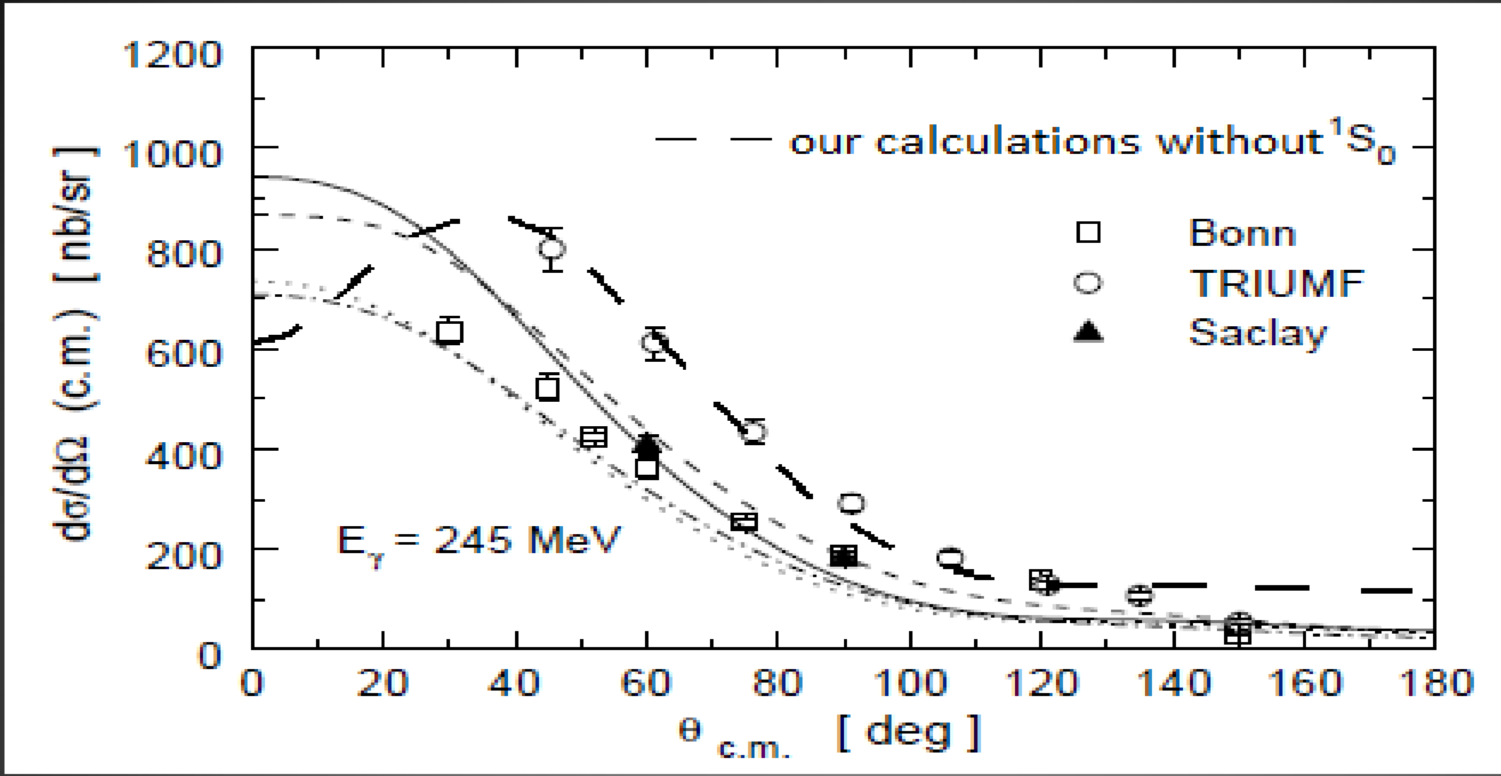

Angular dependence of $^3He(\gamma,p)d$ differential cross-section at photon energy 245 MeV in lab. system. Dashed line represents our calculations. Another calculations from[1]

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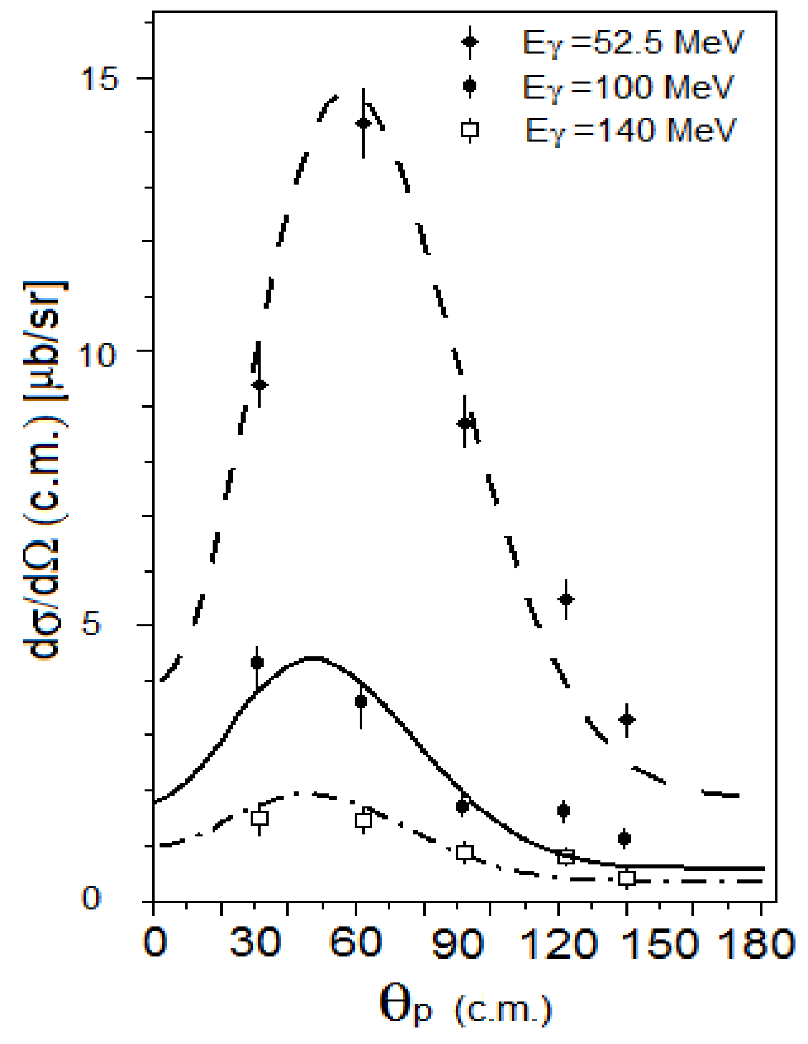
2. Kasatkin Yu.A., Klepikov V.F. Kuznietsov P.E. Письма в журнал «Физика элементарных частиц и атомного ядра»)– 2015. – № 4.



Angular dependence of $^3He(\gamma,p)d$ differential cross-section at fixed photon energies in lab. system. Experimental data[1]

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1. Kolb N. R., Cairns E. B., Hackett E. D. et al. 3He(p)d cross sections with tagged photons below the resonance // Phys. Rev. C. 1994. V. 49, No. 5. P. 2586-2591.
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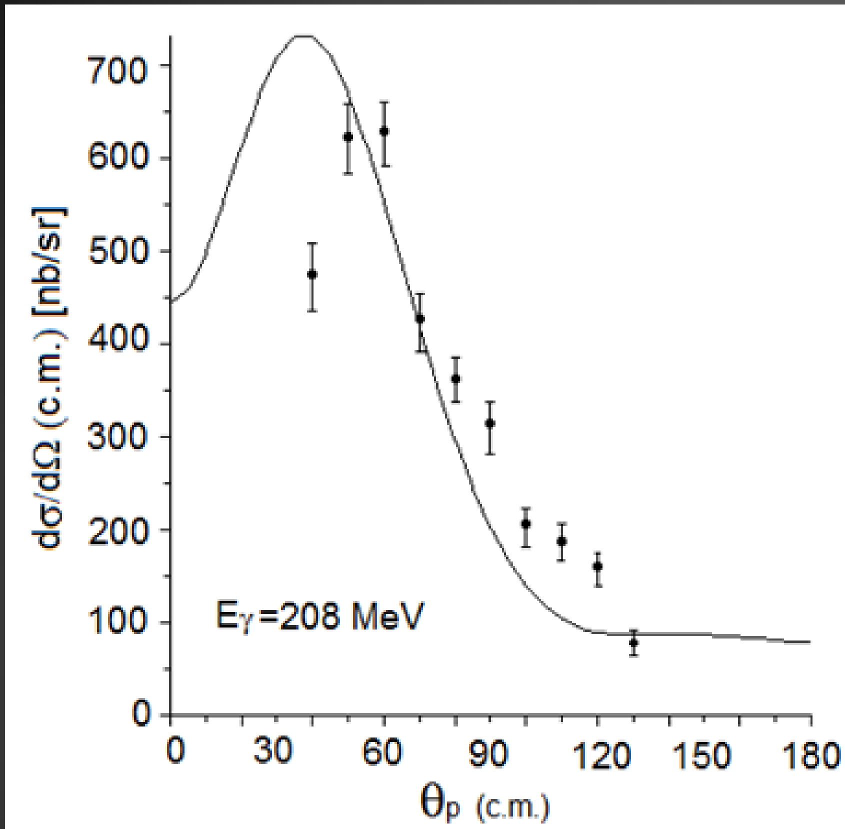

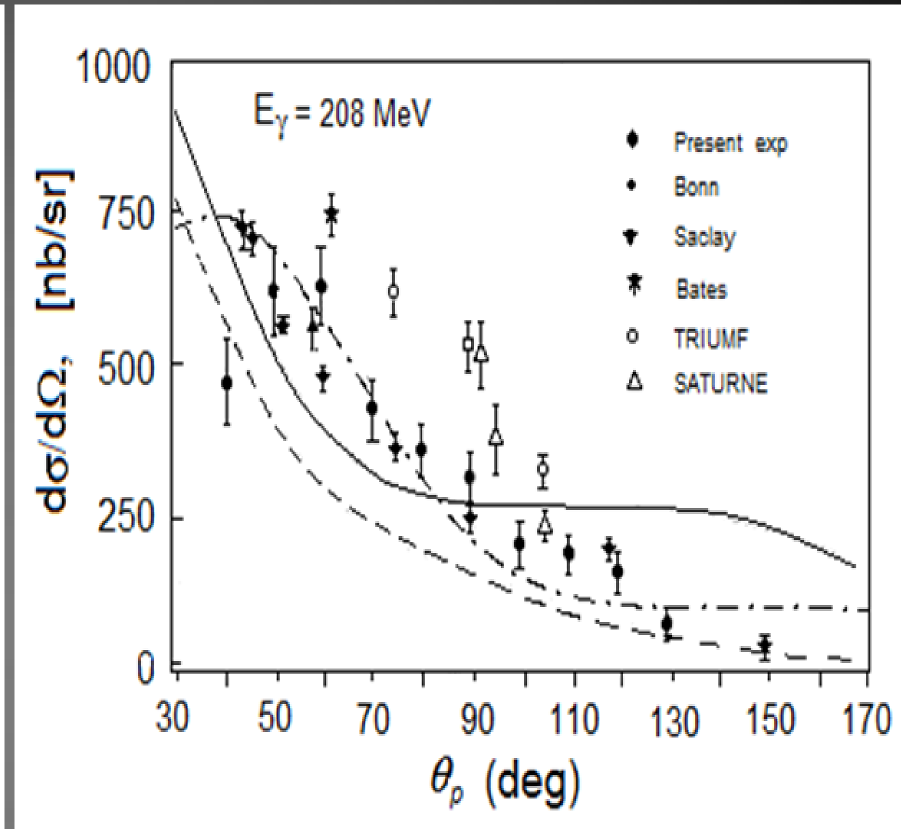

Angular dependence of $^3He(\gamma, p)d$ differential cross-section at photon energy 208 MeV in lab. system. Solid line represents our calculations (Urbana model VII). Experimental data[1]

Angular dependence of $^3He(\gamma, p)d$ differential cross-section at photon energy 208 MeV in lab. system. Dashed and solid lines represent Laget calculations. Dotted-dashed line represents our calculations (Argonne model VII). Experimental data[1]

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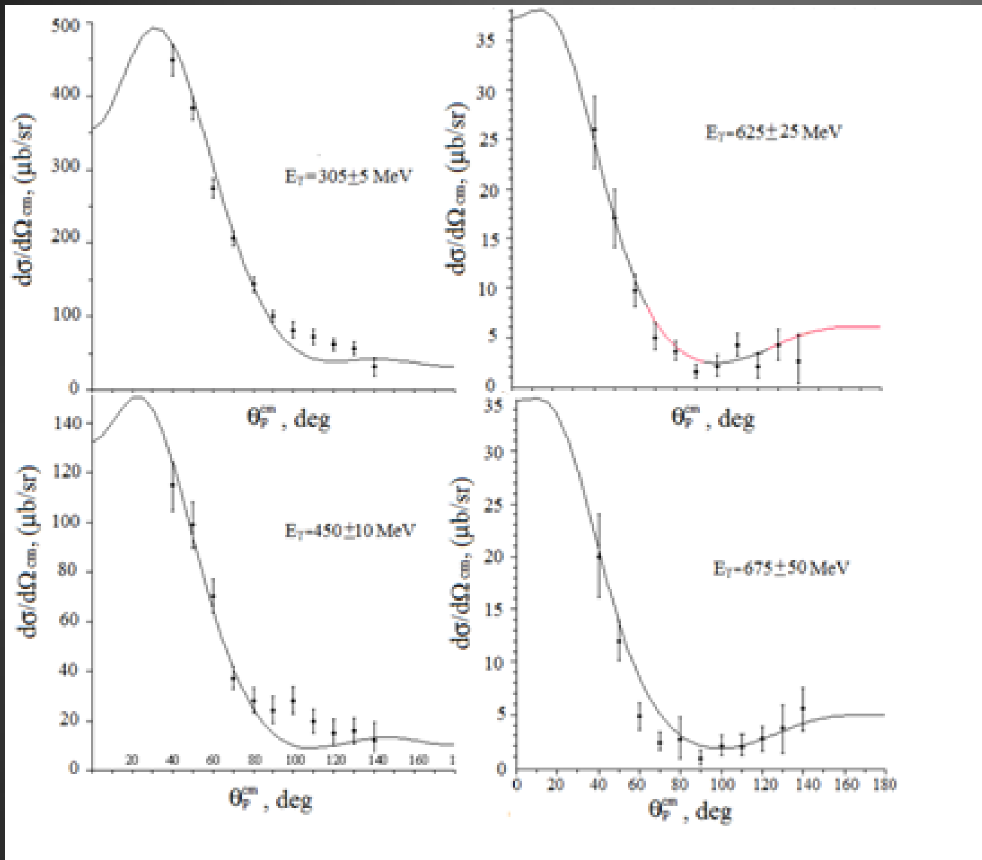
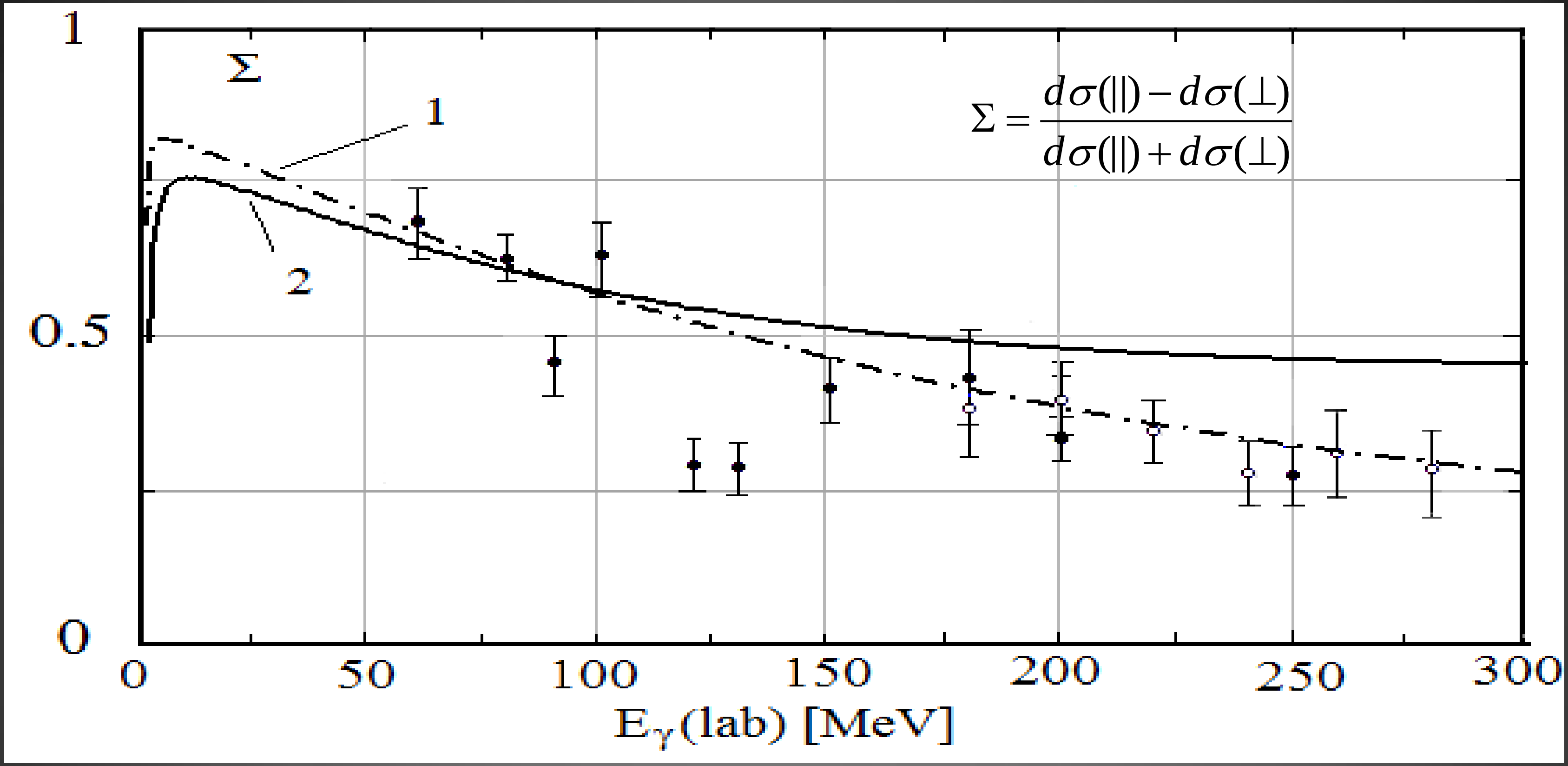
1. Kolb N. R., Cairns E. B., Hackett E. D. et al. 3He(p)d cross sections with tagged photons below the resonance // Phys. Rev. C. 1994. V. 49, No. 5. P. 2586-2591.



Angular dependence of $^3He(\gamma, p)d$ differential cross-section at photon energies from 300 to 675 MeV in lab. system. Experimental data[1]

1. Kolb N. R., Cairns E. B., Hackett E. D. et al. 3He(p)d cross sections with tagged photons below the resonance // Phys. Rev. C. 1994. V. 49, No. 5. P. 2586-2591.



Photon energy $(\theta_p = \pi/2)$ dependence of Σ −assymetry from threshold up to 300 MeV. Solid line represents our calculations for $^3He(\gamma,p)d$. Dashed-dotted line is prediction for $^3H(\gamma,n)d$. Experimental data for $^3He(\gamma,p)d$ [1].

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1. Kotlyar V.V., Belyaev A.A. Calculation of the cross section for the reaction at intermediate photon energies//Problems of atomic science and technology. *Series*: Nucl. Phys. Invest. (37). 2001, No. 1. P. 50-52.
2. Kasatkin Yu.A., Klepikov V.F. Kuznietsov P.E. Письма в журнал «Физика элементарных частиц и атомного ядра»)– 2015. – № 4.

Conclusions and remarks(1):

- The proposed approach eliminates the question about the role of relativistic corrections, and involving to the consideration non nucleon sector and other reaction mechanisms.

- We have created the concept of consideration of the structural particles in the role of elementary one retaining the possibility of applying the Feynman diagram technique.

- We achieved good matching of the theoretical description of reactions with experimental measurements by introducing an additional mechanism - a regular part of the amplitude.

Conclusions and remarks(2):

- We presented the results of covariant investigation of the reaction of the two-particle splitting of Deuteron, ^{3}He, ^{4}He.
- We investigated the role of the contact diagram, and shown that only accounting it provides an adequate agreement with the experimental data.
- We show that only the accounting of the dynamics at the vertex of the strong interaction gives a significant contribution into the reaction cross section
- We have shown an exact conservation of the total nuclear current.
- We have shown that we are able to investigate reactions with virtual photons.
- We plan to carry out the calculations for the reactions with electrons on the basis of the developed approach.

THANKS FOR YOUR ATTENTION!