Эксперимент POLFUSION

коллаборация PolFusion

$$\begin{pmatrix} a_1^f \\ a_2^f \\ a_3^f \\ a_4^f \end{pmatrix} = \begin{pmatrix} A_{11} & A_{12} & A_{13} & A_{14} & A_{15} & A_{16} & A_{17} & A_{18} & A_{19} \\ A_{21} & A_{22} & A_{23} & A_{24} & A_{25} & A_{26} & A_{27} & A_{28} & A_{29} \\ A_{31} & A_{32} & A_{33} & A_{34} & A_{35} & A_{36} & A_{37} & A_{38} & A_{39} \\ A_{41} & A_{42} & A_{43} & A_{44} & A_{45} & A_{46} & A_{47} & A_{48} & A_{49} \end{pmatrix} \begin{pmatrix} a_1^i \\ a_2^i \\ a_3^i \\ a_4^i \\ a_5^i \\ a_6^i \\ a_7^i \\ a_8^i \\ a_9^i \end{pmatrix}$$

$$\begin{pmatrix} \chi_{11} \\ \chi_{10} \\ \chi_{00} \\ \chi_{1-1} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \sqrt{1/2} & \sqrt{1/2} & 0 \\ 0 & \sqrt{1/2} & -\sqrt{1/2} & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} \chi_{\frac{1}{2}g}\chi_{\frac{1}{2}r} \\ \chi_{\frac{1}{2}g}\chi_{-\frac{1}{2}r} \\ \chi_{-\frac{1}{2}g}\chi_{\frac{1}{2}r} \\ \chi_{-\frac{1}{2}g}\chi_{-\frac{1}{2}r} \end{pmatrix}, \qquad (2)$$

$$\begin{pmatrix} \chi_{22} \\ \chi_{21} \\ \chi_{11} \\ \chi_{20} \\ \chi_{10} \\ \chi_{00} \\ \chi_{2-1} \\ \chi_{1-1} \\ \chi_{2-2} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \sqrt{1/2} & 0 & \sqrt{1/2} & 0 & 0 & 0 & 0 & 0 \\ 0 & \sqrt{1/2} & 0 & -\sqrt{1/2} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \sqrt{1/6} & 0 & \sqrt{2/3} & 0 & \sqrt{1/6} & 0 & 0 \\ 0 & 0 & \sqrt{1/2} & 0 & 0 & 0 & -\sqrt{1/2} & 0 & 0 \\ 0 & 0 & \sqrt{1/3} & 0 & -\sqrt{1/3} & 0 & \sqrt{1/3} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \sqrt{1/2} & 0 & \sqrt{1/2} & 0 \\ 0 & 0 & 0 & 0 & 0 & \sqrt{1/2} & 0 & -\sqrt{1/2} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} \chi_{1b}\chi_{1t} \\ \chi_{1b}\chi_{0t} \\ \chi_{1b}\chi_{-1t} \\ \chi_{0b}\chi_{1t} \\ \chi_{0b}\chi_{0t} \\ \chi_{0b}\chi_{-1t} \\ \chi_{-1b}\chi_{1t} \\ \chi_{-1b}\chi_{0t} \\ \chi_{-1b}\chi_{-1t} \end{pmatrix}.$$

Амплитуда реакции будет

$$B = \begin{pmatrix} B^{12}_{12} & B^{12}_{11} & B^{11}_{11} & B^{12}_{10} & B^{11}_{10} & B^{10}_{10} & B^{12}_{1-1} & B^{11}_{1-1} & B^{12}_{1-2} \\ B^{12}_{02} & B^{12}_{01} & B^{11}_{01} & B^{12}_{00} & B^{11}_{00} & B^{10}_{00} & B^{12}_{0-1} & B^{11}_{0-1} & B^{12}_{0-2} \\ B^{02}_{02} & B^{02}_{01} & B^{01}_{01} & B^{02}_{00} & B^{01}_{00} & B^{00}_{00} & B^{02}_{0-1} & B^{01}_{0-1} & B^{02}_{0-2} \\ B^{12}_{-12} & B^{12}_{-11} & B^{11}_{-10} & B^{12}_{-10} & B^{11}_{-10} & B^{10}_{-10} & B^{12}_{-1-1} & B^{11}_{-1-1} & B^{12}_{-1-2} \end{pmatrix}$$

$$B^{10}_{00} = 0\,, \qquad B^{10}_{-10} = B^{10}_{10}\,, \qquad B^{01}_{00} = 0\,, \qquad B^{01}_{0-1} = B^{01}_{01}\,,$$

$$B^{11}_{-1-1} = B^{11}_{11}\,, \quad B^{11}_{0-1} = -B^{11}_{01}\,, \quad B^{11}_{-10} = -B^{11}_{10}\,, \quad B^{11}_{-11} = B^{11}_{1-1}\,,$$

$$B^{02}_{0-1} = -B^{02}_{01}\,, \quad B^{02}_{0-2} = B^{02}_{02}\,, \quad B^{12}_{00} = 0\,,$$

$$B^{12}_{-1-2} = B^{12}_{12}\,, \qquad B^{12}_{-12} = B^{12}_{1-2}\,, \qquad B^{12}_{-1-1} = -B^{12}_{11}\,,$$

$$\frac{d\sigma}{d\Omega} = Spur[\hat{B}.\rho_i.\hat{B}^+]$$

$$\rho = \frac{1}{3}\left[I + \frac{3}{2}(p_x P_x + p_y P_y + p_z P_z) + \frac{2}{3}(p_{xy}P_{xy} + p_{yz}P_{yz} + p_{xz}P_{xz}) + \frac{1}{2}p_{zz}P_{zz} + \frac{1}{6}(p_{xx} - p_{yy})(P_{xx} - P_{yy})\right].$$

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_0}{d\Omega} + \sum_{i=1}^{8} K_i^{(b)} b_i + \sum_{i=1}^{8} K_i^{(t)} t_i + \sum_{i,k=1}^{8} C_{ik}^{(bt)} b_i t_k$$

Наблюдаемые для бинарных реакций частиц со спинами 1+1 → 1/2 + 1/2

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_0}{d\Omega} + \sum_{i=1}^{8} K_i^{(b)} b_i + \sum_{i=1}^{8} K_i^{(t)} t_i + \sum_{i,k=1}^{8} C_{i,k} b_i t_k$$

	x	y	z	xy	xz	yz	zz	xx-yy
	0	K^by	0	0	K^bxz	0	K^bzz	K^bxx-yy
	0	K^ty	0	0	K^txz	0	K^tzz	K^txx-yy
x	Cx,x	0	Cx,z	Cx,xy	0	Cx,yz	0	0
y	0	Cy,y	0	0	Cy,xz	0	Cy,zz	Cy,xx-yy
z	Cz,x	0	Cz,z	Cz,xy	0	Cz,yz	0	0
xy	Cxy,x	0	Cxy,z	Cxy,xy	0	Cxy,yz	0	0
xz	0	Cxz,y	0	0	Cxz,xz	0	Cxz,zz	Cxz,xx-yy
yz	Cyz,x	0	Cyz,z	Cyz,xy	0	Cyz,yz	0	0
zz	0	Czz,y	0	0	Czz,xz	0	Czz,zz	Czz,xx-yy
xx-yy	0	Cxx-yy,y	0	0	Cxx-yy,xz	0	Cxx-yy,zz	Cxx-yy,xx-yy

$$K_y^b = 1/18\sqrt{6} * Im(B_{01}^{01*} B_{00}^{02} + B_{11}^{11*} B_{10}^{12} + B_{1-1}^{11*} B_{10}^{12} + 3(-B_{00}^{02*} B_{01}^{02} - B_{10}^{12*} B_{11}^{12} + B_{10}^{12*} B_{1-1}^{12}))$$
$$+ 3/18\sqrt{2} * Im(-B_{00}^{11*} B_{01}^{11} - B_{10}^{11*} B_{11}^{11} + B_{10}^{11*} B_{1-1}^{11} + B_{00}^{11*} B_{01}^{12} + B_{10}^{11*} B_{11}^{12} + B_{10}^{11*} B_{1-1}^{12})$$
$$+ 4/18\sqrt{3} * Im(+B_{00}^{00*} B_{01}^{01} + B_{10}^{10*} B_{11}^{11} + B_{10}^{10*} B_{1-1}^{11})$$
$$+ 1/3 * Im(+B_{01}^{01*} B_{02}^{02} - B_{01}^{02*} B_{02}^{02} + B_{01}^{11*} B_{02}^{12} - B_{01}^{12*} B_{02}^{12} + B_{11}^{11*} B_{12}^{12} - B_{11}^{12*} B_{12}^{12} + B_{1-1}^{11*} B_{1-2}^{12} + B_{1-1}^{12*} B_{1-2}^{12})$$

$$K_y^t = 1/18\sqrt{6} * Im(-B_{01}^{01*} B_{00}^{02} - B_{11}^{11*} B_{10}^{12} - B_{1-1}^{11*} B_{10}^{12} + 3 * (-B_{00}^{02*} B_{01}^{02} - B_{10}^{12*} B_{11}^{12} + B_{10}^{12*} B_{1-1}^{12}))$$
$$+ 3/18\sqrt{2} * (Im(-B_{00}^{11*} B_{01}^{11} - B_{10}^{11*} B_{11}^{11} + B_{10}^{11*} B_{1-1}^{11} - B_{00}^{11*} B_{01}^{12} - B_{10}^{11*} B_{11}^{12} - B_{10}^{11*} B_{1-1}^{12})$$
$$+ 4/18\sqrt{3} * (Im(-B_{00}^{00*} B_{01}^{01} - B_{10}^{10*} B_{11}^{11} - B_{10}^{10*} B_{1-1}^{11})$$
$$+ 1/3 * Im(-B_{01}^{01*} B_{02}^{02} - B_{01}^{02*} B_{02}^{02} - B_{01}^{11*} B_{02}^{12} - B_{01}^{12*} B_{02}^{12} - B_{11}^{11*} B_{12}^{12} - B_{11}^{12*} B_{12}^{12} - B_{1-1}^{11*} B_{1-2}^{12} + B_{1-1}^{12*} B_{1-2}^{12})$$

$$K_z^b = 0; \qquad K_z^t = 0;$$

$$K_{xy}^b = 0; \qquad K_{xy}^t = 0;$$

$$K_{xz}^b = 1/27\sqrt{6} * Re(B_{00}^{02*} B_{01}^{02} + B_{10}^{12*} B_{11}^{12} - B_{10}^{12*} B_{1-1}^{12} + 3 * (B_{01}^{01*} B_{00}^{02} + B_{11}^{11*} B_{10}^{12} + B_{1-1}^{11*} B_{10}^{12}))$$
$$+ 4/27\sqrt{3} * Re(-B_{00}^{00*} B_{01}^{02} - B_{10}^{10*} B_{11}^{12} + B_{10}^{10*} B_{1-1}^{12})$$
$$+ 3/27\sqrt{2} * Re(-B_{00}^{11*} B_{01}^{11} - B_{10}^{11*} B_{11}^{11} + B_{10}^{11*} B_{1-1}^{11} + B_{00}^{11*} B_{01}^{12} + B_{10}^{11*} B_{11}^{12} + B_{10}^{11*} B_{1-1}^{12})$$
$$+ 2/9 * Re(-B_{01}^{01*} B_{02}^{02} + B_{01}^{02*} B_{02}^{02} - B_{01}^{11*} B_{02}^{12} + B_{01}^{12*} B_{02}^{12} - B_{11}^{11*} B_{12}^{12} + B_{11}^{12*} B_{12}^{12} - B_{1-1}^{11*} B_{1-2}^{12} - B_{1-1}^{12*} B_{1-2}^{12})$$

$$K_{xz}^t = 1/27\sqrt{6} * Re(B_{00}^{02*} B_{01}^{02} + B_{10}^{12*} B_{11}^{12} - B_{10}^{12*} B_{1-1}^{12} - 3 * (B_{01}^{01*} B_{00}^{02} + B_{11}^{11*} B_{10}^{12} + B_{1-1}^{11*} B_{10}^{12}))$$
$$+ 4/27\sqrt{3} * Re(-B_{00}^{00*} B_{01}^{02} - B_{10}^{10*} B_{11}^{12} + B_{10}^{10*} B_{1-1}^{12})$$
$$+ 3/27\sqrt{2} * Re(-B_{00}^{11*} B_{01}^{11} - B_{10}^{11*} B_{11}^{11} + B_{10}^{11*} B_{1-1}^{11} - B_{00}^{11*} B_{01}^{12} - B_{10}^{11*} B_{11}^{12} - B_{10}^{11*} B_{1-1}^{12})$$
$$+ 2/9 * Re(B_{01}^{01*} B_{02}^{02} + B_{01}^{02*} B_{02}^{02} + B_{01}^{11*} B_{02}^{12} + B_{01}^{12*} B_{02}^{12} + B_{11}^{11*} B_{12}^{12} + B_{11}^{12*} B_{12}^{12} + B_{1-1}^{11*} B_{1-2}^{12} - B_{1-1}^{12*} B_{1-2}^{12})$$

$$K_{yz}^b = 0; \qquad K_{yz}^t = 0;$$

$$K_{zz}^b = 1/9\sqrt{2} * Re(B_{00}^{00*} B_{00}^{02} + 2 * B_{10}^{10*} B_{10}^{12})$$
$$+ 1/3 * Re(B_{01}^{01*} B_{01}^{02} + B_{01}^{11*} B_{01}^{12} + B_{11}^{11*} B_{11}^{12} - B_{1-1}^{11*} B_{1-1}^{12})$$
$$+ 1/18 * (-|B_{01}^{01}|^2 - |B_{00}^{02}|^2 - |B_{01}^{02}|^2 + |B_{00}^{11}|^2 - |B_{01}^{11}|^2 - |B_{11}^{11}|^2 - |B_{1-1}^{11}|^2 - |B_{01}^{12}|^2 - |B_{11}^{12}|^2 - |B_{1-1}^{12}|^2$$
$$+ 2 * (|B_{02}^{02}|^2 + |B_{10}^{11}|^2 + |B_{02}^{12}|^2 - |B_{10}^{12}|^2 + |B_{12}^{12}|^2 + |B_{1-2}^{12}|^2))$$

$$K^{t}_{zz} = 1/9\sqrt{2} * Re(B^{00*}_{00}B^{02}_{00} + 2 * B^{10*}_{10}B^{12}_{10})$$
$$+ 1/3 * Re(-B^{01*}_{01}B^{02}_{01} - B^{11*}_{01}B^{12}_{01} - B^{11*}_{11}B^{12}_{11} + B^{11*}_{1-1}B^{12}_{1-1})$$
$$+ 1/18 * (-|B^{01}_{01}|^2 - |B^{02}_{00}|^2 - |B^{02}_{01}|^2 + |B^{11}_{00}|^2 - |B^{11}_{01}|^2 - |B^{11}_{11}|^2 - |B^{11}_{1-1}|^2 - |B^{12}_{01}|^2 - |B^{12}_{11}|^2 - |B^{12}_{1-1}|^2$$
$$+ 2 * (|B^{02}_{02}|^2 + |B^{11}_{10}|^2 + |B^{12}_{02}|^2 - |B^{12}_{10}|^2 + |B^{12}_{12}|^2 + |B^{12}_{1-2}|^2))$$

$$K^{b}_{xx-yy} = 1/27\sqrt{6} * Re(+B^{02*}_{00}B^{02}_{02} + B^{12*}_{10}B^{12}_{12} + B^{12*}_{10}B^{12}_{1-2})$$
$$+ 3/27\sqrt{2} * Re(-B^{11*}_{00}B^{12}_{02} - B^{11*}_{10}B^{12}_{12} + B^{11*}_{10}B^{12}_{1-2})$$
$$+ 2/27\sqrt{3} * Re(+B^{00*}_{00}B^{02}_{02} + B^{10*}_{10}B^{12}_{12} + B^{10*}_{10}B^{12}_{1-2})$$
$$+ 1/9 * Re(-B^{01*}_{01}B^{02}_{01} - B^{11*}_{11}B^{11}_{1-1} + B^{11*}_{01}B^{12}_{01} - B^{11*}_{1-1}B^{12}_{11} + B^{11*}_{11}B^{12}_{1-1} + B^{12*}_{11}B^{12}_{1-1})$$
$$+ 1/18 * (-|B^{01}_{01}|^2 - |B^{02}_{01}|^2 + |B^{11}_{01}|^2 + |B^{12}_{01}|^2)$$

$$K^{t}_{xx-yy} = 1/27\sqrt{6} * Re(B^{02*}_{00}B^{02}_{02} + B^{12*}_{10}B^{12}_{12} + B^{12*}_{10}B^{12}_{1-2})$$
$$+ 3/27\sqrt{2} * Re(B^{11*}_{00}B^{12}_{02} + B^{11*}_{10}B^{12}_{12} - B^{11*}_{10}B^{12}_{1-2})$$
$$+ 2/27\sqrt{3} * Re(B^{00*}_{00}B^{02}_{02} + B^{10*}_{10}B^{12}_{12} + B^{10*}_{10}B^{12}_{1-2}))$$
$$+ 1/9 * Re(B^{01*}_{01}B^{02}_{01} - B^{11*}_{11}B^{11}_{1-1} - B^{11*}_{01}B^{12}_{01} + B^{11*}_{1-1}B^{12}_{11} - B^{11*}_{11}B^{12}_{1-1} + B^{12*}_{11}B^{12}_{1-1})$$
$$+ 1/18 * (-|B^{01}_{01}|^2 - |B^{02}_{01}|^2 + |B^{11}_{01}|^2 + |B^{12}_{01}|^2)$$

$$C_{x,y} = 0; \qquad C_{x,xz} = 0; \qquad C_{x,zz} = 0; \qquad C_{x,xx-yy} = 0;$$

$$C_{x,x} = 1/6\sqrt{6} * Re(B^{02*}_{00}B^{02}_{02} + B^{12*}_{10}B^{12}_{12} + B^{12*}_{10}B^{12}_{1-2})$$
$$+ 1/12\sqrt{2} * Re(B^{00*}_{00}B^{02}_{00} + 2 * B^{10*}_{10}B^{12}_{10})$$
$$+ 2/24\sqrt{3} * (2Re(-B^{00*}_{00}B^{02}_{02} - B^{10*}_{10}B^{12}_{12} - B^{10*}_{10}B^{12}_{1-2}))$$
$$+ 1/2 * Re(B^{11*}_{11}B^{11}_{1-1} + B^{12*}_{11}B^{12}_{1-1})$$
$$+ 1/12 * (4 * (-|B^{10}_{10}|^2 + |B^{12}_{10}|^2) + 2 * (-|B^{00}_{00}|^2 + |B^{02}_{00}|^2) + 6 * (-|B^{11}_{01}|^2 + |B^{12}_{01}|^2)$$
$$+ 3 * (-|B^{11}_{11}|^2 - |B^{11}_{1-1}|^2 + |B^{12}_{11}|^2 + |B^{12}_{1-1}|^2))$$

$$
\begin{aligned}
C_{x,z} &= 1/12\sqrt{6} * Re(-B_{01}^{01*}B_{00}^{02} + B_{00}^{02*}B_{01}^{02} - B_{11}^{11*}B_{10}^{12} - B_{1-1}^{11*}B_{10}^{12} + B_{10}^{12*}B_{11}^{12} - B_{10}^{12*}B_{1-1}^{12}) \\
&+ 3/12\sqrt{2} * Re(B_{00}^{11*}B_{01}^{11} + B_{10}^{11*}B_{11}^{11} - B_{10}^{11*}B_{1-1}^{11} - B_{00}^{11*}B_{01}^{12} - B_{10}^{11*}B_{11}^{12} - B_{10}^{11*}B_{1-1}^{12}) \\
&+ 2/12\sqrt{3} * Re(-B_{00}^{00*}B_{01}^{01} + B_{00}^{00*}B_{01}^{02} - B_{10}^{10*}B_{11}^{11} - B_{10}^{10*}B_{1-1}^{11} + B_{10}^{10*}B_{11}^{12} - B_{10}^{10*}B_{1-1}^{12}) \\
&+ 1/2 * Re(-B_{01}^{01*}B_{02}^{02} + B_{01}^{02*}B_{02}^{02} - B_{01}^{11*}B_{02}^{12} + B_{01}^{12*}B_{02}^{12} - B_{11}^{11*}B_{12}^{12} + B_{11}^{12*}B_{12}^{12} - B_{1-1}^{11*}B_{1-2}^{12} - B_{1-1}^{12*}B_{1-2}^{12})
\end{aligned}
$$

$$
\begin{aligned}
C_{x,xy} &= 1/18\sqrt{6} * Im(-B_{01}^{01*}B_{00}^{02} - B_{00}^{02*}B_{01}^{02} - B_{11}^{11*}B_{10}^{12} - B_{1-1}^{11*}B_{10}^{12} - B_{10}^{12*}B_{11}^{12} + B_{10}^{12*}B_{1-1}^{12}) \\
&+ 3/18\sqrt{2} * Im(B_{00}^{11*}B_{01}^{11} + B_{10}^{11*}B_{11}^{11} - B_{10}^{11*}B_{1-1}^{11} - B_{00}^{11*}B_{01}^{12} - B_{10}^{11*}B_{11}^{12} - B_{10}^{11*}B_{1-1}^{12}) \\
&+ 2/18\sqrt{3} * Im(B_{00}^{00*}B_{01}^{01} - B_{00}^{00*}B_{01}^{02} + B_{10}^{10*}B_{11}^{11} + B_{10}^{10*}B_{1-1}^{11} - B_{10}^{10*}B_{11}^{12} + B_{10}^{10*}B_{1-1}^{12}) \\
&+ 1/3 * Im(-B_{01}^{01*}B_{02}^{02} + B_{01}^{02*}B_{02}^{02} + B_{01}^{11*}B_{02}^{12} - B_{01}^{12*}B_{02}^{12} - B_{1-1}^{11*}B_{12}^{12} + B_{12}^{12*}B_{1-1}^{12} - B_{11}^{11*}B_{1-2}^{12} + B_{11}^{12*}B_{1-2}^{12})
\end{aligned}
$$

$$
\begin{aligned}
C_{x,yz} &= 2/18\sqrt{6} * Im(-B_{00}^{02*}B_{02}^{02} - B_{10}^{12*}B_{12}^{12} - B_{10}^{12*}B_{1-2}^{12}) \\
&+ 2/18\sqrt{3} * Im(B_{00}^{00*}B_{02}^{02} + B_{10}^{10*}B_{12}^{12} + B_{10}^{10*}B_{1-2}^{12}) \\
&+ 3/18\sqrt{2} * Im(B_{00}^{00*}B_{00}^{02}) + 2 * B_{10}^{10*}B_{10}^{12}) \\
&+ 1/3 * Im(-B_{11}^{11*}B_{11}^{12} + B_{1-1}^{11*}B_{11}^{12} - B_{11}^{11*}B_{1-1}^{12} + B_{1-1}^{11*}B_{1-1}^{12} - 2 * B_{01}^{11*}B_{01}^{12})
\end{aligned}
$$

$$
C_{y,x} = 0; \qquad C_{y,z} = 0; \qquad C_{y,xy} = 0; \qquad C_{y,yz} = 0;
$$

$$
\begin{aligned}
C_{y,y} &= +1/6\sqrt{6} * Re(-B_{00}^{02*}B_{02}^{02} - B_{10}^{12*}B_{12}^{12} - B_{10}^{12*}B_{1-2}^{12}) \\
&+ 1/12\sqrt{2} * Re(B_{00}^{00*}B_{00}^{02} + 2 * B_{10}^{10*}B_{10}^{12}) \\
&+ 1/6\sqrt{3} * Re(B_{00}^{00*}B_{02}^{02} + B_{10}^{10*}B_{12}^{12} + B_{10}^{10*}B_{1-2}^{12}) \\
&- 1/2 * Re(B_{11}^{11*}B_{1-1}^{11} + B_{11}^{12*}B_{1-1}^{12}) \\
&+ 1/12 * (6 * (-|B_{01}^{01}|^2 + |B_{01}^{02}|^2) + 4 * (-|B_{10}^{10}|^2 + |B_{10}^{12}|^2) \\
&\qquad + 3 * (-|B_{11}^{11}|^2 - |B_{1-1}^{11}|^2 + |B_{11}^{12}|^2 + |B_{1-1}^{12}|^2) + 2 * (-|B_{00}^{00}|^2 + |B_{00}^{02}|^2))
\end{aligned}
$$

$$
\begin{aligned}
C_{y,xz} &= 1/9\sqrt{6} * Im(-B_{00}^{02*}B_{02}^{02} - B_{10}^{12*}B_{12}^{12} - B_{10}^{12*}B_{1-2}^{12}) \\
&+ 1/9\sqrt{3} * Im(B_{00}^{00*}B_{02}^{02} + B_{10}^{10*}B_{12}^{12} + B_{10}^{10*}B_{1-2}^{12})) \\
&- 3/18\sqrt{2} * Im(B_{00}^{00*}B_{00}^{02} + 2 * (B_{10}^{10*}B_{10}^{12})) \\
&+ 1/3 * Im(B_{11}^{11*}B_{11}^{12} + B_{1-1}^{11*}B_{11}^{12} - B_{11}^{11*}B_{1-1}^{12} - B_{1-1}^{11*}B_{1-1}^{12} + 2 * B_{01}^{01*}B_{01}^{02})
\end{aligned}
$$

$$
\begin{aligned}
C_{y,zz} &= 1/36\sqrt{6} * Im(3 * (B_{00}^{02*}B_{01}^{02} + B_{10}^{12*}B_{11}^{12} - B_{10}^{12*}B_{1-1}^{12}) - 5 * (B_{01}^{01*}B_{00}^{02} + B_{11}^{11*}B_{10}^{12} + B_{1-1}^{11*}B_{10}^{12})) \\
&+ 1/18\sqrt{3} * Im(-B_{00}^{00*}B_{01}^{01} - B_{10}^{10*}B_{11}^{11} - B_{10}^{10*}B_{1-1}^{11} + 3 * (-B_{00}^{00*}B_{01}^{02} - B_{10}^{10*}B_{11}^{12} + B_{10}^{10*}B_{1-1}^{12})) \\
&+ 1/12\sqrt{2} * Im(-B_{00}^{11*}B_{01}^{11} - B_{10}^{11*}B_{11}^{11} + B_{10}^{11*}B_{1-1}^{11} + B_{00}^{11*}B_{01}^{12} + B_{10}^{11*}B_{11}^{12} + B_{10}^{11*}B_{1-1}^{12}) \\
&+ 1/6 * Im(B_{01}^{01*}B_{02}^{02} - B_{01}^{02*}B_{02}^{02} + B_{01}^{11*}B_{02}^{12} - B_{01}^{12*}B_{02}^{12} + B_{11}^{11*}B_{12}^{12} - B_{11}^{12*}B_{12}^{12} + B_{1-1}^{11*}B_{1-2}^{12} + B_{1-1}^{12*}B_{1-2}^{12})
\end{aligned}
$$

$$C_{y,xx-yy} = 1/36\sqrt{6} * Im(B_{01}^{01*}B_{00}^{02} + B_{00}^{02*}B_{01}^{02} + B_{11}^{11*}B_{10}^{12} + B_{1-1}^{11*}B_{10}^{12} + B_{10}^{12*}B_{11}^{12} - B_{10}^{12*}B_{1-1}^{12})$$
$$+ 3/36\sqrt{2} * Im(-B_{00}^{11*}B_{01}^{11} - B_{10}^{11*}B_{11}^{11} + B_{10}^{11*}B_{1-1}^{11} + B_{00}^{11*}B_{01}^{12} + B_{10}^{11*}B_{11}^{12} + B_{10}^{11*}B_{1-1}^{12})$$
$$+ 2/36\sqrt{3} * Im(-B_{00}^{00*}B_{01}^{01} + B_{00}^{00*}B_{01}^{02} - B_{10}^{10*}B_{11}^{11} - B_{10}^{10*}B_{1-1}^{11} + B_{10}^{10*}B_{11}^{12} - B_{10}^{10*}B_{1-1}^{12})$$
$$+ 1/6 * Im(-B_{01}^{01*}B_{02}^{02} + B_{01}^{02*}B_{02}^{02} + B_{01}^{11*}B_{02}^{12} - B_{01}^{12*}B_{02}^{12} - B_{1-1}^{11*}B_{12}^{12} + B_{12}^{12*}B_{1-1}^{12} - B_{11}^{11*}B_{1-2}^{12} + B_{11}^{12*}B_{1-2}^{12})$$

$$C_{z,y} = 0; \qquad C_{z,xz} = 0; \qquad C_{z,zz} = 0; \qquad C_{z,xx-yy} = 0;$$

$$C_{z,x} = 1/12\sqrt{6} * Re(+B_{01}^{01*}B_{00}^{02} + B_{00}^{02*}B_{01}^{02} + B_{11}^{11*}B_{10}^{12} + B_{1-1}^{11*}B_{10}^{12} + B_{10}^{12*}B_{11}^{12} - B_{10}^{12*}B_{1-1}^{12})$$
$$+ 1/6\sqrt{3} * Re(B_{00}^{00*}B_{01}^{01} + B_{00}^{00*}B_{01}^{02} + B_{10}^{10*}B_{11}^{11} + B_{10}^{10*}B_{1-1}^{11} + B_{10}^{10*}B_{11}^{12} - B_{10}^{10*}B_{1-1}^{12})$$
$$+ 1/4\sqrt{2} * Re(B_{00}^{11*}B_{01}^{11} + B_{10}^{11*}B_{11}^{11} - B_{10}^{11*}B_{1-1}^{11} + B_{00}^{11*}B_{01}^{12} + B_{10}^{11*}B_{11}^{12} + B_{10}^{11*}B_{1-1}^{12})$$
$$+ 1/2 * Re(B_{01}^{01*}B_{02}^{02} + B_{01}^{02*}B_{02}^{02} + B_{01}^{11*}B_{02}^{12} + B_{01}^{12*}B_{02}^{12} + B_{11}^{11*}B_{12}^{12} + B_{11}^{12*}B_{12}^{12} + B_{1-1}^{11*}B_{1-2}^{12} - B_{1-1}^{12*}B_{1-2}^{12})$$

$$C_{z,z} = +1/6\sqrt{2} * Re(-B_{00}^{00*}B_{00}^{02} - 2 * B_{10}^{10*}B_{10}^{12})$$
$$+ 1/12 * (-|B_{00}^{02}|^2 - 4 * |B_{10}^{10}|^2 - 3 * |B_{00}^{11}|^2 - 2 * (|B_{00}^{00}|^2 + |B_{10}^{12}|^2)$$
$$+ 6 * (|B_{02}^{02}|^2 - |B_{10}^{11}|^2 + |B_{02}^{12}|^2 + |B_{12}^{12}|^2 + |B_{1-2}^{12}|^2))$$

$$C_{z,xy} = 1/9\sqrt{6} * Im(-B_{00}^{02*}B_{02}^{02} - B_{10}^{12*}B_{12}^{12} - B_{10}^{12*}B_{1-2}^{12})$$
$$+ 2/9\sqrt{3} * Im(-B_{00}^{00*}B_{02}^{02} - B_{10}^{10*}B_{12}^{12} - B_{10}^{10*}B_{1-2}^{12})$$
$$+ 1/3\sqrt{2} * Im(-B_{00}^{11*}B_{02}^{12} - B_{10}^{11*}B_{12}^{12} + B_{10}^{11*}B_{1-2}^{12})$$

$$C_{z,yz} = +1/18\sqrt{6} * Im(-B_{01}^{01*}B_{00}^{02} + B_{00}^{02*}B_{01}^{02} - B_{11}^{11*}B_{10}^{12} - B_{1-1}^{11*}B_{10}^{12} + B_{10}^{12*}B_{11}^{12} - B_{10}^{12*}B_{1-1}^{12})$$
$$+ 1/9\sqrt{3} * Im(B_{00}^{00*}B_{01}^{01} + B_{00}^{00*}B_{01}^{02} + B_{10}^{10*}B_{11}^{11} + B_{10}^{10*}B_{1-1}^{11} + B_{10}^{10*}B_{11}^{12} - B_{10}^{10*}B_{1-1}^{12})$$
$$+ 1/6\sqrt{2} * Im(B_{00}^{11*}B_{01}^{11} + B_{10}^{11*}B_{11}^{11} - B_{10}^{11*}B_{1-1}^{11} + B_{00}^{11*}B_{01}^{12} + B_{10}^{11*}B_{11}^{12} + B_{10}^{11*}B_{1-1}^{12})$$
$$+ 1/3 * Im(-B_{01}^{01*}B_{02}^{02} - B_{01}^{02*}B_{02}^{02} - B_{01}^{11*}B_{02}^{12} - B_{01}^{12*}B_{02}^{12} - B_{11}^{11*}B_{12}^{12} - B_{11}^{12*}B_{12}^{12} - B_{1-1}^{11*}B_{1-2}^{12} + B_{1-1}^{12*}B_{1-2}^{12})$$

$$C_{xy,y} = 0; \qquad C_{xy,xz} = 0; \qquad C_{xy,zz} = 0; \qquad C_{xy,xx-yy} = 0;$$

$$C_{xy,x} = 1/18\sqrt{6} * Im(+B_{01}^{01*}B_{00}^{02} - B_{00}^{02*}B_{01}^{02} + B_{11}^{11*}B_{10}^{12} + B_{1-1}^{11*}B_{10}^{12} - B_{10}^{12*}B_{11}^{12} + B_{10}^{12*}B_{1-1}^{12})$$
$$+ 3/18\sqrt{2} * Im(+B_{00}^{11*}B_{01}^{11} + B_{10}^{11*}B_{11}^{11} - B_{10}^{11*}B_{1-1}^{11} + B_{00}^{11*}B_{01}^{12} + B_{10}^{11*}B_{11}^{12} + B_{10}^{11*}B_{1-1}^{12})$$
$$+ 2/18\sqrt{3} * Im(-B_{00}^{00*}B_{01}^{01} - B_{00}^{00*}B_{01}^{02} - B_{10}^{10*}B_{11}^{11} - B_{10}^{10*}B_{1-1}^{11} - B_{10}^{10*}B_{11}^{12} + B_{10}^{10*}B_{1-1}^{12})$$
$$+ 1/3 * Im(+B_{01}^{01*}B_{02}^{02} + B_{01}^{02*}B_{02}^{02} - B_{01}^{11*}B_{02}^{12} - B_{01}^{12*}B_{02}^{12} + B_{1-1}^{11*}B_{12}^{12} + B_{12}^{12*}B_{1-1}^{12} + B_{11}^{11*}B_{1-2}^{12} + B_{11}^{12*}B_{1-2}^{12})$$

$$C_{xy,z} = 1/9\sqrt{6} * Im(-B_{00}^{02*}B_{02}^{02} - B_{10}^{12*}B_{12}^{12} - B_{10}^{12*}B_{1-2}^{12})$$
$$+ 3/9\sqrt{2} * Im(+B_{00}^{11*}B_{02}^{12} + B_{10}^{11*}B_{12}^{12} - B_{10}^{11*}B_{1-2}^{12})$$
$$+ 2/9\sqrt{3} * Im(-B_{00}^{00*}B_{02}^{02} - B_{10}^{10*}B_{12}^{12} - B_{10}^{10*}B_{1-2}^{12})$$

$$C_{xz,x} = 0; \qquad C_{xz,z} = 0; \qquad C_{xz,xy} = 0; C_{xz,yz} = 0;$$

$$\begin{aligned}
C_{xz,y} &= 1/9\sqrt{6} * Im(-B_{00}^{02*}B_{02}^{02} - B_{10}^{12*}B_{12}^{12} - B_{10}^{12*}B_{1-2}^{12}) \\
&+ 1/9\sqrt{3} * Im(B_{00}^{00*}B_{02}^{02} + B_{10}^{10*}B_{12}^{12} + B_{10}^{10*}B_{1-2}^{12}) \\
&- 1/6\sqrt{2} * Im(B_{00}^{00*}B_{00}^{02} + 2 * B_{10}^{10*}B_{10}^{12}) \\
&+ 1/3 * Im(-B_{11}^{11*}B_{11}^{12} - B_{1-1}^{11*}B_{11}^{12} + B_{11}^{11*}B_{1-1}^{12} + B_{1-1}^{11*}B_{1-1}^{12} - 2 * B_{01}^{01*}B_{01}^{02})
\end{aligned}$$

$$\begin{aligned}
C_{xz,xz} &= +2/27\sqrt{6} * Re(+B_{00}^{02*}B_{02}^{02} + B_{10}^{12*}B_{12}^{12} + B_{10}^{12*}B_{1-2}^{12}) \\
&+ 2/27\sqrt{3} * Re(-B_{00}^{00*}B_{02}^{02} - B_{10}^{10*}B_{12}^{12} - B_{10}^{10*}B_{1-2}^{12}) \\
&+ 1/27\sqrt{2} * Re(-B_{00}^{00*}B_{00}^{02} - 2 * B_{10}^{10*}B_{10}^{12})) \\
&- 2/9 * Re(B_{11}^{11*}B_{1-1}^{11} + B_{11}^{12*}B_{1-1}^{12}) \\
&+ 1/27 * (6 * (-|B_{01}^{01}|^2 + |B_{01}^{02}|^2) - 3 * (|B_{11}^{11}|^2 + |B_{1-1}^{11}|^2 - |B_{11}^{12}|^2 - |B_{1-1}^{12}|^2) \\
&\quad + 4 * (|B_{10}^{10}|^2 - |B_{10}^{12}|^2) + 2 * (|B_{00}^{00}|^2 - |B_{00}^{02}|^2))
\end{aligned}$$

$$\begin{aligned}
C_{xz,zz} &= +1/54\sqrt{6} * Re(3 * (-B_{01}^{01*}B_{00}^{02} - B_{11}^{11*}B_{10}^{12} - B_{1-1}^{11*}B_{10}^{12}) + 5 * (-B_{00}^{02*}B_{01}^{02} - B_{10}^{12*}B_{11}^{12} + B_{10}^{12*}B_{1-1}^{12})) \\
&+ 1/27\sqrt{3} * Re(B_{00}^{00*}B_{01}^{02} + B_{10}^{10*}B_{11}^{12} - B_{10}^{10*}B_{1-1}^{12} + 3 * (B_{00}^{00*}B_{01}^{01} + B_{10}^{10*}B_{11}^{11} + B_{10}^{10*}B_{1-1}^{11})) \\
&+ 3/54\sqrt{2} * Re(-B_{00}^{11*}B_{01}^{11} - B_{10}^{11*}B_{11}^{11} + B_{10}^{11*}B_{1-1}^{11} + B_{00}^{11*}B_{01}^{12} + B_{10}^{11*}B_{11}^{12} + B_{10}^{11*}B_{1-1}^{12}) \\
&+ 1/9 * Re(-B_{01}^{01*}B_{02}^{02} + B_{01}^{02*}B_{02}^{02} - B_{01}^{11*}B_{02}^{12} + B_{01}^{12*}B_{02}^{12} - B_{11}^{11*}B_{12}^{12} + B_{11}^{12*}B_{12}^{12} - B_{1-1}^{11*}B_{1-2}^{12} - B_{1-1}^{12*}B_{1-2}^{12})
\end{aligned}$$

$$\begin{aligned}
C_{xz,xx-yy} &= 1/54\sqrt{6} * Re(-B_{01}^{01*}B_{00}^{02} + B_{00}^{02*}B_{01}^{02} - B_{11}^{11*}B_{10}^{12} - B_{1-1}^{11*}B_{10}^{12} + B_{10}^{12*}B_{11}^{12} - B_{10}^{12*}B_{1-1}^{12}) \\
&+ 3/54\sqrt{2} * Re(-B_{00}^{11*}B_{01}^{11} - B_{10}^{11*}B_{11}^{11} + B_{10}^{11*}B_{1-1}^{11} + B_{00}^{11*}B_{01}^{12} + B_{10}^{11*}B_{11}^{12} + B_{10}^{11*}B_{1-1}^{12}) \\
&+ 2/54\sqrt{3} * Re(-B_{00}^{00*}B_{01}^{01} + B_{00}^{00*}B_{01}^{02} - B_{10}^{10*}B_{11}^{11} - B_{10}^{10*}B_{1-1}^{11} + B_{10}^{10*}B_{11}^{12} - B_{10}^{10*}B_{1-1}^{12}) \\
&+ 1/9 * Re(+B_{01}^{01*}B_{02}^{02} - B_{01}^{02*}B_{02}^{02} - B_{01}^{11*}B_{02}^{12} + B_{01}^{12*}B_{02}^{12} + B_{1-1}^{11*}B_{12}^{12} + B_{12}^{12*}B_{1-1}^{12} + B_{11}^{11*}B_{1-2}^{12} - B_{11}^{12*}B_{1-2}^{12})
\end{aligned}$$

$$C_{yz,y} = 0; \qquad C_{yz,xz} = 0; \qquad C_{yz,zz} = 0; \qquad C_{yz,xx-yy} = 0;$$

$$\begin{aligned}
C_{yz,x} &= 1/9\sqrt{6} * Im(-B_{00}^{02*}B_{02}^{02} - B_{10}^{12*}B_{12}^{12} - B_{10}^{12*}B_{1-2}^{12}) \\
&+ 1/9\sqrt{3} * Im(B_{00}^{00*}B_{02}^{02} + B_{10}^{10*}B_{12}^{12} + B_{10}^{10*}B_{1-2}^{12}) \\
&+ 1/6\sqrt{2} * Im(B_{00}^{00*}B_{00}^{02} + 2 * B_{10}^{10*}B_{10}^{12}) \\
&+ 1/3 * Im(B_{11}^{11*}B_{11}^{12} - B_{1-1}^{11*}B_{11}^{12} + B_{11}^{11*}B_{1-1}^{12} - B_{1-1}^{11*}B_{1-1}^{12} + 2 * B_{01}^{11*}B_{01}^{12})
\end{aligned}$$

$$\begin{aligned}
C_{yz,z} &= 1/18\sqrt{6} * Im(B_{01}^{01*}B_{00}^{02} + B_{00}^{02*}B_{01}^{02} + B_{11}^{11*}B_{10}^{12} + B_{1-1}^{11*}B_{10}^{12} + B_{10}^{12*}B_{11}^{12} - B_{10}^{12*}B_{1-1}^{12}) \\
&+ 1/9\sqrt{3} * Im(-B_{00}^{00*}B_{01}^{01} + B_{00}^{00*}B_{01}^{02} - B_{10}^{10*}B_{11}^{11} - B_{10}^{10*}B_{1-1}^{11} + B_{10}^{10*}B_{11}^{12} - B_{10}^{10*}B_{1-1}^{12}) \\
&+ 1/6\sqrt{2} * Im(B_{00}^{11*}B_{01}^{11} + B_{10}^{11*}B_{11}^{11} - B_{10}^{11*}B_{1-1}^{11} - B_{00}^{11*}B_{01}^{12} - B_{10}^{11*}B_{11}^{12} - B_{10}^{11*}B_{1-1}^{12}) \\
&+ 2/6 * Im(B_{01}^{01*}B_{02}^{02} - B_{01}^{02*}B_{02}^{02} + B_{01}^{11*}B_{02}^{12} - B_{01}^{12*}B_{02}^{12} + B_{11}^{11*}B_{12}^{12} - B_{11}^{12*}B_{12}^{12} + B_{1-1}^{11*}B_{1-2}^{12} + B_{1-1}^{12*}B_{1-2}^{12})
\end{aligned}$$

$$C_{yz,xy} = 1/27\sqrt{6} * Re(-B_{01}^{01*}B_{00}^{02} + B_{00}^{02*}B_{01}^{02} - B_{11}^{11*}B_{10}^{12} - B_{1-1}^{11*}B_{10}^{12} + B_{10}^{12*}B_{11}^{12} - B_{10}^{12*}B_{1-1}^{12})$$
$$+ 2/27\sqrt{3} * Re(-B_{00}^{00*}B_{01}^{01} + B_{00}^{00*}B_{01}^{02} - B_{10}^{10*}B_{11}^{11} - B_{10}^{10*}B_{1-1}^{11} + B_{10}^{10*}B_{11}^{12} - B_{10}^{10*}B_{1-1}^{12})$$
$$+ 1/9\sqrt{2} * Re(-B_{00}^{11*}B_{01}^{11} - B_{10}^{11*}B_{11}^{11} + B_{10}^{11*}B_{1-1}^{11} + B_{00}^{11*}B_{01}^{12} + B_{10}^{11*}B_{11}^{12} + B_{10}^{11*}B_{1-1}^{12})$$
$$+ 2/9 * Re(-B_{01}^{01*}B_{02}^{02} + B_{01}^{02*}B_{02}^{02} + B_{01}^{11*}B_{02}^{12} - B_{01}^{12*}B_{02}^{12} - B_{1-1}^{11*}B_{12}^{12} - B_{12}^{12*}B_{1-1}^{12} - B_{11}^{11*}B_{1-2}^{12} + B_{11}^{12*}B_{1-2}^{12})$$

$$C_{yz,yz} = -2/27\sqrt{6} * Re(B_{00}^{02*}B_{02}^{02} + B_{10}^{12*}B_{12}^{12} + B_{10}^{12*}B_{1-2}^{12})$$
$$+ 2/27\sqrt{3} * Re(B_{00}^{00*}B_{02}^{02} + B_{10}^{10*}B_{12}^{12} + B_{10}^{10*}B_{1-2}^{12})$$

$$- 1/27\sqrt{2} * Re(B_{00}^{00*}B_{00}^{02} + 2 * B_{10}^{10*}B_{10}^{12})$$
$$+ 2/9Re(B_{11}^{11*}B_{1-1}^{11} + B_{11}^{12*}B_{1-1}^{12})$$
$$+ 1/27 * (4 * (|B_{10}^{10}|^2 - |B_{10}^{12}|^2) + 6 * (-|B_{01}^{11}|^2 + |B_{01}^{12}|^2) + 2 * (|B_{00}^{00}|^2 - |B_{00}^{02}|^2)$$
$$+ 3 * (-|B_{11}^{11}|^2 - |B_{1-1}^{11}|^2 + |B_{11}^{12}|^2 + |B_{1-1}^{12}|^2))$$

$$C_{zz,x} = 0; \qquad C_{zz,z} = 0; \qquad C_{zz,xy} = 0; \qquad C_{zz,yz} = 0;$$

$$C_{zz,y} = +1/36\sqrt{6} * Im(5 * (B_{01}^{01*}B_{00}^{02} + B_{11}^{11*}B_{10}^{12} + B_{1-1}^{11*}B_{10}^{12}) + 3 * (B_{00}^{02*}B_{01}^{02} + B_{10}^{12*}B_{11}^{12} - B_{10}^{12*}B_{1-1}^{12})$$
$$+ 1/18\sqrt{3} * Im(B_{00}^{00*}B_{01}^{01} + B_{10}^{10*}B_{11}^{11} + B_{10}^{10*}B_{1-1}^{11} + 3 * (-B_{00}^{00*}B_{01}^{02} - B_{10}^{10*}B_{11}^{12} + B_{10}^{10*}B_{1-1}^{12}))$$
$$+ 1/12\sqrt{2} * Im(-B_{00}^{11*}B_{01}^{11} - B_{10}^{11*}B_{11}^{11} + B_{10}^{11*}B_{1-1}^{11} - B_{00}^{11*}B_{01}^{12} - B_{10}^{11*}B_{11}^{12} - B_{10}^{11*}B_{1-1}^{12})$$
$$+ 1/6 * Im(-B_{01}^{01*}B_{02}^{02} - B_{01}^{02*}B_{02}^{02} - B_{01}^{11*}B_{02}^{12} - B_{01}^{12*}B_{02}^{12} - B_{11}^{11*}B_{12}^{12} - B_{11}^{12*}B_{12}^{12} - B_{1-1}^{11*}B_{1-2}^{12} + B_{1-1}^{12*}B_{1-2}^{12}$$

$$C_{zz,xz} = 1/54\sqrt{6} * Re(5 * (-B_{00}^{02*}B_{01}^{02} - B_{10}^{12*}B_{11}^{12} + B_{10}^{12*}B_{1-1}^{12}) + 3 * (B_{01}^{01*}B_{00}^{02} + B_{11}^{11*}B_{10}^{12} + B_{1-1}^{11*}B_{10}^{12}$$
$$+ 2/54\sqrt{3} * Re(B_{00}^{00*}B_{01}^{02} + B_{10}^{10*}B_{11}^{12} - B_{10}^{10*}B_{1-1}^{12} + 3 * (-B_{00}^{00*}B_{01}^{01} - B_{10}^{10*}B_{11}^{11} - B_{10}^{10*}B_{1-1}^{11}))$$
$$+ 3/54\sqrt{2} * Re(-B_{00}^{11*}B_{01}^{11} - B_{10}^{11*}B_{11}^{11} + B_{10}^{11*}B_{1-1}^{11} - B_{00}^{11*}B_{01}^{12} - B_{10}^{11*}B_{11}^{12} - B_{10}^{11*}B_{1-1}^{12})$$
$$+ 1/9 * Re(B_{01}^{01*}B_{02}^{02} + B_{01}^{02*}B_{02}^{02} + B_{01}^{11*}B_{02}^{12} + B_{01}^{12*}B_{02}^{12} + B_{11}^{11*}B_{12}^{12} + B_{11}^{12*}B_{12}^{12} + B_{1-1}^{11*}B_{1-2}^{12} - B_{1-1}^{12*}B_{1-2}^{12})$$

$$
\begin{aligned}
C_{zz,zz} &= -1/18\sqrt{2} * Re(B_{00}^{00*} B_{00}^{02} + 2 * B_{10}^{10*} B_{10}^{12}) \\
&+ 1/36 * (|B_{00}^{11}|^2 + 3 * |B_{00}^{02}|^2 + 6 * |B_{10}^{12}|^2 \\
&\quad + 4 * (-|B_{01}^{01}|^2 - |B_{01}^{02}|^2 + |B_{10}^{10}|^2 - |B_{01}^{11}|^2 - |B_{11}^{11}|^2 - |B_{1-1}^{11}|^2 - |B_{01}^{12}|^2 - |B_{11}^{12}|^2 - |B_{1-1}^{12}|^2) \\
&\quad + 2 * (B_{00}^{00}|^2 + |B_{02}^{02}|^2 + |B_{10}^{11}|^2 + |B_{02}^{12}|^2 + |B_{12}^{12}|^2 + |B_{1-2}^{12}|^2))
\end{aligned}
$$

$$
\begin{aligned}
C_{zz,xx-yy} &= +1/54\sqrt{6} * Re(B_{00}^{02*} B_{02}^{02} + B_{10}^{12*} B_{12}^{12} + B_{10}^{12*} B_{1-2}^{12}) \\
&+ 1/27\sqrt{3} * Re(B_{00}^{00*} B_{02}^{02} + B_{10}^{10*} B_{12}^{12} + B_{10}^{10*} B_{1-2}^{12}) \\
&+ 1/18\sqrt{2} * Re(B_{00}^{11*} B_{02}^{12} + B_{10}^{11*} B_{12}^{12} - B_{10}^{11*} B_{1-2}^{12}) \\
&+ 1/9 * Re(-B_{01}^{01*} B_{01}^{02} + B_{11}^{11*} B_{1-1}^{11} + B_{01}^{11*} B_{01}^{12} - B_{1-1}^{11} B_{11}^{12} + B_{11}^{11*} B_{1-1}^{12} - B_{11}^{12*} B_{1-1}^{12}) \\
&+ 1/18 * (|B_{01}^{01}|^2 + |B_{01}^{02}|^2 - |B_{01}^{11}|^2 - |B_{01}^{12}|^2)
\end{aligned}
$$

$$
C_{xx-yy,x} = 0; \qquad C_{xx-yy,z} = 0; \qquad C_{xx-yy,xy} = 0; \qquad C_{xx-yy,yz} = 0;
$$

$$
\begin{aligned}
C_{xx-yy,y} &= +1/36\sqrt{6} * Im(-B_{01}^{01*} B_{00}^{02} + B_{00}^{02*} B_{01}^{02} - B_{11}^{11*} B_{10}^{12} - B_{1-1}^{11} B_{10}^{12} + B_{10}^{12*} B_{11}^{12} - B_{10}^{12*} B_{1-1}^{12}) \\
&+ 3/36\sqrt{2} * Im(-B_{00}^{11*} B_{01}^{11} - B_{10}^{11*} B_{11}^{11} + B_{10}^{11*} B_{1-1}^{11} - B_{00}^{11*} B_{01}^{12} - B_{10}^{11*} B_{11}^{12} - B_{10}^{11*} B_{1-1}^{12}) \\
&+ 2/36\sqrt{3} * Im(B_{00}^{00*} B_{01}^{01} + B_{00}^{00*} B_{01}^{02} + B_{10}^{10*} B_{11}^{11} + B_{10}^{10*} B_{1-1}^{11} + B_{10}^{10*} B_{11}^{12} - B_{10}^{10*} B_{1-1}^{12})) \\
&+ 1/6 * Im(B_{01}^{01*} B_{02}^{02} + B_{01}^{02*} B_{02}^{02} - B_{01}^{11*} B_{02}^{12} - B_{01}^{12*} B_{02}^{12} + B_{1-1}^{11} B_{12}^{12} + B_{12}^{12*} B_{1-1}^{12} + B_{11}^{11*} B_{1-2}^{12} + B_{11}^{12*} B_{1-2}^{12})
\end{aligned}
$$

$$
\begin{aligned}
C_{xx-yy,xz} &= +1/54\sqrt{6} * Re(B_{01}^{01*} B_{00}^{02} + B_{00}^{02*} B_{01}^{02} + B_{11}^{11*} B_{10}^{12} + B_{1-1}^{11} B_{10}^{12} + B_{10}^{12*} B_{11}^{12} - B_{10}^{12*} B_{1-1}^{12}) \\
&+ 3/54\sqrt{2} * Re(-B_{00}^{11*} B_{01}^{11} - B_{10}^{11*} B_{11}^{11} + B_{10}^{11*} B_{1-1}^{11} - B_{00}^{11*} B_{01}^{12} - B_{10}^{11*} B_{11}^{12} - B_{10}^{11*} B_{1-1}^{12}) \\
&+ 2/54\sqrt{3} * Re(B_{00}^{00*} B_{01}^{01} + B_{00}^{00*} B_{01}^{02} + B_{10}^{10*} B_{11}^{11} + B_{10}^{10*} B_{1-1}^{11} + B_{10}^{10*} B_{11}^{12} - B_{10}^{10*} B_{1-1}^{12}) \\
&+ 1/9 * Re(-B_{01}^{01*} B_{02}^{02} - B_{01}^{02*} B_{02}^{02} + B_{01}^{11*} B_{02}^{12} + B_{01}^{12*} B_{02}^{12} - B_{1-1}^{11} B_{12}^{12} + B_{12}^{12*} B_{1-1}^{12} - B_{11}^{11*} B_{1-2}^{12} - B_{11}^{12*} B_{1-2}^{12})
\end{aligned}
$$

$$C_{xx-yy,zz} = 1/54\sqrt{6} * Re(+B_{00}^{02*}B_{02}^{02} + B_{10}^{12*}B_{12}^{12} + B_{10}^{12*}B_{1-2}^{12})$$
$$+ 2/54\sqrt{3} * Re(+B_{00}^{00*}B_{02}^{02} + B_{10}^{10*}B_{12}^{12} + B_{10}^{10*}B_{1-2}^{12})$$
$$+ 3/54\sqrt{2} * Re(-B_{00}^{11*}B_{02}^{12} - B_{10}^{11*}B_{12}^{12} + B_{10}^{11*}B_{1-2}^{12})$$
$$+ 1/9 * Re(+B_{01}^{01*}B_{01}^{02} + B_{11}^{11*}B_{1-1}^{11} - B_{01}^{11*}B_{01}^{12} + B_{1-1}^{11*}B_{11}^{12} - B_{11}^{11*}B_{1-1}^{12} - B_{11}^{12*}B_{1-1}^{12})$$
$$+ 1/18 * (+|B_{01}^{01}|^2 + |B_{01}^{02}|^2 - |B_{01}^{11}|^2 - |B_{01}^{12}|^2)$$

$$C_{xx-yy,xx-yy} = +1/54\sqrt{2} * Re(B_{00}^{00*}B_{00}^{02} + 2 * B_{10}^{10*}B_{10}^{12})$$
$$+ 1/108 * (|B_{00}^{02}|^2 + 4 * |B_{10}^{10}|^2 - 3 * |B_{00}^{11}|^2 + 2 * (|B_{00}^{00}|^2 + |B_{10}^{12}|^2)$$
$$+ 6 * (|B_{02}^{02}|^2 - |B_{10}^{11}|^2 - |B_{02}^{12}|^2))$$
$$+ 1/9 * Re(B_{12}^{12*}B_{1-2}^{12})$$

Однако из сорока ненулевых наблюдаемых не все независимы. Независимыми будут 4 анализирующие способности, 8 диагональных корреляций спина и 12 недиагональных. Остальные 16 наблюдаемых (4 анализирующие способности и 12 недиагональных корреляций спина мишени) описываются теми же функциями что и симметричные им наблюдаемые пучка, только от инверсной угловой оси и некоторые противоположного знака:

$K_y^t(\theta) = K_y^b(\pi - \theta)$; $K_{xz}^t(\theta) = -K_{xz}^b(\pi - \theta)$; $K_{xx-yy}^t(\theta) = -K_{xx-yy}^b(\pi - \theta)$;
$K_{zz}^t(\theta) = -K_{zz}^b(\pi - \theta)$; $C_{x,z}^t(\theta) = -C_{z,x}^b(\pi - \theta)$; $C_{xx-yy,xz}^t(\theta) = -C_{xz,xx-yy}^b(\pi - \theta)$;
$C_{xz,y}^t(\theta) = C_{y,xz}^b(\pi - \theta)$; $C_{x,xy}^t(\theta) = -C_{xy,x}^b(\pi - \theta)$; $C_{xx-yy,y}^t(\theta) = -C_{y,xx-yy}^b(\pi - \theta)$;
$C_{y,zz}^t(\theta) = C_{zz,y}^b(\pi - \theta)$; $C_{xy,z}^t(\theta) = C_{z,xy}^b(\pi - \theta)$; $C_{xx-yy,zz}^t(\theta) = C_{zz,xx-yy}^b(\pi - \theta)$;
$C_{z,yz}^t(\theta) = -C_{yz,z}^b(\pi - \theta)$; $C_{xz,zz}^t(\theta) = -C_{zz,xz}^b(\pi - \theta)$; $C_{xy,yz}^t(\theta) = -C_{yz,xy}^b(\pi - \theta)$;
$C_{x,yz}^t(\theta) = C_{yz,x}^b(\pi - \theta)$.

Т.о., для вычисления дифференциального сечения термоядерной реакции при столкновении поляризованных дейтонов при любых поляризациях пучка и мишени надо знать 25 вещественных функции (24 наблюдаемых и неполяризованное дифференциальное сечение). Это значит, что измерение только дифференциальных сечений при сколь угодно богатом наборе разных поляризаций недостаточно для однозначного восстановления амплитуды реакции, ибо амплитуда содержит 18 комплексных т.е. 36 вещественных функций.

Вращение системы координат

При переходе в повёрнутую систему координат матрица плотности преобразуется с помощью D-функций:

$$\rho' = D\,\rho\,D^{+}\,.$$

$$D = \frac{1}{2}\begin{pmatrix} e^{i(\psi+\phi)}(1+\cos\theta) & \sqrt{2}e^{i\psi}\sin\theta & e^{i(\psi-\phi)}(1-\cos\theta) \\ -\sqrt{2}e^{i\phi}\sin\theta & 2\cos\theta & \sqrt{2}e^{-i\phi}\sin\theta \\ e^{-i(\psi-\phi)}(1-\cos\theta) & -\sqrt{2}e^{-i\psi}\sin\theta & e^{-i(\psi+\phi)}(1+\cos\theta) \end{pmatrix}$$

Преобразования матрицы плотности, необходимые для эксперимента

$$D_H = \begin{pmatrix} e^{-i\varphi} & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & e^{i\varphi} \end{pmatrix} \frac{1}{2} \begin{pmatrix} 1+\cos\vartheta & -\sqrt{2}\sin\vartheta & 1-\cos\vartheta \\ \sqrt{2}\sin\vartheta & 2\cos\vartheta & -\sqrt{2}\sin\vartheta \\ 1-\cos\vartheta & \sqrt{2}\sin\vartheta & 1+\cos\vartheta \end{pmatrix}$$

и матрица плотности в лабораторной системе ρ_{lab} вычисляется по формуле

$$\rho_{lab} = D_H \rho_H D_H^+ .$$

Разложив её по декартовым поляризационным операторам циклического базиса, получим:

$$\begin{aligned}
p_x^{lab} &= p_z^{(ABS)} \cos\varphi \sin\vartheta \\
p_y^{lab} &= p_z^{(ABS)} \sin\varphi \sin\vartheta \\
p_z^{lab} &= p_z^{(ABS)} \cos\vartheta \\
p_{xy}^{lab} &= \frac{3}{4} p_{zz}^{(ABS)} \sin 2\varphi \sin^2\vartheta \\
p_{xz}^{lab} &= \frac{3}{4} p_{zz}^{(ABS)} \cos\varphi \sin 2\vartheta \\
p_{yz}^{lab} &= \frac{3}{4} p_{zz}^{(ABS)} \sin\varphi \sin 2\vartheta \\
p_{zz}^{lab} &= \frac{1}{4} p_{zz}^{(ABS)} (1 + 3\cos 2\vartheta) \\
p_{xx-yy}^{lab} &= \frac{3}{2} p_{zz}^{(ABS)} \cos 2\varphi \sin^2\vartheta \\
p_{xx}^{lab} &= \frac{1}{8} p_{zz}^{(ABS)} (-1 - 3\cos 2\varphi + 6\cos 2\varphi \sin^2\vartheta) \\
p_{yy}^{lab} &= \frac{1}{8} p_{zz}^{(ABS)} (-1 - 3\cos 2\varphi - 6\cos 2\varphi \sin^2\vartheta)
\end{aligned}$$

$$
\begin{aligned}
p_x &= p_x^{lab}\cos\phi - p_y^{lab}\sin\phi \\
p_y &= p_x^{lab}\sin\phi + p_y^{lab}\cos\phi \\
p_z &= p_z^{lab} \\
p_{xy} &= p_{xy}^{lab}\cos(2\phi) + \frac{1}{2}p_{xx-yy}^{lab}\sin(2\phi) \\
p_{xz} &= p_{xz}^{lab}\cos\phi - p_{yz}^{lab}\sin\phi \\
p_{yz} &= p_{yz}^{lab}\cos\phi + p_{xz}^{lab}\sin\phi \\
p_{zz} &= p_{zz}^{lab} \\
p_{xx-yy} &= p_{xx-yy}^{lab}\cos(2\phi) - 2p_{xy}^{lab}\sin(2\phi)
\end{aligned}
$$

Дифференциальное сечение для полностью поляризованных начальных состояний

$$\rho_{++} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \quad \rho_{00} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \quad \rho_{--} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$I_{++} = |B_{12}^{12}|^2 + |B_{-12}^{12}|^2 + |B_{02}^{02}|^2 + |B_{02}^{12}|^2;$$

$$I_{+-} = \frac{2}{3}|B_{10}^{10} + \frac{1}{\sqrt{2}}B_{10}^{12}|^2 + \frac{1}{3}|B_{00}^{00} + \frac{1}{\sqrt{2}}B_{00}^{02}|^2 + |B_{10}^{11}|^2 + \frac{1}{2}|B_{00}^{11}|^2;$$

$$I_{+0} = \frac{1}{2}|B_{11}^{11} + B_{11}^{12}|^2 + \frac{1}{2}|B_{-11}^{11} + B_{-11}^{12}|^2 + \frac{1}{2}|B_{01}^{11} + B_{01}^{12}|^2 + \frac{1}{2}|B_{01}^{01} + B_{01}^{02}|^2;$$

$$I_{0+} = \frac{1}{2}|B_{11}^{12} - B_{11}^{11}|^2 + \frac{1}{2}|B_{-11}^{12} - B_{-11}^{11}|^2 + \frac{1}{2}|B_{01}^{12} - B_{01}^{11}|^2 + \frac{1}{2}|B_{01}^{02} - B_{01}^{01}|^2;$$

$$I_{00} = \frac{2}{3}|-B_{10}^{10} + \sqrt{2}B_{10}^{12}|^2 + \frac{1}{3}|-B_{00}^{00} + \sqrt{2}B_{00}^{02}|^2.$$

Выводы

Не все 18 матричных элемента независимы. Инвариантность к обращению времени накладывает одно довольно сложное условие и независимых остаётся 17.
Эти амплитуды содержат 33 вещественных числа и значит должно быть измерено 33 линейно независимых комбинаций матричных элементов амплитуды реакции.

Между тем из 40 наблюдаемых, дающих вклад в дифференциальное сечение, не все Несут независимую информацию. При замене r на –r 16 наблюдаемых пучка описываются теми же функциями что и симметричные им наблюдаемые мишени. Поэтому независимых уравнений будет всего 24.

Это значит что для полного опыта нужны ещё измерения поляризаций продуктов реакции!

$$K^t_y(\theta) = K^b_y(\pi-\theta); \quad K^t_{xz}(\theta) = -K^b_{xz}(\pi-\theta); \quad K^t_{xx-yy}(\theta) = -K^b_{xx-yy}(\pi-\theta);$$
$$K^t_{zz}(\theta) = -K^b_{zz}(\pi-\theta); \quad C^t_{x,z}(\theta) = -C^b_{z,x}(\pi-\theta); \quad C^t_{xx-yy,xz}(\theta) = -C^b_{xz,xx-yy}(\pi-\theta);$$
$$C^t_{xz,y}(\theta) = C^b_{y,xz}(\pi-\theta); \quad C^t_{x,xy}(\theta) = -C^b_{xy,x}(\pi-\theta); \quad C^t_{xx-yy,y}(\theta) = -C^b_{y,xx-yy}(\pi-\theta);$$
$$C^t_{y,zz}(\theta) = C^b_{zz,y}(\pi-\theta); \quad C^t_{xy,z}(\theta) = C^b_{z,xy}(\pi-\theta); \quad C^t_{xx-yy,zz}(\theta) = C^b_{zz,xx-yy}(\pi-\theta);$$
$$C^t_{z,yz}(\theta) = -C^b_{yz,z}(\pi-\theta); \quad C^t_{xz,zz}(\theta) = -C^b_{zz,xz}(\pi-\theta); \quad C^t_{xy,yz}(\theta) = -C^b_{yz,xy}(\pi-\theta);$$
$$C^t_{x,yz}(\theta) = C^b_{yz,x}(\pi-\theta).$$

Формулы

$$
\begin{aligned}
\sigma(\Theta,\Phi) = \sigma_0(\Theta)\,\{1 \;&+\; \frac{3}{2}\left[A_y^{(b)}(\Theta)p_y + A_y^{(t)}q_y\right] + \frac{1}{2}\left[A_{zz}^{(b)}(\Theta)p_{zz} + A_{zz}^{(t)}(\Theta)q_{zz}\right] \\
&+\; \frac{1}{6}\left[A_{xx-yy}^{(b)}(\Theta)p_{xx-yy} + A_{xx-yy}^{(t)}(\Theta)q_{xx-yy}\right] \\
&+\; \frac{2}{3}\left[A_{xz}^{(b)}(\Theta)p_{xz} + A_{xz}^{(t)}(\Theta)q_{xz}\right] \\
&+\; \frac{9}{4}\left[C_{y,y}(\Theta)p_yq_y + C_{x,x}(\Theta)p_xq_x + C_{x,z}(\Theta)p_xq_z\right. \\
&\quad \left. + C_{z,x}(\Theta)p_zq_x + C_{z,z}(\Theta)p_zq_z\right] \\
&+\; \frac{3}{4}\left[C_{y,zz}(\Theta)p_yq_{zz} + C_{zz,y}(\Theta)p_{zz}q_y\right] \\
&+\; C_{y,xz}(\Theta)p_yq_{xz} + C_{xz,y}(\Theta)p_{xz}q_y + C_{x,yz}(\Theta)p_xq_{yz} \\
&+\; C_{yz,x}(\Theta)p_{yz}q_x + C_{z,yz}(\Theta)p_zq_{yz} + C_{yz,z}(\Theta)p_{yz}q_z \\
&+\; \frac{1}{4}\left[C_{y,xx-yy}(\Theta)p_yq_{xx-yy} + C_{xx-yy,y}(\Theta)p_{xx-yy}q_y\right. \\
&\quad \left. + C_{zz,zz}(\Theta)p_{zz}q_{zz}\right] \\
&+\; \frac{1}{3}\left[C_{zz,xz}(\Theta)p_{zz}q_{xz} + C_{xz,zz}(\Theta)p_{xz}q_{zz}\right] \\
&+\; \frac{1}{12}\left[C_{zz,xx-yy}(\Theta)p_{zz}q_{xx-yy} + C_{xx-yy,zz}(\Theta)p_{xx-yy}q_{zz}\right] \\
&+\; \frac{4}{9}\left[C_{xz,xz}(\Theta)p_{xz}q_{xz} + C_{yz,yz}(\Theta)p_{yz}q_{yz}\right] \\
&+\; \frac{8}{9}\left[C_{xy,yz}(\Theta)p_{xy}q_{yz} + C_{yz,xy}(\Theta)p_{yz}q_{xy}\right] \\
&+\; \frac{16}{9}C_{xy,xy}(\Theta)p_{xy}q_{xy} \\
&+\; \frac{1}{9}\left[C_{xz,xx-yy}(\Theta)p_{xz}q_{xx-yy} + C_{xx-yy,xz}(\Theta)p_{xx-yy}q_{xz}\right] \\
&+\; \frac{1}{36}C_{xx-yy,xx-yy}(\Theta)p_{xx-yy}q_{xx-yy} \\
&+\; \frac{1}{2}\left[C_{x,xy}(\Theta)p_xq_{xy} + C_{xy,x}(\Theta)p_{xy}q_x + C_{z,xy}(\Theta)p_zq_{xy}\right. \\
&\quad \left. + C_{xy,z}(\Theta)p_{xy}q_z\right]\,\}
\end{aligned}
$$

Для описания наблюдаемых необходимо знать 36 параметров

При пучках с цилиндрической симметрией:

только $p_z(q_z)$ and $p_{zz}(q_{zz}) \neq 0$

$$
\begin{aligned}
\sigma(\Theta,\Phi) = \sigma_0(\Theta)\,\{1 \;&+\; \frac{3}{2}\left[A_{zz}^{(b)}(\Theta)p_{zz} + A_{zz}^{(t)}(\Theta)q_{zz}\right] \\
&+\; \frac{9}{4}C_{z,z}(\Theta)p_zq_z + \frac{1}{4}C_{zz,zz}(\Theta)p_{zz}q_{zz}\Big\}
\end{aligned}
$$

Поляризован только один дейтрон:

$(p_{i,j} \neq 0,\ q_{i,j} = 0)$

$\sigma(\Theta,\Phi) = \sigma_0(\Theta) \cdot \{1 + 3/2\ A_y(\Theta)\ p_y$

$+ 1/2\ A_{xz}(\Theta)\ p_{zz}$

$+ 1/6\ A_{xx\text{-}yy}(\Theta)\ p_{xx\text{-}zz}$

$+ 2/3\ A_{zz}(\Theta)\ p_{xz}\}$