

PG No. 31 T_d $\bar{4}3m$ [cubic] (lg basis)

bra: $\langle s |$
ket: $| s \rangle$

Table 1: (s,s) block.

| No. | multipole | matrix |
|-----|---------------------------|-----------------------------------|
| 1 | symmetry | 1 |
| | $\mathbb{Q}_0^{(a)}(A_1)$ | $\begin{bmatrix} 1 \end{bmatrix}$ |

bra: $\langle s |$
ket: $| p_x \rangle, | p_y \rangle, | p_z \rangle$

Table 2: (s,p) block.

| No. | multipole | matrix |
|-----|-------------------------------|---|
| 2 | symmetry | x |
| | $\mathbb{Q}_{1,1}^{(a)}(T_2)$ | $\begin{bmatrix} \frac{\sqrt{2}}{2} & 0 & 0 \end{bmatrix}$ |
| 3 | symmetry | y |
| | $\mathbb{Q}_{1,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & \frac{\sqrt{2}}{2} & 0 \end{bmatrix}$ |
| 4 | symmetry | z |
| | $\mathbb{Q}_{1,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{2}}{2} \end{bmatrix}$ |
| 5 | symmetry | x |
| | $\mathbb{T}_{1,1}^{(a)}(T_2)$ | $\begin{bmatrix} \frac{\sqrt{2}i}{2} & 0 & 0 \end{bmatrix}$ |
| 6 | symmetry | y |
| | $\mathbb{T}_{1,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & \frac{\sqrt{2}i}{2} & 0 \end{bmatrix}$ |
| 7 | symmetry | z |
| | $\mathbb{T}_{1,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{2}i}{2} \end{bmatrix}$ |

bra: $\langle s |$
ket: $| d_v \rangle, | d_{xy} \rangle, | d_{xz} \rangle, | d_{yz} \rangle, | d_u \rangle$

Table 3: (s,d) block.

| No. | multipole | matrix |
|-----|-----------|---|
| 8 | symmetry | $-\frac{x^2}{2} - \frac{y^2}{2} + z^2$ $\mathbb{Q}_{2,1}^{(a)}(E)$ $\begin{bmatrix} 0 & 0 & 0 & 0 & \frac{\sqrt{2}}{2} \end{bmatrix}$ |
| 9 | symmetry | $\frac{\sqrt{3}(x-y)(x+y)}{2}$ $\mathbb{Q}_{2,2}^{(a)}(E)$ $\begin{bmatrix} \frac{\sqrt{2}}{2} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 10 | symmetry | $\sqrt{3}yz$ $\mathbb{Q}_{2,1}^{(a)}(T_2)$ $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{2}}{2} & 0 \end{bmatrix}$ |
| 11 | symmetry | $\sqrt{3}xz$ $\mathbb{Q}_{2,2}^{(a)}(T_2)$ $\begin{bmatrix} 0 & 0 & \frac{\sqrt{2}}{2} & 0 & 0 \end{bmatrix}$ |
| 12 | symmetry | $\sqrt{3}xy$ $\mathbb{Q}_{2,3}^{(a)}(T_2)$ $\begin{bmatrix} 0 & \frac{\sqrt{2}}{2} & 0 & 0 & 0 \end{bmatrix}$ |
| 13 | symmetry | $-\frac{x^2}{2} - \frac{y^2}{2} + z^2$ $\mathbb{T}_{2,1}^{(a)}(E)$ $\begin{bmatrix} 0 & 0 & 0 & 0 & \frac{\sqrt{2}i}{2} \end{bmatrix}$ |
| 14 | symmetry | $\frac{\sqrt{3}(x-y)(x+y)}{2}$ $\mathbb{T}_{2,2}^{(a)}(E)$ $\begin{bmatrix} \frac{\sqrt{2}i}{2} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 15 | symmetry | $\sqrt{3}yz$ $\mathbb{T}_{2,1}^{(a)}(T_2)$ $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{2}i}{2} & 0 \end{bmatrix}$ |
| 16 | symmetry | $\sqrt{3}xz$ $\mathbb{T}_{2,2}^{(a)}(T_2)$ $\begin{bmatrix} 0 & 0 & \frac{\sqrt{2}i}{2} & 0 & 0 \end{bmatrix}$ |
| 17 | symmetry | $\sqrt{3}xy$ $\mathbb{T}_{2,3}^{(a)}(T_2)$ $\begin{bmatrix} 0 & \frac{\sqrt{2}i}{2} & 0 & 0 & 0 \end{bmatrix}$ |

bra: = $\langle s |$ ket: = $|f_2\rangle, |f_1\rangle, |f_{bz}\rangle, |f_3\rangle, |f_{3x}\rangle, |f_{3y}\rangle, |f_{az}\rangle$

Table 4: (s,f) block.

| No. | multipole | matrix |
|-----|-------------------------------|---|
| 18 | symmetry | $\sqrt{15}xyz$ |
| | $\mathbb{Q}_3^{(a)}(A_1)$ | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{2}}{2} & 0 & 0 & 0 \end{bmatrix}$ |
| 19 | symmetry | $\frac{\sqrt{15}x(y-z)(y+z)}{2}$ |
| | $\mathbb{Q}_{3,1}^{(a)}(T_1)$ | $\begin{bmatrix} -\frac{\sqrt{3}}{4} & 0 & 0 & 0 & -\frac{\sqrt{5}}{4} & 0 & 0 \end{bmatrix}$ |
| 20 | symmetry | $-\frac{\sqrt{15}y(x-z)(x+z)}{2}$ |
| | $\mathbb{Q}_{3,2}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & -\frac{\sqrt{3}}{4} & 0 & 0 & 0 & \frac{\sqrt{5}}{4} & 0 \end{bmatrix}$ |
| 21 | symmetry | $\frac{\sqrt{15}z(x-y)(x+y)}{2}$ |
| | $\mathbb{Q}_{3,3}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{2}}{2} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 22 | symmetry | $\frac{x(2x^2-3y^2-3z^2)}{2}$ |
| | $\mathbb{Q}_{3,1}^{(a)}(T_2)$ | $\begin{bmatrix} \frac{\sqrt{5}}{4} & 0 & 0 & 0 & -\frac{\sqrt{3}}{4} & 0 & 0 \end{bmatrix}$ |
| 23 | symmetry | $-\frac{y(3x^2-2y^2+3z^2)}{2}$ |
| | $\mathbb{Q}_{3,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & -\frac{\sqrt{5}}{4} & 0 & 0 & 0 & -\frac{\sqrt{3}}{4} & 0 \end{bmatrix}$ |
| 24 | symmetry | $-\frac{z(3x^2+3y^2-2z^2)}{2}$ |
| | $\mathbb{Q}_{3,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{2}}{2} \end{bmatrix}$ |
| 25 | symmetry | $\sqrt{15}xyz$ |
| | $\mathbb{T}_3^{(a)}(A_1)$ | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{2}i}{2} & 0 & 0 & 0 \end{bmatrix}$ |
| 26 | symmetry | $\frac{\sqrt{15}x(y-z)(y+z)}{2}$ |
| | $\mathbb{T}_{3,1}^{(a)}(T_1)$ | $\begin{bmatrix} -\frac{\sqrt{3}i}{4} & 0 & 0 & 0 & -\frac{\sqrt{5}i}{4} & 0 & 0 \end{bmatrix}$ |
| 27 | symmetry | $-\frac{\sqrt{15}y(x-z)(x+z)}{2}$ |
| | $\mathbb{T}_{3,2}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & -\frac{\sqrt{3}i}{4} & 0 & 0 & 0 & \frac{\sqrt{5}i}{4} & 0 \end{bmatrix}$ |
| 28 | symmetry | $\frac{\sqrt{15}z(x-y)(x+y)}{2}$ |
| | $\mathbb{T}_{3,3}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{2}i}{2} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 29 | symmetry | $\frac{x(2x^2-3y^2-3z^2)}{2}$ |
| | $\mathbb{T}_{3,1}^{(a)}(T_2)$ | $\begin{bmatrix} \frac{\sqrt{5}i}{4} & 0 & 0 & 0 & -\frac{\sqrt{3}i}{4} & 0 & 0 \end{bmatrix}$ |
| 30 | symmetry | $-\frac{y(3x^2-2y^2+3z^2)}{2}$ |
| | $\mathbb{T}_{3,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & -\frac{\sqrt{5}i}{4} & 0 & 0 & 0 & -\frac{\sqrt{3}i}{4} & 0 \end{bmatrix}$ |
| 31 | symmetry | $-\frac{z(3x^2+3y^2-2z^2)}{2}$ |

continued ...

Table 4

| No. | multipole | matrix |
|-----|-------------------------------|---|
| | $\mathbb{T}_{3,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{2}i}{2} \end{bmatrix}$ |

bra: $= \langle p_x |, \langle p_y |, \langle p_z |$
ket: $= |p_x \rangle, |p_y \rangle, |p_z \rangle$

Table 5: (p,p) block.

| No. | multipole | matrix |
|-----|-------------------------------|--|
| 32 | symmetry | 1 |
| | $\mathbb{Q}_0^{(a)}(A_1)$ | $\begin{bmatrix} \frac{\sqrt{3}}{3} & 0 & 0 \\ 0 & \frac{\sqrt{3}}{3} & 0 \\ 0 & 0 & \frac{\sqrt{3}}{3} \end{bmatrix}$ |
| 33 | symmetry | $-\frac{x^2}{2} - \frac{y^2}{2} + z^2$ |
| | $\mathbb{Q}_{2,1}^{(a)}(E)$ | $\begin{bmatrix} -\frac{\sqrt{6}}{6} & 0 & 0 \\ 0 & -\frac{\sqrt{6}}{6} & 0 \\ 0 & 0 & \frac{\sqrt{6}}{3} \end{bmatrix}$ |
| 34 | symmetry | $\frac{\sqrt{3}(x-y)(x+y)}{2}$ |
| | $\mathbb{Q}_{2,2}^{(a)}(E)$ | $\begin{bmatrix} \frac{\sqrt{2}}{2} & 0 & 0 \\ 0 & -\frac{\sqrt{2}}{2} & 0 \\ 0 & 0 & 0 \end{bmatrix}$ |
| 35 | symmetry | $\sqrt{3}yz$ |
| | $\mathbb{Q}_{2,1}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{2}}{2} \\ 0 & \frac{\sqrt{2}}{2} & 0 \end{bmatrix}$ |
| 36 | symmetry | $\sqrt{3}xz$ |
| | $\mathbb{Q}_{2,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{2}}{2} \\ 0 & 0 & 0 \\ \frac{\sqrt{2}}{2} & 0 & 0 \end{bmatrix}$ |

continued ...

Table 5

| No. | multipole | matrix |
|-----|-----------|--|
| 37 | symmetry | $\sqrt{3}xy$ |
| | | $\mathbb{Q}_{2,3}^{(a)}(T_2) \begin{bmatrix} 0 & \frac{\sqrt{2}}{2} & 0 \\ \frac{\sqrt{2}}{2} & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$ |
| 38 | symmetry | x |
| | | $\mathbb{M}_{1,1}^{(a)}(T_1) \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{2}i}{2} \\ 0 & \frac{\sqrt{2}i}{2} & 0 \end{bmatrix}$ |
| 39 | symmetry | y |
| | | $\mathbb{M}_{1,2}^{(a)}(T_1) \begin{bmatrix} 0 & 0 & \frac{\sqrt{2}i}{2} \\ 0 & 0 & 0 \\ -\frac{\sqrt{2}i}{2} & 0 & 0 \end{bmatrix}$ |
| 40 | symmetry | z |
| | | $\mathbb{M}_{1,3}^{(a)}(T_1) \begin{bmatrix} 0 & -\frac{\sqrt{2}i}{2} & 0 \\ \frac{\sqrt{2}i}{2} & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$ |

bra: $= \langle p_x |, \langle p_y |, \langle p_z |$ ket: $= |d_v\rangle, |d_{xy}\rangle, |d_{xz}\rangle, |d_{yz}\rangle, |d_u\rangle$

Table 6: (p,d) block.

| No. | multipole | matrix |
|-----|-----------|---|
| 41 | symmetry | x |
| | | $\mathbb{Q}_{1,1}^{(a)}(T_2) \begin{bmatrix} \frac{\sqrt{15}}{10} & 0 & 0 & 0 & -\frac{\sqrt{5}}{10} \\ 0 & \frac{\sqrt{15}}{10} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{15}}{10} & 0 & 0 \end{bmatrix}$ |
| 42 | symmetry | y |

continued ...

Table 6

| No. | multipole | matrix |
|-----|-------------------------------|--|
| | $\mathbb{Q}_{1,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & \frac{\sqrt{15}}{10} & 0 & 0 & 0 \\ -\frac{\sqrt{15}}{10} & 0 & 0 & 0 & -\frac{\sqrt{5}}{10} \\ 0 & 0 & 0 & \frac{\sqrt{15}}{10} & 0 \end{bmatrix}$ |
| 43 | symmetry | z $\begin{bmatrix} 0 & 0 & \frac{\sqrt{15}}{10} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{15}}{10} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{5}}{5} \end{bmatrix}$ |
| 44 | symmetry | $\sqrt{15}xyz$ $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{6}}{6} & 0 \\ 0 & 0 & \frac{\sqrt{6}}{6} & 0 & 0 \\ 0 & \frac{\sqrt{6}}{6} & 0 & 0 & 0 \end{bmatrix}$ |
| 45 | symmetry | $\frac{\sqrt{15}x(y-z)(y+z)}{2}$ $\begin{bmatrix} -\frac{\sqrt{6}}{12} & 0 & 0 & 0 & -\frac{\sqrt{2}}{4} \\ 0 & \frac{\sqrt{6}}{6} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{6}}{6} & 0 & 0 \end{bmatrix}$ |
| 46 | symmetry | $-\frac{\sqrt{15}y(x-z)(x+z)}{2}$ $\begin{bmatrix} 0 & -\frac{\sqrt{6}}{6} & 0 & 0 & 0 \\ -\frac{\sqrt{6}}{12} & 0 & 0 & 0 & \frac{\sqrt{2}}{4} \\ 0 & 0 & 0 & \frac{\sqrt{6}}{6} & 0 \end{bmatrix}$ |
| 47 | symmetry | $\frac{\sqrt{15}z(x-y)(x+y)}{2}$ $\begin{bmatrix} 0 & 0 & \frac{\sqrt{6}}{6} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{6}}{6} & 0 \\ \frac{\sqrt{6}}{6} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 48 | symmetry | $\frac{x(2x^2-3y^2-3z^2)}{2}$ $\begin{bmatrix} \frac{3\sqrt{10}}{20} & 0 & 0 & 0 & -\frac{\sqrt{30}}{20} \\ 0 & -\frac{\sqrt{10}}{10} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{10}}{10} & 0 & 0 \end{bmatrix}$ |
| 49 | symmetry | $-\frac{y(3x^2-2y^2+3z^2)}{2}$ |

continued ...

Table 6

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} 0 & -\frac{\sqrt{10}}{10} & 0 & 0 & 0 \\ -\frac{3\sqrt{10}}{20} & 0 & 0 & 0 & -\frac{\sqrt{30}}{20} \\ 0 & 0 & 0 & -\frac{\sqrt{10}}{10} & 0 \end{bmatrix}$ |
| 50 | symmetry | $-\frac{z(3x^2+3y^2-2z^2)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{10}}{10} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{10}}{10} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{30}}{10} \end{bmatrix}$ |
| 51 | symmetry | $-\frac{\sqrt{3}(x-y)(x+y)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & -\frac{\sqrt{3}}{6} & 0 \\ 0 & 0 & -\frac{\sqrt{3}}{6} & 0 & 0 \\ 0 & \frac{\sqrt{3}}{3} & 0 & 0 & 0 \end{bmatrix}$ |
| 52 | symmetry | $-\frac{x^2}{2} - \frac{y^2}{2} + z^2$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & \frac{1}{2} & 0 \\ 0 & 0 & -\frac{1}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 53 | symmetry | $\sqrt{3}yz$ |
| | | $\begin{bmatrix} -\frac{\sqrt{3}}{6} & 0 & 0 & 0 & -\frac{1}{2} \\ 0 & -\frac{\sqrt{3}}{6} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{3}}{6} & 0 & 0 \end{bmatrix}$ |
| 54 | symmetry | $\sqrt{3}xz$ |
| | | $\begin{bmatrix} 0 & \frac{\sqrt{3}}{6} & 0 & 0 & 0 \\ -\frac{\sqrt{3}}{6} & 0 & 0 & 0 & \frac{1}{2} \\ 0 & 0 & 0 & -\frac{\sqrt{3}}{6} & 0 \end{bmatrix}$ |
| 55 | symmetry | $\sqrt{3}xy$ |
| | | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{3}}{6} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{3}}{6} & 0 \\ \frac{\sqrt{3}}{3} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 56 | symmetry | x |

continued ...

Table 6

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} \frac{\sqrt{15}i}{10} & 0 & 0 & 0 & -\frac{\sqrt{5}i}{10} \\ 0 & \frac{\sqrt{15}i}{10} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{15}i}{10} & 0 & 0 \end{bmatrix}$ |
| 57 | symmetry | y |
| | | $\begin{bmatrix} 0 & \frac{\sqrt{15}i}{10} & 0 & 0 & 0 \\ -\frac{\sqrt{15}i}{10} & 0 & 0 & 0 & -\frac{\sqrt{5}i}{10} \\ 0 & 0 & 0 & \frac{\sqrt{15}i}{10} & 0 \end{bmatrix}$ |
| 58 | symmetry | z |
| | | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{15}i}{10} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{15}i}{10} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{5}i}{5} \end{bmatrix}$ |
| 59 | symmetry | $\sqrt{15}xyz$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{6}i}{6} & 0 \\ 0 & 0 & \frac{\sqrt{6}i}{6} & 0 & 0 \\ 0 & \frac{\sqrt{6}i}{6} & 0 & 0 & 0 \end{bmatrix}$ |
| 60 | symmetry | $\frac{\sqrt{15}x(y-z)(y+z)}{2}$ |
| | | $\begin{bmatrix} -\frac{\sqrt{6}i}{12} & 0 & 0 & 0 & -\frac{\sqrt{2}i}{4} \\ 0 & \frac{\sqrt{6}i}{6} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 \end{bmatrix}$ |
| 61 | symmetry | $-\frac{\sqrt{15}y(x-z)(x+z)}{2}$ |
| | | $\begin{bmatrix} 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 \\ -\frac{\sqrt{6}i}{12} & 0 & 0 & 0 & \frac{\sqrt{2}i}{4} \\ 0 & 0 & 0 & \frac{\sqrt{6}i}{6} & 0 \end{bmatrix}$ |
| 62 | symmetry | $\frac{\sqrt{15}z(x-y)(x+y)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{6}i}{6} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 \\ \frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 63 | symmetry | $\frac{x(2x^2-3y^2-3z^2)}{2}$ |

continued ...

Table 6

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} \frac{3\sqrt{10}i}{20} & 0 & 0 & 0 & -\frac{\sqrt{30}i}{20} \\ 0 & -\frac{\sqrt{10}i}{10} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{10}i}{10} & 0 & 0 \end{bmatrix}$ |
| 64 | symmetry | $-\frac{y(3x^2-2y^2+3z^2)}{2}$ |
| | | $\begin{bmatrix} 0 & -\frac{\sqrt{10}i}{10} & 0 & 0 & 0 \\ -\frac{3\sqrt{10}i}{20} & 0 & 0 & 0 & -\frac{\sqrt{30}i}{20} \\ 0 & 0 & 0 & -\frac{\sqrt{10}i}{10} & 0 \end{bmatrix}$ |
| 65 | symmetry | $-\frac{z(3x^2+3y^2-2z^2)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{10}i}{10} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{10}i}{10} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{30}i}{10} \end{bmatrix}$ |
| 66 | symmetry | $-\frac{\sqrt{3}(x-y)(x+y)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{3}i}{6} & 0 \\ 0 & 0 & \frac{\sqrt{3}i}{6} & 0 & 0 \\ 0 & -\frac{\sqrt{3}i}{3} & 0 & 0 & 0 \end{bmatrix}$ |
| 67 | symmetry | $-\frac{x^2}{2} - \frac{y^2}{2} + z^2$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & -\frac{i}{2} & 0 \\ 0 & 0 & \frac{i}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 68 | symmetry | $\sqrt{3}yz$ |
| | | $\begin{bmatrix} \frac{\sqrt{3}i}{6} & 0 & 0 & 0 & \frac{i}{2} \\ 0 & \frac{\sqrt{3}i}{6} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{3}i}{6} & 0 & 0 \end{bmatrix}$ |
| 69 | symmetry | $\sqrt{3}xz$ |
| | | $\begin{bmatrix} 0 & -\frac{\sqrt{3}i}{6} & 0 & 0 & 0 \\ \frac{\sqrt{3}i}{6} & 0 & 0 & 0 & -\frac{i}{2} \\ 0 & 0 & \frac{\sqrt{3}i}{6} & 0 & 0 \end{bmatrix}$ |
| 70 | symmetry | $\sqrt{3}xy$ |

continued ...

Table 6

| No. | multipole | matrix |
|-----|-------------------------------|---|
| | $\mathbb{M}_{2,3}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{3}i}{6} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{3}i}{6} & 0 \\ -\frac{\sqrt{3}i}{3} & 0 & 0 & 0 & 0 \end{bmatrix}$ |

bra: $= \langle p_x |, \langle p_y |, \langle p_z |$ ket: $= |f_2\rangle, |f_1\rangle, |f_{bz}\rangle, |f_3\rangle, |f_{3x}\rangle, |f_{3y}\rangle, |f_{az}\rangle$

Table 7: (p,f) block.

| No. | multipole | matrix |
|-----|-----------|---|
| 71 | symmetry | $-\frac{x^2}{2} - \frac{y^2}{2} + z^2$ $\begin{bmatrix} 0 & 0 & 0 & 0 & \frac{\sqrt{7}}{7} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{7}}{7} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{42}}{14} \end{bmatrix}$ |
| 72 | symmetry | $\frac{\sqrt{3}(x-y)(x+y)}{2}$ $\begin{bmatrix} \frac{\sqrt{35}}{14} & 0 & 0 & 0 & -\frac{\sqrt{21}}{42} & 0 & 0 \\ 0 & \frac{\sqrt{35}}{14} & 0 & 0 & 0 & \frac{\sqrt{21}}{42} & 0 \\ 0 & 0 & \frac{\sqrt{210}}{42} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 73 | symmetry | $\sqrt{3}yz$ $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{210}}{42} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{210}}{42} & 0 & 0 & 0 & -\frac{\sqrt{14}}{14} \\ 0 & 0 & 0 & 0 & 0 & \frac{2\sqrt{21}}{21} & 0 \end{bmatrix}$ |
| 74 | symmetry | $\sqrt{3}xz$ $\begin{bmatrix} 0 & 0 & \frac{\sqrt{210}}{42} & 0 & 0 & 0 & -\frac{\sqrt{14}}{14} \\ 0 & 0 & 0 & \frac{\sqrt{210}}{42} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{2\sqrt{21}}{21} & 0 & 0 \end{bmatrix}$ |
| 75 | symmetry | $\sqrt{3}xy$ |

continued ...

Table 7

| No. | multipole | matrix |
|-----|-------------------------------|--|
| | $\mathbb{Q}_{2,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & \frac{\sqrt{35}}{14} & 0 & 0 & 0 & -\frac{\sqrt{21}}{42} & 0 \\ -\frac{\sqrt{35}}{14} & 0 & 0 & 0 & -\frac{\sqrt{21}}{42} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{210}}{42} & 0 & 0 & 0 \end{bmatrix}$ |
| 76 | symmetry | $\frac{\sqrt{21}(x^4 - 3x^2y^2 - 3x^2z^2 + y^4 - 3y^2z^2 + z^4)}{6}$ |
| | $\mathbb{Q}_4^{(a)}(A_1)$ | $\begin{bmatrix} \frac{\sqrt{15}}{12} & 0 & 0 & 0 & -\frac{1}{4} & 0 & 0 \\ 0 & -\frac{\sqrt{15}}{12} & 0 & 0 & 0 & -\frac{1}{4} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{6}}{6} \end{bmatrix}$ |
| 77 | symmetry | $-\frac{\sqrt{15}(x^4 - 12x^2y^2 + 6x^2z^2 + y^4 + 6y^2z^2 - 2z^4)}{12}$ |
| | $\mathbb{Q}_{4,1}^{(a)}(E)$ | $\begin{bmatrix} -\frac{\sqrt{21}}{12} & 0 & 0 & 0 & -\frac{\sqrt{35}}{28} & 0 & 0 \\ 0 & \frac{\sqrt{21}}{12} & 0 & 0 & 0 & -\frac{\sqrt{35}}{28} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{210}}{42} \end{bmatrix}$ |
| 78 | symmetry | $\frac{\sqrt{5}(x-y)(x+y)(x^2+y^2-6z^2)}{4}$ |
| | $\mathbb{Q}_{4,2}^{(a)}(E)$ | $\begin{bmatrix} \frac{\sqrt{7}}{28} & 0 & 0 & 0 & -\frac{\sqrt{105}}{28} & 0 & 0 \\ 0 & \frac{\sqrt{7}}{28} & 0 & 0 & 0 & \frac{\sqrt{105}}{28} & 0 \\ 0 & 0 & -\frac{\sqrt{42}}{14} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 79 | symmetry | $\frac{\sqrt{35}yz(y-z)(y+z)}{2}$ |
| | $\mathbb{Q}_{4,1}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{6}}{8} & 0 & 0 & 0 & -\frac{\sqrt{10}}{8} \\ 0 & -\frac{1}{8} & 0 & 0 & 0 & -\frac{\sqrt{15}}{8} & 0 \end{bmatrix}$ |
| 80 | symmetry | $-\frac{\sqrt{35}xz(x-z)(x+z)}{2}$ |
| | $\mathbb{Q}_{4,2}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{6}}{8} & 0 & 0 & 0 & \frac{\sqrt{10}}{8} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{1}{8} & 0 & 0 & 0 & \frac{\sqrt{15}}{8} & 0 & 0 \end{bmatrix}$ |
| 81 | symmetry | $\frac{\sqrt{35}xy(x-y)(x+y)}{2}$ |
| | $\mathbb{Q}_{4,3}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & \frac{1}{2} & 0 & 0 & 0 & 0 & 0 \\ \frac{1}{2} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 82 | symmetry | $\frac{\sqrt{5}yz(6x^2 - y^2 - z^2)}{2}$ |

continued ...

Table 7

| No. | multipole | matrix |
|-----|-------------------------------|--|
| | $\mathbb{Q}_{4,1}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{42}}{14} & 0 & 0 & 0 \\ 0 & 0 & \frac{3\sqrt{42}}{56} & 0 & 0 & 0 & -\frac{\sqrt{70}}{56} \\ 0 & \frac{\sqrt{7}}{8} & 0 & 0 & 0 & -\frac{\sqrt{105}}{56} & 0 \end{bmatrix}$ |
| 83 | symmetry | $-\frac{\sqrt{5}xz(x^2-6y^2+z^2)}{2}$ |
| | $\mathbb{Q}_{4,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & -\frac{3\sqrt{42}}{56} & 0 & 0 & 0 & -\frac{\sqrt{70}}{56} \\ 0 & 0 & 0 & \frac{\sqrt{42}}{14} & 0 & 0 & 0 \\ -\frac{\sqrt{7}}{8} & 0 & 0 & 0 & -\frac{\sqrt{105}}{56} & 0 & 0 \end{bmatrix}$ |
| 84 | symmetry | $-\frac{\sqrt{5}xy(x^2+y^2-6z^2)}{2}$ |
| | $\mathbb{Q}_{4,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & -\frac{\sqrt{7}}{28} & 0 & 0 & 0 & \frac{\sqrt{105}}{28} & 0 \\ \frac{\sqrt{7}}{28} & 0 & 0 & 0 & \frac{\sqrt{105}}{28} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{42}}{14} & 0 & 0 & 0 \end{bmatrix}$ |
| 85 | symmetry | $\sqrt{15}xyz$ |
| | $\mathbb{G}_3^{(a)}(A_2)$ | $\begin{bmatrix} -\frac{1}{4} & 0 & 0 & 0 & -\frac{\sqrt{15}}{12} & 0 & 0 \\ 0 & -\frac{1}{4} & 0 & 0 & 0 & \frac{\sqrt{15}}{12} & 0 \\ 0 & 0 & \frac{\sqrt{6}}{6} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 86 | symmetry | $\frac{x(2x^2-3y^2-3z^2)}{2}$ |
| | $\mathbb{G}_{3,1}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{10}}{8} & 0 & 0 & 0 & -\frac{\sqrt{6}}{8} \\ 0 & -\frac{\sqrt{15}}{8} & 0 & 0 & 0 & \frac{1}{8} & 0 \end{bmatrix}$ |
| 87 | symmetry | $-\frac{y(3x^2-2y^2+3z^2)}{2}$ |
| | $\mathbb{G}_{3,2}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{10}}{8} & 0 & 0 & 0 & \frac{\sqrt{6}}{8} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{15}}{8} & 0 & 0 & 0 & -\frac{1}{8} & 0 & 0 \end{bmatrix}$ |
| 88 | symmetry | $-\frac{z(3x^2+3y^2-2z^2)}{2}$ |
| | $\mathbb{G}_{3,3}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & \frac{1}{2} & 0 \\ 0 & 0 & 0 & 0 & -\frac{1}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 89 | symmetry | $\frac{\sqrt{15}x(y-z)(y+z)}{2}$ |

continued ...

Table 7

| No. | multipole | matrix |
|-----|-------------------------------|---|
| | $\mathbb{G}_{3,1}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & 0 & -\frac{\sqrt{6}}{6} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{6}}{24} & 0 & 0 & 0 & -\frac{\sqrt{10}}{8} \\ 0 & \frac{3}{8} & 0 & 0 & 0 & \frac{\sqrt{15}}{24} & 0 \end{bmatrix}$ |
| 90 | symmetry | $-\frac{\sqrt{15}y(x-z)(x+z)}{2}$ |
| | $\mathbb{G}_{3,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{6}}{24} & 0 & 0 & 0 & -\frac{\sqrt{10}}{8} \\ 0 & 0 & 0 & -\frac{\sqrt{6}}{6} & 0 & 0 & 0 \\ -\frac{3}{8} & 0 & 0 & 0 & \frac{\sqrt{15}}{24} & 0 & 0 \end{bmatrix}$ |
| 91 | symmetry | $\frac{\sqrt{15}z(x-y)(x+y)}{2}$ |
| | $\mathbb{G}_{3,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & \frac{1}{4} & 0 & 0 & 0 & \frac{\sqrt{15}}{12} & 0 \\ -\frac{1}{4} & 0 & 0 & 0 & \frac{\sqrt{15}}{12} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{6}}{6} & 0 & 0 & 0 \end{bmatrix}$ |
| 92 | symmetry | $-\frac{x^2}{2} - \frac{y^2}{2} + z^2$ |
| | $\mathbb{T}_{2,1}^{(a)}(E)$ | $\begin{bmatrix} 0 & 0 & 0 & 0 & \frac{\sqrt{7}i}{7} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{7}i}{7} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{42}i}{14} \end{bmatrix}$ |
| 93 | symmetry | $\frac{\sqrt{3}(x-y)(x+y)}{2}$ |
| | $\mathbb{T}_{2,2}^{(a)}(E)$ | $\begin{bmatrix} \frac{\sqrt{35}i}{14} & 0 & 0 & 0 & -\frac{\sqrt{21}i}{42} & 0 & 0 \\ 0 & \frac{\sqrt{35}i}{14} & 0 & 0 & 0 & \frac{\sqrt{21}i}{42} & 0 \\ 0 & 0 & \frac{\sqrt{210}i}{42} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 94 | symmetry | $\sqrt{3}yz$ |
| | $\mathbb{T}_{2,1}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{210}i}{42} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{210}i}{42} & 0 & 0 & 0 & -\frac{\sqrt{14}i}{14} \\ 0 & 0 & 0 & 0 & 0 & \frac{2\sqrt{21}i}{21} & 0 \end{bmatrix}$ |
| 95 | symmetry | $\sqrt{3}xz$ |
| | $\mathbb{T}_{2,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{210}i}{42} & 0 & 0 & 0 & -\frac{\sqrt{14}i}{14} \\ 0 & 0 & 0 & \frac{\sqrt{210}i}{42} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{2\sqrt{21}i}{21} & 0 & 0 \end{bmatrix}$ |
| 96 | symmetry | $\sqrt{3}xy$ |

continued ...

Table 7

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & \frac{\sqrt{35}i}{14} & 0 & 0 & 0 & -\frac{\sqrt{21}i}{42} & 0 \\ -\frac{\sqrt{35}i}{14} & 0 & 0 & 0 & -\frac{\sqrt{21}i}{42} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{210}i}{42} & 0 & 0 & 0 \end{bmatrix}$ |
| 97 | symmetry | $\frac{\sqrt{21}(x^4 - 3x^2y^2 - 3x^2z^2 + y^4 - 3y^2z^2 + z^4)}{6}$ |
| | | $\begin{bmatrix} \frac{\sqrt{15}i}{12} & 0 & 0 & 0 & -\frac{i}{4} & 0 & 0 \\ 0 & -\frac{\sqrt{15}i}{12} & 0 & 0 & 0 & -\frac{i}{4} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{6}i}{6} \end{bmatrix}$ |
| 98 | symmetry | $-\frac{\sqrt{15}(x^4 - 12x^2y^2 + 6x^2z^2 + y^4 + 6y^2z^2 - 2z^4)}{12}$ |
| | | $\begin{bmatrix} -\frac{\sqrt{21}i}{12} & 0 & 0 & 0 & -\frac{\sqrt{35}i}{28} & 0 & 0 \\ 0 & \frac{\sqrt{21}i}{12} & 0 & 0 & 0 & -\frac{\sqrt{35}i}{28} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{210}i}{42} \end{bmatrix}$ |
| 99 | symmetry | $\frac{\sqrt{5}(x-y)(x+y)(x^2+y^2-6z^2)}{4}$ |
| | | $\begin{bmatrix} \frac{\sqrt{7}i}{28} & 0 & 0 & 0 & -\frac{\sqrt{105}i}{28} & 0 & 0 \\ 0 & \frac{\sqrt{7}i}{28} & 0 & 0 & 0 & \frac{\sqrt{105}i}{28} & 0 \\ 0 & 0 & -\frac{\sqrt{42}i}{14} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 100 | symmetry | $\frac{\sqrt{35}yz(y-z)(y+z)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{6}i}{8} & 0 & 0 & 0 & -\frac{\sqrt{10}i}{8} \\ 0 & -\frac{i}{8} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{8} & 0 \end{bmatrix}$ |
| 101 | symmetry | $-\frac{\sqrt{35}xz(x-z)(x+z)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{6}i}{8} & 0 & 0 & 0 & \frac{\sqrt{10}i}{8} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{i}{8} & 0 & 0 & 0 & \frac{\sqrt{15}i}{8} & 0 & 0 \end{bmatrix}$ |
| 102 | symmetry | $\frac{\sqrt{35}xy(x-y)(x+y)}{2}$ |
| | | $\begin{bmatrix} 0 & \frac{i}{2} & 0 & 0 & 0 & 0 & 0 \\ \frac{i}{2} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 103 | symmetry | $\frac{\sqrt{5}yz(6x^2-y^2-z^2)}{2}$ |

continued ...

Table 7

| No. | multipole | matrix |
|-----|-------------------------------|---|
| | $\mathbb{T}_{4,1}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{42}i}{14} & 0 & 0 & 0 \\ 0 & 0 & \frac{3\sqrt{42}i}{56} & 0 & 0 & 0 & -\frac{\sqrt{70}i}{56} \\ 0 & \frac{\sqrt{7}i}{8} & 0 & 0 & 0 & -\frac{\sqrt{105}i}{56} & 0 \end{bmatrix}$ |
| 104 | symmetry | $-\frac{\sqrt{5}xz(x^2-6y^2+z^2)}{2}$ |
| | $\mathbb{T}_{4,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & -\frac{3\sqrt{42}i}{56} & 0 & 0 & 0 & -\frac{\sqrt{70}i}{56} \\ 0 & 0 & 0 & \frac{\sqrt{42}i}{14} & 0 & 0 & 0 \\ -\frac{\sqrt{7}i}{8} & 0 & 0 & 0 & -\frac{\sqrt{105}i}{56} & 0 & 0 \end{bmatrix}$ |
| 105 | symmetry | $-\frac{\sqrt{5}xy(x^2+y^2-6z^2)}{2}$ |
| | $\mathbb{T}_{4,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & -\frac{\sqrt{7}i}{28} & 0 & 0 & 0 & \frac{\sqrt{105}i}{28} & 0 \\ \frac{\sqrt{7}i}{28} & 0 & 0 & 0 & \frac{\sqrt{105}i}{28} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{42}i}{14} & 0 & 0 & 0 \end{bmatrix}$ |
| 106 | symmetry | $\sqrt{15}xyz$ |
| | $\mathbb{M}_3^{(a)}(A_2)$ | $\begin{bmatrix} \frac{i}{4} & 0 & 0 & 0 & \frac{\sqrt{15}i}{12} & 0 & 0 \\ 0 & \frac{i}{4} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 \\ 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 107 | symmetry | $\frac{x(2x^2-3y^2-3z^2)}{2}$ |
| | $\mathbb{M}_{3,1}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{10}i}{8} & 0 & 0 & 0 & \frac{\sqrt{6}i}{8} \\ 0 & \frac{\sqrt{15}i}{8} & 0 & 0 & 0 & -\frac{i}{8} & 0 \end{bmatrix}$ |
| 108 | symmetry | $-\frac{y(3x^2-2y^2+3z^2)}{2}$ |
| | $\mathbb{M}_{3,2}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{10}i}{8} & 0 & 0 & 0 & -\frac{\sqrt{6}i}{8} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{15}i}{8} & 0 & 0 & 0 & \frac{i}{8} & 0 & 0 \end{bmatrix}$ |
| 109 | symmetry | $-\frac{z(3x^2+3y^2-2z^2)}{2}$ |
| | $\mathbb{M}_{3,3}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -\frac{i}{2} & 0 \\ 0 & 0 & 0 & 0 & \frac{i}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 110 | symmetry | $\frac{\sqrt{15}x(y-z)(y+z)}{2}$ |

continued ...

Table 7

| No. | multipole | matrix |
|-----|-------------------------------|---|
| | $\mathbb{M}_{3,1}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{6}i}{6} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{6}i}{24} & 0 & 0 & 0 & \frac{\sqrt{10}i}{8} \\ 0 & -\frac{3i}{8} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{24} & 0 \end{bmatrix}$ |
| 111 | symmetry | $-\frac{\sqrt{15}y(x-z)(x+z)}{2}$ |
| | $\mathbb{M}_{3,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{6}i}{24} & 0 & 0 & 0 & \frac{\sqrt{10}i}{8} \\ 0 & 0 & 0 & \frac{\sqrt{6}i}{6} & 0 & 0 & 0 \\ \frac{3i}{8} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{24} & 0 & 0 \end{bmatrix}$ |
| 112 | symmetry | $\frac{\sqrt{15}z(x-y)(x+y)}{2}$ |
| | $\mathbb{M}_{3,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & -\frac{i}{4} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 \\ \frac{i}{4} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{6}i}{6} & 0 & 0 & 0 \end{bmatrix}$ |

bra: $= \langle d_v |, \langle d_{xy} |, \langle d_{xz} |, \langle d_{yz} |, \langle d_u |$
ket: $= |d_v\rangle, |d_{xy}\rangle, |d_{xz}\rangle, |d_{yz}\rangle, |d_u\rangle$

Table 8: (d,d) block.

| No. | multipole | matrix |
|-----|---------------------------|--|
| 113 | symmetry | 1 |
| | $\mathbb{Q}_0^{(a)}(A_1)$ | $\begin{bmatrix} \frac{\sqrt{5}}{5} & 0 & 0 & 0 & 0 \\ 0 & \frac{\sqrt{5}}{5} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{5}}{5} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{5}}{5} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{5}}{5} \end{bmatrix}$ |
| 114 | symmetry | $-\frac{x^2}{2} - \frac{y^2}{2} + z^2$ |

continued ...

Table 8

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} -\frac{\sqrt{14}}{7} & 0 & 0 & 0 & 0 \\ 0 & -\frac{\sqrt{14}}{7} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{14}}{14} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{14}}{14} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{14}}{7} \end{bmatrix}$ |
| 115 | symmetry | $\frac{\sqrt{3}(x-y)(x+y)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & -\frac{\sqrt{14}}{7} \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{42}}{14} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{42}}{14} & 0 \\ -\frac{\sqrt{14}}{7} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 116 | symmetry | $\sqrt{3}yz$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & -\frac{\sqrt{42}}{14} & 0 \\ 0 & 0 & \frac{\sqrt{42}}{14} & 0 & 0 \\ 0 & \frac{\sqrt{42}}{14} & 0 & 0 & 0 \\ -\frac{\sqrt{42}}{14} & 0 & 0 & 0 & \frac{\sqrt{14}}{14} \\ 0 & 0 & 0 & \frac{\sqrt{14}}{14} & 0 \end{bmatrix}$ |
| 117 | symmetry | $\sqrt{3}xz$ |
| | | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{42}}{14} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{42}}{14} & 0 \\ \frac{\sqrt{42}}{14} & 0 & 0 & 0 & \frac{\sqrt{14}}{14} \\ 0 & \frac{\sqrt{42}}{14} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{14}}{14} & 0 & 0 \end{bmatrix}$ |
| 118 | symmetry | $\sqrt{3}xy$ |

continued ...

Table 8

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\frac{\sqrt{14}}{7} \\ 0 & 0 & 0 & \frac{\sqrt{14}}{14} & 0 \\ 0 & 0 & \frac{\sqrt{42}}{14} & 0 & 0 \\ 0 & -\frac{\sqrt{14}}{7} & 0 & 0 & 0 \end{bmatrix}$ |
| 119 | symmetry | $\frac{\sqrt{21}(x^4 - 3x^2y^2 - 3x^2z^2 + y^4 - 3y^2z^2 + z^4)}{6}$ |
| | | $\begin{bmatrix} \frac{\sqrt{30}}{10} & 0 & 0 & 0 & 0 \\ 0 & -\frac{\sqrt{30}}{15} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{30}}{15} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{30}}{15} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{30}}{10} \end{bmatrix}$ |
| 120 | symmetry | $-\frac{\sqrt{15}(x^4 - 12x^2y^2 + 6x^2z^2 + y^4 + 6y^2z^2 - 2z^4)}{12}$ |
| | | $\begin{bmatrix} -\frac{\sqrt{42}}{14} & 0 & 0 & 0 & 0 \\ 0 & \frac{2\sqrt{42}}{21} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{42}}{21} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{42}}{21} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{42}}{14} \end{bmatrix}$ |
| 121 | symmetry | $\frac{\sqrt{5}(x-y)(x+y)(x^2+y^2-6z^2)}{4}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & -\frac{\sqrt{42}}{14} \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{14}}{7} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{14}}{7} & 0 \\ -\frac{\sqrt{42}}{14} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 122 | symmetry | $\frac{\sqrt{35}yz(y-z)(y+z)}{2}$ |

continued ...

Table 8

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & 0 & 0 & -\frac{\sqrt{2}}{4} & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{2}}{4} & 0 & 0 & 0 & -\frac{\sqrt{6}}{4} \\ 0 & 0 & 0 & -\frac{\sqrt{6}}{4} & 0 \end{bmatrix}$ |
| 123 | symmetry | $-\frac{\sqrt{35}xz(x-z)(x+z)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{2}}{4} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{2}}{4} & 0 & 0 & 0 & \frac{\sqrt{6}}{4} \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{6}}{4} & 0 & 0 \end{bmatrix}$ |
| 124 | symmetry | $\frac{\sqrt{35}xy(x-y)(x+y)}{2}$ |
| | | $\begin{bmatrix} 0 & \frac{\sqrt{2}}{2} & 0 & 0 & 0 \\ \frac{\sqrt{2}}{2} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 125 | symmetry | $\frac{\sqrt{5}yz(6x^2-y^2-z^2)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & \frac{3\sqrt{14}}{28} & 0 \\ 0 & 0 & \frac{\sqrt{14}}{7} & 0 & 0 \\ 0 & \frac{\sqrt{14}}{7} & 0 & 0 & 0 \\ \frac{3\sqrt{14}}{28} & 0 & 0 & 0 & -\frac{\sqrt{42}}{28} \\ 0 & 0 & 0 & -\frac{\sqrt{42}}{28} & 0 \end{bmatrix}$ |
| 126 | symmetry | $-\frac{\sqrt{5}xz(x^2-6y^2+z^2)}{2}$ |

continued ...

Table 8

| No. | multipole | matrix |
|-------------------------------|-----------|--|
| $\mathbb{Q}_{4,2}^{(a)}(T_2)$ | | $\begin{bmatrix} 0 & 0 & -\frac{3\sqrt{14}}{28} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{14}}{7} & 0 \\ -\frac{3\sqrt{14}}{28} & 0 & 0 & 0 & -\frac{\sqrt{42}}{28} \\ 0 & \frac{\sqrt{14}}{7} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{42}}{28} & 0 & 0 \end{bmatrix}$ |
| 127 | symmetry | $-\frac{\sqrt{5}xy(x^2+y^2-6z^2)}{2}$ |
| $\mathbb{Q}_{4,3}^{(a)}(T_2)$ | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{42}}{14} \\ 0 & 0 & 0 & \frac{\sqrt{14}}{7} & 0 \\ 0 & 0 & \frac{\sqrt{14}}{7} & 0 & 0 \\ 0 & \frac{\sqrt{42}}{14} & 0 & 0 & 0 \end{bmatrix}$ |
| 128 | symmetry | x |
| $\mathbb{M}_{1,1}^{(a)}(T_1)$ | | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{10}i}{10} & 0 \\ 0 & 0 & -\frac{\sqrt{10}i}{10} & 0 & 0 \\ 0 & \frac{\sqrt{10}i}{10} & 0 & 0 & 0 \\ -\frac{\sqrt{10}i}{10} & 0 & 0 & 0 & -\frac{\sqrt{30}i}{10} \\ 0 & 0 & 0 & \frac{\sqrt{30}i}{10} & 0 \end{bmatrix}$ |
| 129 | symmetry | y |
| $\mathbb{M}_{1,2}^{(a)}(T_1)$ | | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{10}i}{10} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{10}i}{10} & 0 \\ -\frac{\sqrt{10}i}{10} & 0 & 0 & 0 & \frac{\sqrt{30}i}{10} \\ 0 & -\frac{\sqrt{10}i}{10} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{30}i}{10} & 0 & 0 \end{bmatrix}$ |
| 130 | symmetry | z |

continued ...

Table 8

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} 0 & -\frac{\sqrt{10}i}{5} & 0 & 0 & 0 \\ \frac{\sqrt{10}i}{5} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{10}i}{10} & 0 \\ 0 & 0 & \frac{\sqrt{10}i}{10} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 131 | symmetry | $\sqrt{15}xyz$ $\begin{bmatrix} 0 & 0 & 0 & 0 & \frac{\sqrt{2}i}{2} \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{2}i}{2} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 132 | symmetry | $\frac{x(2x^2-3y^2-3z^2)}{2}$ $\begin{bmatrix} 0 & 0 & 0 & -\frac{\sqrt{10}i}{20} & 0 \\ 0 & 0 & -\frac{\sqrt{10}i}{5} & 0 & 0 \\ 0 & \frac{\sqrt{10}i}{5} & 0 & 0 & 0 \\ \frac{\sqrt{10}i}{20} & 0 & 0 & 0 & \frac{\sqrt{30}i}{20} \\ 0 & 0 & 0 & -\frac{\sqrt{30}i}{20} & 0 \end{bmatrix}$ |
| 133 | symmetry | $-\frac{y(3x^2-2y^2+3z^2)}{2}$ $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{10}i}{20} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{10}i}{5} & 0 \\ \frac{\sqrt{10}i}{20} & 0 & 0 & 0 & -\frac{\sqrt{30}i}{20} \\ 0 & -\frac{\sqrt{10}i}{5} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{30}i}{20} & 0 & 0 \end{bmatrix}$ |
| 134 | symmetry | $-\frac{z(3x^2+3y^2-2z^2)}{2}$ |

continued ...

Table 8

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & \frac{\sqrt{10}i}{10} & 0 & 0 & 0 \\ -\frac{\sqrt{10}i}{10} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{10}i}{5} & 0 \\ 0 & 0 & \frac{\sqrt{10}i}{5} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 135 | symmetry | $\frac{\sqrt{15}x(y-z)(y+z)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{6}i}{4} & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{6}i}{4} & 0 & 0 & 0 & \frac{\sqrt{2}i}{4} \\ 0 & 0 & 0 & -\frac{\sqrt{2}i}{4} & 0 \end{bmatrix}$ |
| 136 | symmetry | $-\frac{\sqrt{15}y(x-z)(x+z)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{6}i}{4} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{6}i}{4} & 0 & 0 & 0 & \frac{\sqrt{2}i}{4} \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{2}i}{4} & 0 & 0 \end{bmatrix}$ |
| 137 | symmetry | $\frac{\sqrt{15}z(x-y)(x+y)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\frac{\sqrt{2}i}{2} \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{\sqrt{2}i}{2} & 0 & 0 & 0 \end{bmatrix}$ |

bra: = $\langle d_v |, \langle d_{xy} |, \langle d_{xz} |, \langle d_{yz} |, \langle d_u |$ ket: = $|f_2\rangle, |f_1\rangle, |f_{bz}\rangle, |f_3\rangle, |f_{3x}\rangle, |f_{3y}\rangle, |f_{az}\rangle$

Table 9: (d,f) block.

| No. | multipole | matrix |
|-----|-----------|---|
| 138 | symmetry | x |
| | | $\begin{bmatrix} \frac{\sqrt{21}}{14} & 0 & 0 & 0 & -\frac{\sqrt{35}}{70} & 0 & 0 \\ 0 & \frac{\sqrt{21}}{14} & 0 & 0 & 0 & -\frac{\sqrt{35}}{70} & 0 \\ \mathbb{Q}_{1,1}^{(a)}(T_2) & 0 & 0 & \frac{\sqrt{14}}{14} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{14}}{14} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{105}}{35} & 0 & 0 \end{bmatrix}$ |
| 139 | symmetry | y |
| | | $\begin{bmatrix} 0 & \frac{\sqrt{21}}{14} & 0 & 0 & 0 & \frac{\sqrt{35}}{70} & 0 \\ -\frac{\sqrt{21}}{14} & 0 & 0 & 0 & -\frac{\sqrt{35}}{70} & 0 & 0 \\ \mathbb{Q}_{1,2}^{(a)}(T_2) & 0 & 0 & 0 & \frac{\sqrt{14}}{14} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{14}}{14} & 0 & 0 & -\frac{\sqrt{210}}{70} \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{105}}{35} & 0 \end{bmatrix}$ |
| 140 | symmetry | z |
| | | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{14}}{14} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{14}}{14} & 0 & 0 & 0 \\ \mathbb{Q}_{1,3}^{(a)}(T_2) & 0 & 0 & 0 & 0 & \frac{2\sqrt{35}}{35} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{2\sqrt{35}}{35} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{3\sqrt{70}}{70} \end{bmatrix}$ |
| 141 | symmetry | $\sqrt{15}xyz$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{6}}{6} \\ \mathbb{Q}_3^{(a)}(A_1) & 0 & \frac{\sqrt{15}}{12} & 0 & 0 & \frac{1}{4} & 0 \\ -\frac{\sqrt{15}}{12} & 0 & 0 & 0 & \frac{1}{4} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 142 | symmetry | $\frac{\sqrt{15}x(y-z)(y+z)}{2}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-------------------------------|---|
| | $\mathbb{Q}_{3,1}^{(a)}(T_1)$ | $\begin{bmatrix} \frac{\sqrt{15}}{24} & 0 & 0 & 0 & -\frac{1}{8} & 0 & 0 \\ 0 & \frac{\sqrt{15}}{24} & 0 & 0 & 0 & -\frac{3}{8} & 0 \\ 0 & 0 & -\frac{\sqrt{10}}{8} & 0 & 0 & 0 & -\frac{\sqrt{6}}{24} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{5}}{8} & 0 & 0 & 0 & -\frac{\sqrt{3}}{8} & 0 & 0 \end{bmatrix}$ |
| 143 | symmetry | $-\frac{\sqrt{15}y(x-z)(x+z)}{2}$ $\begin{bmatrix} 0 & -\frac{\sqrt{15}}{24} & 0 & 0 & 0 & -\frac{1}{8} & 0 \\ \frac{\sqrt{15}}{24} & 0 & 0 & 0 & \frac{3}{8} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{10}}{8} & 0 & 0 & 0 & \frac{\sqrt{6}}{24} \\ 0 & \frac{\sqrt{5}}{8} & 0 & 0 & 0 & \frac{\sqrt{3}}{8} & 0 \end{bmatrix}$ |
| 144 | symmetry | $\frac{\sqrt{15}z(x-y)(x+y)}{2}$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{6}}{6} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{15}}{12} & 0 & 0 & 0 & \frac{1}{4} & 0 & 0 \\ 0 & \frac{\sqrt{15}}{12} & 0 & 0 & 0 & -\frac{1}{4} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 145 | symmetry | $\frac{x(2x^2-3y^2-3z^2)}{2}$ $\begin{bmatrix} \frac{1}{8} & 0 & 0 & 0 & -\frac{11\sqrt{15}}{120} & 0 & 0 \\ 0 & \frac{1}{8} & 0 & 0 & 0 & -\frac{\sqrt{15}}{120} & 0 \\ 0 & 0 & \frac{\sqrt{6}}{24} & 0 & 0 & 0 & -\frac{\sqrt{10}}{40} \\ 0 & 0 & 0 & -\frac{\sqrt{6}}{6} & 0 & 0 & 0 \\ -\frac{5\sqrt{3}}{24} & 0 & 0 & 0 & -\frac{3\sqrt{5}}{40} & 0 & 0 \end{bmatrix}$ |
| 146 | symmetry | $-\frac{y(3x^2-2y^2+3z^2)}{2}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-------------------------------|---|
| | $\mathbb{Q}_{3,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & \frac{1}{8} & 0 & 0 & 0 & \frac{11\sqrt{15}}{120} & 0 \\ -\frac{1}{8} & 0 & 0 & 0 & -\frac{\sqrt{15}}{120} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{6}}{6} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{6}}{24} & 0 & 0 & 0 & -\frac{\sqrt{10}}{40} \\ 0 & \frac{5\sqrt{3}}{24} & 0 & 0 & 0 & -\frac{3\sqrt{5}}{40} & 0 \end{bmatrix}$ |
| 147 | symmetry | $-\frac{z(3x^2+3y^2-2z^2)}{2}$ |
| | $\mathbb{Q}_{3,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{6}}{6} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{6}}{6} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{15}}{30} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{15}}{30} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{30}}{15} \end{bmatrix}$ |
| 148 | symmetry | $-\frac{\sqrt{105}xyz(x^2+y^2-2z^2)}{2}$ |
| | $\mathbb{Q}_{5,1}^{(a)}(E)$ | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{3}}{6} \\ 0 & -\frac{\sqrt{30}}{60} & 0 & 0 & 0 & \frac{\sqrt{2}}{4} & 0 \\ \frac{\sqrt{30}}{60} & 0 & 0 & 0 & \frac{\sqrt{2}}{4} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{15}}{10} & 0 & 0 & 0 \end{bmatrix}$ |
| 149 | symmetry | $\frac{3\sqrt{35}xyz(x-y)(x+y)}{2}$ |
| | $\mathbb{Q}_{5,2}^{(a)}(E)$ | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{15}}{10} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{15}}{10} & 0 & 0 & 0 & 0 \\ 0 & \frac{\sqrt{10}}{10} & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{10}}{10} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 150 | symmetry | $\frac{\sqrt{105}x(y-z)(y+z)(2x^2-y^2-z^2)}{4}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-------------------------------|---|
| | $\mathbb{Q}_{5,1}^{(a)}(T_1)$ | $\begin{bmatrix} -\frac{7\sqrt{30}}{120} & 0 & 0 & 0 & -\frac{\sqrt{2}}{8} & 0 & 0 \\ 0 & \frac{\sqrt{30}}{15} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{5}}{10} & 0 & 0 & 0 & \frac{\sqrt{3}}{6} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{10}}{40} & 0 & 0 & 0 & \frac{\sqrt{6}}{8} & 0 & 0 \end{bmatrix}$ |
| 151 | symmetry | $\frac{\sqrt{105}y(x-z)(x+z)(x^2-2y^2+z^2)}{4}$ $\begin{bmatrix} 0 & \frac{7\sqrt{30}}{120} & 0 & 0 & 0 & -\frac{\sqrt{2}}{8} & 0 \\ \frac{\sqrt{30}}{15} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{5}}{10} & 0 & 0 & 0 & -\frac{\sqrt{3}}{6} \\ 0 & -\frac{\sqrt{10}}{40} & 0 & 0 & 0 & -\frac{\sqrt{6}}{8} & 0 \end{bmatrix}$ |
| 152 | symmetry | $-\frac{\sqrt{105}z(x-y)(x+y)(x^2+y^2-2z^2)}{4}$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{3}}{6} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{30}}{60} & 0 & 0 & 0 & \frac{\sqrt{2}}{4} & 0 & 0 \\ 0 & -\frac{\sqrt{30}}{60} & 0 & 0 & 0 & -\frac{\sqrt{2}}{4} & 0 \\ 0 & 0 & \frac{\sqrt{15}}{10} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 153 | symmetry | $\frac{x(8x^4-40x^2y^2-40x^2z^2+15y^4+30y^2z^2+15z^4)}{8}$ $\begin{bmatrix} \frac{11\sqrt{14}}{112} & 0 & 0 & 0 & -\frac{5\sqrt{210}}{336} & 0 & 0 \\ 0 & -\frac{5\sqrt{14}}{56} & 0 & 0 & 0 & \frac{\sqrt{210}}{168} & 0 \\ 0 & 0 & -\frac{5\sqrt{21}}{84} & 0 & 0 & 0 & \frac{\sqrt{35}}{28} \\ 0 & 0 & 0 & \frac{\sqrt{21}}{42} & 0 & 0 & 0 \\ -\frac{\sqrt{42}}{48} & 0 & 0 & 0 & \frac{3\sqrt{70}}{112} & 0 & 0 \end{bmatrix}$ |
| 154 | symmetry | $\frac{y(15x^4-40x^2y^2+30x^2z^2+8y^4-40y^2z^2+15z^4)}{8}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & \frac{11\sqrt{14}}{112} & 0 & 0 & 0 & \frac{5\sqrt{210}}{336} & 0 \\ \frac{5\sqrt{14}}{56} & 0 & 0 & 0 & \frac{\sqrt{210}}{168} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{21}}{42} & 0 & 0 & 0 \\ 0 & 0 & \frac{5\sqrt{21}}{84} & 0 & 0 & 0 & \frac{\sqrt{35}}{28} \\ 0 & \frac{\sqrt{42}}{48} & 0 & 0 & 0 & \frac{3\sqrt{70}}{112} & 0 \end{bmatrix}$ |
| 155 | symmetry | $\frac{z(15x^4 + 30x^2y^2 - 40x^2z^2 + 15y^4 - 40y^2z^2 + 8z^4)}{8}$ $\begin{bmatrix} 0 & 0 & \frac{\sqrt{21}}{42} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{21}}{42} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\frac{\sqrt{210}}{42} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{210}}{42} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{105}}{21} \end{bmatrix}$ |
| 156 | symmetry | $\frac{3\sqrt{35}x(y^2 - 2yz - z^2)(y^2 + 2yz - z^2)}{8}$ $\begin{bmatrix} \frac{3\sqrt{10}}{80} & 0 & 0 & 0 & \frac{\sqrt{6}}{16} & 0 & 0 \\ 0 & -\frac{\sqrt{10}}{40} & 0 & 0 & 0 & -\frac{\sqrt{6}}{8} & 0 \\ 0 & 0 & \frac{\sqrt{15}}{20} & 0 & 0 & 0 & \frac{1}{4} \\ 0 & 0 & 0 & -\frac{\sqrt{15}}{10} & 0 & 0 & 0 \\ \frac{3\sqrt{30}}{80} & 0 & 0 & 0 & \frac{3\sqrt{2}}{16} & 0 & 0 \end{bmatrix}$ |
| 157 | symmetry | $\frac{3\sqrt{35}y(x^2 - 2xz - z^2)(x^2 + 2xz - z^2)}{8}$ $\begin{bmatrix} 0 & \frac{3\sqrt{10}}{80} & 0 & 0 & 0 & -\frac{\sqrt{6}}{16} & 0 \\ \frac{\sqrt{10}}{40} & 0 & 0 & 0 & -\frac{\sqrt{6}}{8} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{15}}{10} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{15}}{20} & 0 & 0 & 0 & \frac{1}{4} \\ 0 & -\frac{3\sqrt{30}}{80} & 0 & 0 & 0 & \frac{3\sqrt{2}}{16} & 0 \end{bmatrix}$ |
| 158 | symmetry | $\frac{3\sqrt{35}z(x^2 - 2xy - y^2)(x^2 + 2xy - y^2)}{8}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{15}}{10} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{15}}{10} & 0 & 0 & 0 \\ \frac{\sqrt{10}}{10} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\frac{\sqrt{10}}{10} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 159 | symmetry | $-\frac{\sqrt{3}(x-y)(x+y)}{2}$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{7}}{14} \\ 0 & \frac{\sqrt{70}}{28} & 0 & 0 & 0 & -\frac{\sqrt{42}}{28} & 0 \\ -\frac{\sqrt{70}}{28} & 0 & 0 & 0 & -\frac{\sqrt{42}}{28} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{35}}{14} & 0 & 0 & 0 \end{bmatrix}$ |
| 160 | symmetry | $-\frac{x^2}{2} - \frac{y^2}{2} + z^2$ $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{35}}{14} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{35}}{14} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{14}}{14} & 0 \\ 0 & 0 & 0 & 0 & -\frac{\sqrt{14}}{14} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 161 | symmetry | $\sqrt{3}yz$ $\begin{bmatrix} -\frac{\sqrt{70}}{28} & 0 & 0 & 0 & -\frac{\sqrt{42}}{28} & 0 & 0 \\ 0 & -\frac{\sqrt{70}}{28} & 0 & 0 & 0 & -\frac{\sqrt{42}}{28} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{7}}{7} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{14}}{14} & 0 & 0 \end{bmatrix}$ |
| 162 | symmetry | $\sqrt{3}xz$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & \frac{\sqrt{70}}{28} & 0 & 0 & 0 & -\frac{\sqrt{42}}{28} & 0 \\ -\frac{\sqrt{70}}{28} & 0 & 0 & 0 & \frac{\sqrt{42}}{28} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{7}}{7} \\ 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{14}}{14} & 0 \end{bmatrix}$ |
| 163 | symmetry | $\sqrt{3}xy$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{7}}{14} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{70}}{28} & 0 & 0 & 0 & -\frac{\sqrt{42}}{28} & 0 & 0 \\ 0 & \frac{\sqrt{70}}{28} & 0 & 0 & 0 & \frac{\sqrt{42}}{28} & 0 \\ 0 & 0 & \frac{\sqrt{35}}{14} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 164 | symmetry | $\frac{\sqrt{21}(x^4 - 3x^2y^2 - 3x^2z^2 + y^4 - 3y^2z^2 + z^4)}{6}$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{6}}{6} & 0 & 0 & 0 & 0 \\ 0 & -\frac{1}{4} & 0 & 0 & 0 & \frac{\sqrt{15}}{12} & 0 \\ -\frac{1}{4} & 0 & 0 & 0 & -\frac{\sqrt{15}}{12} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 165 | symmetry | $-\frac{\sqrt{5}(x-y)(x+y)(x^2+y^2-6z^2)}{4}$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{42}}{14} \\ 0 & \frac{3\sqrt{105}}{140} & 0 & 0 & 0 & \frac{\sqrt{7}}{28} & 0 \\ -\frac{3\sqrt{105}}{140} & 0 & 0 & 0 & \frac{\sqrt{7}}{28} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{210}}{35} & 0 & 0 & 0 \end{bmatrix}$ |
| 166 | symmetry | $-\frac{\sqrt{15}(x^4 - 12x^2y^2 + 6x^2z^2 + y^4 + 6y^2z^2 - 2z^4)}{12}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-------------------------------|--|
| | $\mathbb{G}_{4,2}^{(a)}(E)$ | $\begin{bmatrix} 0 & 0 & 0 & -\frac{\sqrt{210}}{35} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{210}}{210} & 0 & 0 & 0 & 0 \\ 0 & \frac{\sqrt{35}}{20} & 0 & 0 & 0 & \frac{5\sqrt{21}}{84} & 0 \\ \frac{\sqrt{35}}{20} & 0 & 0 & 0 & -\frac{5\sqrt{21}}{84} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 167 | symmetry | $\frac{\sqrt{5}yz(6x^2-y^2-z^2)}{2}$ |
| | $\mathbb{G}_{4,1}^{(a)}(T_1)$ | $\begin{bmatrix} -\frac{\sqrt{105}}{280} & 0 & 0 & 0 & -\frac{9\sqrt{7}}{56} & 0 & 0 \\ 0 & -\frac{\sqrt{105}}{280} & 0 & 0 & 0 & \frac{5\sqrt{7}}{56} & 0 \\ 0 & 0 & \frac{\sqrt{70}}{40} & 0 & 0 & 0 & \frac{\sqrt{42}}{56} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{3\sqrt{35}}{40} & 0 & 0 & 0 & -\frac{\sqrt{21}}{56} & 0 & 0 \end{bmatrix}$ |
| 168 | symmetry | $-\frac{\sqrt{5}xz(x^2-6y^2+z^2)}{2}$ |
| | $\mathbb{G}_{4,2}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & \frac{\sqrt{105}}{280} & 0 & 0 & 0 & -\frac{9\sqrt{7}}{56} & 0 \\ -\frac{\sqrt{105}}{280} & 0 & 0 & 0 & -\frac{5\sqrt{7}}{56} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{70}}{40} & 0 & 0 & 0 & -\frac{\sqrt{42}}{56} \\ 0 & \frac{3\sqrt{35}}{40} & 0 & 0 & 0 & \frac{\sqrt{21}}{56} & 0 \end{bmatrix}$ |
| 169 | symmetry | $-\frac{\sqrt{5}xy(x^2+y^2-6z^2)}{2}$ |
| | $\mathbb{G}_{4,3}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{42}}{14} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{3\sqrt{105}}{140} & 0 & 0 & 0 & -\frac{\sqrt{7}}{28} & 0 & 0 \\ 0 & -\frac{3\sqrt{105}}{140} & 0 & 0 & 0 & \frac{\sqrt{7}}{28} & 0 \\ 0 & 0 & \frac{\sqrt{210}}{35} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 170 | symmetry | $\frac{\sqrt{35}yz(y-z)(y+z)}{2}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-------------------------------|--|
| | $\mathbb{G}_{4,1}^{(a)}(T_2)$ | $\begin{bmatrix} -\frac{\sqrt{15}}{40} & 0 & 0 & 0 & -\frac{1}{8} & 0 & 0 \\ 0 & -\frac{\sqrt{15}}{40} & 0 & 0 & 0 & -\frac{3}{8} & 0 \\ 0 & 0 & \frac{3\sqrt{10}}{40} & 0 & 0 & 0 & \frac{\sqrt{6}}{8} \\ 0 & 0 & 0 & \frac{\sqrt{10}}{10} & 0 & 0 & 0 \\ -\frac{3\sqrt{5}}{40} & 0 & 0 & 0 & -\frac{\sqrt{3}}{8} & 0 & 0 \end{bmatrix}$ |
| 171 | symmetry | $-\frac{\sqrt{35}xz(x-z)(x+z)}{2}$ |
| | $\mathbb{G}_{4,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & -\frac{\sqrt{15}}{40} & 0 & 0 & 0 & \frac{1}{8} & 0 \\ \frac{\sqrt{15}}{40} & 0 & 0 & 0 & -\frac{3}{8} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{10}}{10} & 0 & 0 & 0 \\ 0 & 0 & -\frac{3\sqrt{10}}{40} & 0 & 0 & 0 & \frac{\sqrt{6}}{8} \\ 0 & \frac{3\sqrt{5}}{40} & 0 & 0 & 0 & -\frac{\sqrt{3}}{8} & 0 \end{bmatrix}$ |
| 172 | symmetry | $\frac{\sqrt{35}xy(x-y)(x+y)}{2}$ |
| | $\mathbb{G}_{4,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{10}}{10} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{10}}{10} & 0 & 0 & 0 \\ \frac{\sqrt{15}}{10} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\frac{\sqrt{15}}{10} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 173 | symmetry | x |
| | $\mathbb{T}_{1,1}^{(a)}(T_2)$ | $\begin{bmatrix} \frac{\sqrt{21}i}{14} & 0 & 0 & 0 & -\frac{\sqrt{35}i}{70} & 0 & 0 \\ 0 & \frac{\sqrt{21}i}{14} & 0 & 0 & 0 & -\frac{\sqrt{35}i}{70} & 0 \\ 0 & 0 & \frac{\sqrt{14}i}{14} & 0 & 0 & 0 & -\frac{\sqrt{210}i}{70} \\ 0 & 0 & 0 & \frac{\sqrt{14}i}{14} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{105}i}{35} & 0 & 0 \end{bmatrix}$ |
| 174 | symmetry | y |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-------------------------------|---|
| | $\mathbb{T}_{1,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & \frac{\sqrt{21}i}{14} & 0 & 0 & 0 & \frac{\sqrt{35}i}{70} & 0 \\ -\frac{\sqrt{21}i}{14} & 0 & 0 & 0 & -\frac{\sqrt{35}i}{70} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{14}i}{14} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{14}i}{14} & 0 & 0 & 0 & -\frac{\sqrt{210}i}{70} \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{105}i}{35} & 0 \end{bmatrix}$ |
| 175 | symmetry | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{14}i}{14} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{14}i}{14} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{2\sqrt{35}i}{35} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{2\sqrt{35}i}{35} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{3\sqrt{70}i}{70} \end{bmatrix}$ |
| 176 | symmetry | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{6}i}{6} \\ 0 & \frac{\sqrt{15}i}{12} & 0 & 0 & 0 & \frac{i}{4} & 0 \\ -\frac{\sqrt{15}i}{12} & 0 & 0 & 0 & \frac{i}{4} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 177 | symmetry | $\begin{bmatrix} \frac{\sqrt{15}i}{24} & 0 & 0 & 0 & -\frac{i}{8} & 0 & 0 \\ 0 & \frac{\sqrt{15}i}{24} & 0 & 0 & 0 & -\frac{3i}{8} & 0 \\ 0 & 0 & -\frac{\sqrt{10}i}{8} & 0 & 0 & 0 & -\frac{\sqrt{6}i}{24} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{5}i}{8} & 0 & 0 & 0 & -\frac{\sqrt{3}i}{8} & 0 & 0 \end{bmatrix}$ |
| 178 | symmetry | $-\frac{\sqrt{15}y(x-z)(x+z)}{2}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} 0 & -\frac{\sqrt{15}i}{24} & 0 & 0 & 0 & -\frac{i}{8} & 0 \\ \frac{\sqrt{15}i}{24} & 0 & 0 & 0 & \frac{3i}{8} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{10}i}{8} & 0 & 0 & 0 & \frac{\sqrt{6}i}{24} \\ 0 & \frac{\sqrt{5}i}{8} & 0 & 0 & 0 & \frac{\sqrt{3}i}{8} & 0 \end{bmatrix}$ |
| 179 | symmetry | $\frac{\sqrt{15}z(x-y)(x+y)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{6}i}{6} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{15}i}{12} & 0 & 0 & 0 & \frac{i}{4} & 0 & 0 \\ 0 & \frac{\sqrt{15}i}{12} & 0 & 0 & 0 & -\frac{i}{4} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 180 | symmetry | $\frac{x(2x^2-3y^2-3z^2)}{2}$ |
| | | $\begin{bmatrix} \frac{i}{8} & 0 & 0 & 0 & -\frac{11\sqrt{15}i}{120} & 0 & 0 \\ 0 & \frac{i}{8} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{120} & 0 \\ 0 & 0 & \frac{\sqrt{6}i}{24} & 0 & 0 & 0 & -\frac{\sqrt{10}i}{40} \\ 0 & 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 \\ -\frac{5\sqrt{3}i}{24} & 0 & 0 & 0 & -\frac{3\sqrt{5}i}{40} & 0 & 0 \end{bmatrix}$ |
| 181 | symmetry | $-\frac{y(3x^2-2y^2+3z^2)}{2}$ |
| | | $\begin{bmatrix} 0 & \frac{i}{8} & 0 & 0 & 0 & \frac{11\sqrt{15}i}{120} & 0 \\ -\frac{i}{8} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{120} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{6}i}{24} & 0 & 0 & 0 & -\frac{\sqrt{10}i}{40} \\ 0 & \frac{5\sqrt{3}i}{24} & 0 & 0 & 0 & -\frac{3\sqrt{5}i}{40} & 0 \end{bmatrix}$ |
| 182 | symmetry | $-\frac{z(3x^2+3y^2-2z^2)}{2}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-------------------------------|--|
| | $\mathbb{T}_{3,3}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{15}i}{30} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{15}i}{30} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{30}i}{15} \end{bmatrix}$ |
| 183 | symmetry | $-\frac{\sqrt{105}xyz(x^2+y^2-2z^2)}{2}$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{3}i}{6} \\ 0 & -\frac{\sqrt{30}i}{60} & 0 & 0 & 0 & \frac{\sqrt{2}i}{4} & 0 \\ \frac{\sqrt{30}i}{60} & 0 & 0 & 0 & \frac{\sqrt{2}i}{4} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{15}i}{10} & 0 & 0 & 0 \end{bmatrix}$ |
| 184 | symmetry | $\frac{3\sqrt{35}xyz(x-y)(x+y)}{2}$ $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{15}i}{10} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{15}i}{10} & 0 & 0 & 0 & 0 \\ 0 & \frac{\sqrt{10}i}{10} & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{10}i}{10} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 185 | symmetry | $\frac{\sqrt{105}x(y-z)(y+z)(2x^2-y^2-z^2)}{4}$ $\begin{bmatrix} -\frac{7\sqrt{30}i}{120} & 0 & 0 & 0 & -\frac{\sqrt{2}i}{8} & 0 & 0 \\ 0 & \frac{\sqrt{30}i}{15} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{5}i}{10} & 0 & 0 & 0 & \frac{\sqrt{3}i}{6} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{10}i}{40} & 0 & 0 & 0 & \frac{\sqrt{6}i}{8} & 0 & 0 \end{bmatrix}$ |
| 186 | symmetry | $\frac{\sqrt{105}y(x-z)(x+z)(x^2-2y^2+z^2)}{4}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|----------------------------------|---|
| | $\mathbb{T}_{5,2}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & \frac{7\sqrt{30}i}{120} & 0 & 0 & 0 & -\frac{\sqrt{2}i}{8} & 0 \\ \frac{\sqrt{30}i}{15} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{5}i}{10} & 0 & 0 & 0 & -\frac{\sqrt{3}i}{6} \\ 0 & -\frac{\sqrt{10}i}{40} & 0 & 0 & 0 & -\frac{\sqrt{6}i}{8} & 0 \end{bmatrix}$ |
| 187 | symmetry | $-\frac{\sqrt{105}z(x-y)(x+y)(x^2+y^2-2z^2)}{4}$ |
| | $\mathbb{T}_{5,3}^{(a)}(T_1)$ | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{3}i}{6} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{30}i}{60} & 0 & 0 & 0 & \frac{\sqrt{2}i}{4} & 0 & 0 \\ 0 & -\frac{\sqrt{30}i}{60} & 0 & 0 & 0 & -\frac{\sqrt{2}i}{4} & 0 \\ 0 & 0 & \frac{\sqrt{15}i}{10} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 188 | symmetry | $\frac{x(8x^4-40x^2y^2-40x^2z^2+15y^4+30y^2z^2+15z^4)}{8}$ |
| | $\mathbb{T}_{5,1}^{(a)}(T_2, 1)$ | $\begin{bmatrix} \frac{11\sqrt{14}i}{112} & 0 & 0 & 0 & -\frac{5\sqrt{210}i}{336} & 0 & 0 \\ 0 & -\frac{5\sqrt{14}i}{56} & 0 & 0 & 0 & \frac{\sqrt{210}i}{168} & 0 \\ 0 & 0 & -\frac{5\sqrt{21}i}{84} & 0 & 0 & 0 & \frac{\sqrt{35}i}{28} \\ 0 & 0 & 0 & \frac{\sqrt{21}i}{42} & 0 & 0 & 0 \\ -\frac{\sqrt{42}i}{48} & 0 & 0 & 0 & \frac{3\sqrt{70}i}{112} & 0 & 0 \end{bmatrix}$ |
| 189 | symmetry | $\frac{y(15x^4-40x^2y^2+30x^2z^2+8y^4-40y^2z^2+15z^4)}{8}$ |
| | $\mathbb{T}_{5,2}^{(a)}(T_2, 1)$ | $\begin{bmatrix} 0 & \frac{11\sqrt{14}i}{112} & 0 & 0 & 0 & \frac{5\sqrt{210}i}{336} & 0 \\ \frac{5\sqrt{14}i}{56} & 0 & 0 & 0 & \frac{\sqrt{210}i}{168} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{21}i}{42} & 0 & 0 & 0 \\ 0 & 0 & \frac{5\sqrt{21}i}{84} & 0 & 0 & 0 & \frac{\sqrt{35}i}{28} \\ 0 & \frac{\sqrt{42}i}{48} & 0 & 0 & 0 & \frac{3\sqrt{70}i}{112} & 0 \end{bmatrix}$ |
| 190 | symmetry | $\frac{z(15x^4+30x^2y^2-40x^2z^2+15y^4-40y^2z^2+8z^4)}{8}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{21}i}{42} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{21}i}{42} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\frac{\sqrt{210}i}{42} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{210}i}{42} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{105}i}{21} \end{bmatrix}$ |
| 191 | symmetry | $\frac{3\sqrt{35}x(y^2-2yz-z^2)(y^2+2yz-z^2)}{8}$ |
| | | $\begin{bmatrix} \frac{3\sqrt{10}i}{80} & 0 & 0 & 0 & \frac{\sqrt{6}i}{16} & 0 & 0 \\ 0 & -\frac{\sqrt{10}i}{40} & 0 & 0 & 0 & -\frac{\sqrt{6}i}{8} & 0 \\ 0 & 0 & \frac{\sqrt{15}i}{20} & 0 & 0 & 0 & \frac{i}{4} \\ 0 & 0 & 0 & -\frac{\sqrt{15}i}{10} & 0 & 0 & 0 \\ \frac{3\sqrt{30}i}{80} & 0 & 0 & 0 & \frac{3\sqrt{2}i}{16} & 0 & 0 \end{bmatrix}$ |
| 192 | symmetry | $\frac{3\sqrt{35}y(x^2-2xz-z^2)(x^2+2xz-z^2)}{8}$ |
| | | $\begin{bmatrix} 0 & \frac{3\sqrt{10}i}{80} & 0 & 0 & 0 & -\frac{\sqrt{6}i}{16} & 0 \\ \frac{\sqrt{10}i}{40} & 0 & 0 & 0 & -\frac{\sqrt{6}i}{8} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{15}i}{10} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{15}i}{20} & 0 & 0 & 0 & \frac{i}{4} \\ 0 & -\frac{3\sqrt{30}i}{80} & 0 & 0 & 0 & \frac{3\sqrt{2}i}{16} & 0 \end{bmatrix}$ |
| 193 | symmetry | $\frac{3\sqrt{35}z(x^2-2xy-y^2)(x^2+2xy-y^2)}{8}$ |
| | | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{15}i}{10} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{15}i}{10} & 0 & 0 & 0 \\ \frac{\sqrt{10}i}{10} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\frac{\sqrt{10}i}{10} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 194 | symmetry | $-\frac{\sqrt{3}(x-y)(x+y)}{2}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{7}i}{14} \\ 0 & -\frac{\sqrt{70}i}{28} & 0 & 0 & 0 & \frac{\sqrt{42}i}{28} & 0 \\ \frac{\sqrt{70}i}{28} & 0 & 0 & 0 & \frac{\sqrt{42}i}{28} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{35}i}{14} & 0 & 0 & 0 \end{bmatrix}$ |
| 195 | symmetry | $-\frac{x^2}{2} - \frac{y^2}{2} + z^2$ $\begin{bmatrix} 0 & 0 & 0 & -\frac{\sqrt{35}i}{14} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{35}i}{14} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{14}i}{14} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{14}i}{14} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 196 | symmetry | $\sqrt{3}yz$ $\begin{bmatrix} \frac{\sqrt{70}i}{28} & 0 & 0 & 0 & \frac{\sqrt{42}i}{28} & 0 & 0 \\ 0 & \frac{\sqrt{70}i}{28} & 0 & 0 & 0 & \frac{\sqrt{42}i}{28} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{7}i}{7} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\frac{\sqrt{14}i}{14} & 0 & 0 \end{bmatrix}$ |
| 197 | symmetry | $\sqrt{3}xz$ $\begin{bmatrix} 0 & -\frac{\sqrt{70}i}{28} & 0 & 0 & 0 & \frac{\sqrt{42}i}{28} & 0 \\ \frac{\sqrt{70}i}{28} & 0 & 0 & 0 & -\frac{\sqrt{42}i}{28} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{7}i}{7} \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{14}i}{14} & 0 \end{bmatrix}$ |
| 198 | symmetry | $\sqrt{3}xy$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{7}i}{14} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{-\sqrt{70}i}{28} & 0 & 0 & 0 & \frac{\sqrt{42}i}{28} & 0 & 0 \\ 0 & -\frac{\sqrt{70}i}{28} & 0 & 0 & 0 & -\frac{\sqrt{42}i}{28} & 0 \\ 0 & 0 & -\frac{\sqrt{35}i}{14} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 199 | symmetry | $\frac{\sqrt{21}(x^4 - 3x^2y^2 - 3x^2z^2 + y^4 - 3y^2z^2 + z^4)}{6}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 \\ 0 & \frac{i}{4} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 \\ \frac{i}{4} & 0 & 0 & 0 & \frac{\sqrt{15}i}{12} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 200 | symmetry | $-\frac{\sqrt{5}(x-y)(x+y)(x^2+y^2-6z^2)}{4}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{42}i}{14} \\ 0 & -\frac{3\sqrt{105}i}{140} & 0 & 0 & 0 & -\frac{\sqrt{7}i}{28} & 0 \\ \frac{3\sqrt{105}i}{140} & 0 & 0 & 0 & -\frac{\sqrt{7}i}{28} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{210}i}{35} & 0 & 0 & 0 \end{bmatrix}$ |
| 201 | symmetry | $-\frac{\sqrt{15}(x^4 - 12x^2y^2 + 6x^2z^2 + y^4 + 6y^2z^2 - 2z^4)}{12}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{210}i}{35} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{210}i}{210} & 0 & 0 & 0 & 0 \\ 0 & -\frac{\sqrt{35}i}{20} & 0 & 0 & 0 & -\frac{5\sqrt{21}i}{84} & 0 \\ -\frac{\sqrt{35}i}{20} & 0 & 0 & 0 & \frac{5\sqrt{21}i}{84} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 202 | symmetry | $\frac{\sqrt{5}yz(6x^2 - y^2 - z^2)}{2}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} \frac{\sqrt{105}i}{280} & 0 & 0 & 0 & \frac{9\sqrt{7}i}{56} & 0 & 0 \\ 0 & \frac{\sqrt{105}i}{280} & 0 & 0 & 0 & -\frac{5\sqrt{7}i}{56} & 0 \\ \mathbb{M}_{4,1}^{(a)}(T_1) & 0 & 0 & -\frac{\sqrt{70}i}{40} & 0 & 0 & -\frac{\sqrt{42}i}{56} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{3\sqrt{35}i}{40} & 0 & 0 & 0 & \frac{\sqrt{21}i}{56} & 0 & 0 \end{bmatrix}$ |
| 203 | symmetry | $-\frac{\sqrt{5}xz(x^2-6y^2+z^2)}{2}$ |
| | | $\begin{bmatrix} 0 & -\frac{\sqrt{105}i}{280} & 0 & 0 & 0 & \frac{9\sqrt{7}i}{56} & 0 \\ \frac{\sqrt{105}i}{280} & 0 & 0 & 0 & \frac{5\sqrt{7}i}{56} & 0 & 0 \\ \mathbb{M}_{4,2}^{(a)}(T_1) & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{70}i}{40} & 0 & 0 & 0 & \frac{\sqrt{42}i}{56} \\ 0 & -\frac{3\sqrt{35}i}{40} & 0 & 0 & 0 & -\frac{\sqrt{21}i}{56} & 0 \end{bmatrix}$ |
| 204 | symmetry | $-\frac{\sqrt{5}xy(x^2+y^2-6z^2)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{42}i}{14} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \mathbb{M}_{4,3}^{(a)}(T_1) & \frac{3\sqrt{105}i}{140} & 0 & 0 & 0 & \frac{\sqrt{7}i}{28} & 0 \\ 0 & \frac{3\sqrt{105}i}{140} & 0 & 0 & 0 & -\frac{\sqrt{7}i}{28} & 0 \\ 0 & 0 & -\frac{\sqrt{210}i}{35} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 205 | symmetry | $\frac{\sqrt{35}yz(y-z)(y+z)}{2}$ |
| | | $\begin{bmatrix} \frac{\sqrt{15}i}{40} & 0 & 0 & 0 & \frac{i}{8} & 0 & 0 \\ 0 & \frac{\sqrt{15}i}{40} & 0 & 0 & 0 & \frac{3i}{8} & 0 \\ \mathbb{M}_{4,1}^{(a)}(T_2) & 0 & 0 & -\frac{3\sqrt{10}i}{40} & 0 & 0 & 0 & -\frac{\sqrt{6}i}{8} \\ 0 & 0 & 0 & -\frac{\sqrt{10}i}{10} & 0 & 0 & 0 \\ \frac{3\sqrt{5}i}{40} & 0 & 0 & 0 & \frac{\sqrt{3}i}{8} & 0 & 0 \end{bmatrix}$ |
| 206 | symmetry | $-\frac{\sqrt{35}xz(x-z)(x+z)}{2}$ |

continued ...

Table 9

| No. | multipole | matrix |
|-----|-------------------------------|--|
| | $\mathbb{M}_{4,2}^{(a)}(T_2)$ | $\begin{bmatrix} 0 & \frac{\sqrt{15}i}{40} & 0 & 0 & 0 & -\frac{i}{8} & 0 \\ -\frac{\sqrt{15}i}{40} & 0 & 0 & 0 & \frac{3i}{8} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{10}i}{10} & 0 & 0 & 0 \\ 0 & 0 & \frac{3\sqrt{10}i}{40} & 0 & 0 & 0 & -\frac{\sqrt{6}i}{8} \\ 0 & -\frac{3\sqrt{5}i}{40} & 0 & 0 & 0 & \frac{\sqrt{3}i}{8} & 0 \end{bmatrix}$ |
| 207 | symmetry | $\frac{\sqrt{35}xy(x-y)(x+y)}{2}$ $\begin{bmatrix} 0 & 0 & \frac{\sqrt{10}i}{10} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{10}i}{10} & 0 & 0 & 0 \\ -\frac{\sqrt{15}i}{10} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{\sqrt{15}i}{10} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |

bra: = $\langle f_2 |, \langle f_1 |, \langle f_{bz} |, \langle f_3 |, \langle f_{3x} |, \langle f_{3y} |, \langle f_{az} |$ ket: = $|f_2 \rangle, |f_1 \rangle, |f_{bz} \rangle, |f_3 \rangle, |f_{3x} \rangle, |f_{3y} \rangle, |f_{az} \rangle$

Table 10: (f,f) block.

| No. | multipole | matrix |
|-----|-----------|--|
| 208 | symmetry | 1 $\begin{bmatrix} \frac{\sqrt{7}}{7} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{\sqrt{7}}{7} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{7}}{7} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{7}}{7} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{7}}{7} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{7}}{7} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{7}}{7} \end{bmatrix}$ |
| 209 | symmetry | $-\frac{x^2}{2} - \frac{y^2}{2} + z^2$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} -\frac{5\sqrt{21}}{42} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\frac{5\sqrt{21}}{42} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{21}}{14} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{21}}{14} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{2\sqrt{21}}{21} \end{bmatrix}$ |
| 210 | symmetry | $\frac{\sqrt{3}(x-y)(x+y)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & -\frac{\sqrt{105}}{42} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{105}}{42} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{105}}{21} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{105}}{42} & 0 & 0 & 0 & \frac{\sqrt{7}}{7} & 0 & 0 \\ 0 & -\frac{\sqrt{105}}{42} & 0 & 0 & 0 & -\frac{\sqrt{7}}{7} & 0 \\ 0 & 0 & -\frac{\sqrt{105}}{21} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 211 | symmetry | $\sqrt{3}yz$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & -\frac{5\sqrt{42}}{84} & 0 & 0 & 0 \\ 0 & 0 & \frac{5\sqrt{42}}{84} & 0 & 0 & 0 & 0 \\ 0 & \frac{5\sqrt{42}}{84} & 0 & 0 & 0 & -\frac{\sqrt{70}}{28} & 0 \\ -\frac{5\sqrt{42}}{84} & 0 & 0 & 0 & \frac{\sqrt{70}}{28} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{70}}{28} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{70}}{28} & 0 & 0 & 0 & \frac{\sqrt{42}}{42} \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{42}}{42} & 0 \end{bmatrix}$ |
| 212 | symmetry | $\sqrt{3}xz$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & 0 & \frac{5\sqrt{42}}{84} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{5\sqrt{42}}{84} & 0 & 0 & 0 \\ \frac{5\sqrt{42}}{84} & 0 & 0 & 0 & \frac{\sqrt{70}}{28} & 0 & 0 \\ 0 & \frac{5\sqrt{42}}{84} & 0 & 0 & 0 & \frac{\sqrt{70}}{28} & 0 \\ 0 & 0 & \frac{\sqrt{70}}{28} & 0 & 0 & 0 & \frac{\sqrt{42}}{42} \\ 0 & 0 & 0 & \frac{\sqrt{70}}{28} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{42}}{42} & 0 & 0 \end{bmatrix}$ |
| 213 | symmetry | $\sqrt{3}xy$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{105}}{42} & 0 \\ 0 & 0 & 0 & 0 & -\frac{\sqrt{105}}{42} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{105}}{21} \\ 0 & -\frac{\sqrt{105}}{42} & 0 & 0 & 0 & \frac{\sqrt{7}}{7} & 0 \\ \frac{\sqrt{105}}{42} & 0 & 0 & 0 & \frac{\sqrt{7}}{7} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{105}}{21} & 0 & 0 & 0 \end{bmatrix}$ |
| 214 | symmetry | $\frac{\sqrt{21}(x^4 - 3x^2y^2 - 3x^2z^2 + y^4 - 3y^2z^2 + z^4)}{6}$ $\begin{bmatrix} \frac{\sqrt{66}}{44} & 0 & 0 & 0 & -\frac{\sqrt{110}}{44} & 0 & 0 \\ 0 & \frac{\sqrt{66}}{44} & 0 & 0 & 0 & \frac{\sqrt{110}}{44} & 0 \\ 0 & 0 & -\frac{\sqrt{66}}{66} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{66}}{11} & 0 & 0 & 0 \\ -\frac{\sqrt{110}}{44} & 0 & 0 & 0 & \frac{\sqrt{66}}{132} & 0 & 0 \\ 0 & \frac{\sqrt{110}}{44} & 0 & 0 & 0 & \frac{\sqrt{66}}{132} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{66}}{22} \end{bmatrix}$ |
| 215 | symmetry | $-\frac{\sqrt{15}(x^4 - 12x^2y^2 + 6x^2z^2 + y^4 + 6y^2z^2 - 2z^4)}{12}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} \frac{\sqrt{2310}}{308} & 0 & 0 & 0 & \frac{\sqrt{154}}{44} & 0 & 0 \\ 0 & \frac{\sqrt{2310}}{308} & 0 & 0 & 0 & -\frac{\sqrt{154}}{44} & 0 \\ 0 & 0 & -\frac{\sqrt{2310}}{66} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{154}}{44} & 0 & 0 & 0 & \frac{\sqrt{2310}}{924} & 0 & 0 \\ 0 & -\frac{\sqrt{154}}{44} & 0 & 0 & 0 & \frac{\sqrt{2310}}{924} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{2310}}{154} \end{bmatrix}$ |
| 216 | symmetry | $\frac{\sqrt{5}(x-y)(x+y)(x^2+y^2-6z^2)}{4}$ $\begin{bmatrix} 0 & 0 & 0 & 0 & -\frac{3\sqrt{462}}{154} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{3\sqrt{462}}{154} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{462}}{154} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{3\sqrt{462}}{154} & 0 & 0 & 0 & -\frac{\sqrt{770}}{77} & 0 & 0 \\ 0 & -\frac{3\sqrt{462}}{154} & 0 & 0 & 0 & \frac{\sqrt{770}}{77} & 0 \\ 0 & 0 & \frac{\sqrt{462}}{154} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 217 | symmetry | $\frac{\sqrt{35}yz(y-z)(y+z)}{2}$ $\begin{bmatrix} 0 & 0 & 0 & -\frac{\sqrt{165}}{44} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{165}}{44} & 0 & 0 & 0 & \frac{3\sqrt{11}}{44} \\ 0 & \frac{\sqrt{165}}{44} & 0 & 0 & 0 & \frac{3\sqrt{11}}{44} & 0 \\ -\frac{\sqrt{165}}{44} & 0 & 0 & 0 & -\frac{5\sqrt{11}}{44} & 0 & 0 \\ 0 & 0 & 0 & -\frac{5\sqrt{11}}{44} & 0 & 0 & 0 \\ 0 & 0 & \frac{3\sqrt{11}}{44} & 0 & 0 & 0 & -\frac{\sqrt{165}}{44} \\ 0 & \frac{3\sqrt{11}}{44} & 0 & 0 & 0 & -\frac{\sqrt{165}}{44} & 0 \end{bmatrix}$ |
| 218 | symmetry | $-\frac{\sqrt{35}xz(x-z)(x+z)}{2}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{165}}{44} & 0 & 0 & 0 & \frac{3\sqrt{11}}{44} \\ 0 & 0 & 0 & -\frac{\sqrt{165}}{44} & 0 & 0 & 0 \\ -\frac{\sqrt{165}}{44} & 0 & 0 & 0 & \frac{3\sqrt{11}}{44} & 0 & 0 \\ 0 & -\frac{\sqrt{165}}{44} & 0 & 0 & 0 & \frac{5\sqrt{11}}{44} & 0 \\ 0 & 0 & \frac{3\sqrt{11}}{44} & 0 & 0 & 0 & \frac{\sqrt{165}}{44} \\ 0 & 0 & 0 & \frac{5\sqrt{11}}{44} & 0 & 0 & 0 \\ \frac{3\sqrt{11}}{44} & 0 & 0 & 0 & \frac{\sqrt{165}}{44} & 0 & 0 \end{bmatrix}$ |
| 219 | symmetry | $\frac{\sqrt{35}xy(x-y)(x+y)}{2}$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{66}}{22} & 0 \\ 0 & 0 & 0 & 0 & -\frac{\sqrt{66}}{22} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{110}}{22} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{110}}{22} & 0 & 0 & 0 & 0 \\ 0 & -\frac{\sqrt{66}}{22} & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{66}}{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 220 | symmetry | $\frac{\sqrt{5}yz(6x^2-y^2-z^2)}{2}$ $\begin{bmatrix} 0 & 0 & 0 & -\frac{\sqrt{1155}}{308} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{1155}}{308} & 0 & 0 & 0 & -\frac{3\sqrt{77}}{44} \\ 0 & \frac{\sqrt{1155}}{308} & 0 & 0 & 0 & \frac{\sqrt{77}}{28} & 0 \\ -\frac{\sqrt{1155}}{308} & 0 & 0 & 0 & \frac{3\sqrt{77}}{308} & 0 & 0 \\ 0 & 0 & 0 & \frac{3\sqrt{77}}{308} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{77}}{28} & 0 & 0 & 0 & -\frac{\sqrt{1155}}{308} \\ 0 & -\frac{3\sqrt{77}}{44} & 0 & 0 & 0 & -\frac{\sqrt{1155}}{308} & 0 \end{bmatrix}$ |
| 221 | symmetry | $-\frac{\sqrt{5}xz(x^2-6y^2+z^2)}{2}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{1155}}{308} & 0 & 0 & 0 & \frac{3\sqrt{77}}{44} \\ 0 & 0 & 0 & \frac{\sqrt{1155}}{308} & 0 & 0 & 0 \\ \frac{\sqrt{1155}}{308} & 0 & 0 & 0 & -\frac{\sqrt{77}}{28} & 0 & 0 \\ 0 & \frac{\sqrt{1155}}{308} & 0 & 0 & 0 & \frac{3\sqrt{77}}{308} & 0 \\ 0 & 0 & -\frac{\sqrt{77}}{28} & 0 & 0 & 0 & -\frac{\sqrt{1155}}{308} \\ 0 & 0 & 0 & \frac{3\sqrt{77}}{308} & 0 & 0 & 0 \\ \frac{3\sqrt{77}}{44} & 0 & 0 & 0 & -\frac{\sqrt{1155}}{308} & 0 & 0 \end{bmatrix}$ |
| 222 | symmetry | $-\frac{\sqrt{5}xy(x^2+y^2-6z^2)}{2}$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -\frac{3\sqrt{462}}{154} & 0 \\ 0 & 0 & 0 & 0 & \frac{3\sqrt{462}}{154} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{462}}{154} \\ 0 & \frac{3\sqrt{462}}{154} & 0 & 0 & 0 & \frac{\sqrt{770}}{77} & 0 \\ -\frac{3\sqrt{462}}{154} & 0 & 0 & 0 & \frac{\sqrt{770}}{77} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{462}}{154} & 0 & 0 & 0 \end{bmatrix}$ |
| 223 | symmetry | $\frac{\sqrt{2}(2x^6-15x^4y^2-15x^4z^2-15x^2y^4+180x^2y^2z^2-15x^2z^4+2y^6-15y^4z^2-15y^2z^4+2z^6)}{8}$ $\begin{bmatrix} -\frac{\sqrt{462}}{1848} & 0 & 0 & 0 & -\frac{\sqrt{770}}{88} & 0 & 0 \\ 0 & -\frac{\sqrt{462}}{1848} & 0 & 0 & 0 & \frac{\sqrt{770}}{88} & 0 \\ 0 & 0 & -\frac{3\sqrt{462}}{154} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{2\sqrt{462}}{77} & 0 & 0 & 0 \\ -\frac{\sqrt{770}}{88} & 0 & 0 & 0 & -\frac{5\sqrt{462}}{616} & 0 & 0 \\ 0 & \frac{\sqrt{770}}{88} & 0 & 0 & 0 & -\frac{5\sqrt{462}}{616} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{5\sqrt{462}}{462} \end{bmatrix}$ |
| 224 | symmetry | $-\frac{\sqrt{2310}(x-y)(x+y)(x-z)(x+z)(y-z)(y+z)}{8}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------------------------|---|
| | | $\begin{bmatrix} \frac{\sqrt{10}}{8} & 0 & 0 & 0 & \frac{\sqrt{6}}{24} & 0 & 0 \\ 0 & -\frac{\sqrt{10}}{8} & 0 & 0 & 0 & \frac{\sqrt{6}}{24} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{6}}{6} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{6}}{24} & 0 & 0 & 0 & -\frac{\sqrt{10}}{8} & 0 & 0 \\ 0 & \frac{\sqrt{6}}{24} & 0 & 0 & 0 & \frac{\sqrt{10}}{8} & 0 \\ 0 & 0 & -\frac{\sqrt{6}}{6} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 225 | $\mathbb{Q}_6^{(a)}(A_2)$ | $\frac{-\sqrt{14}(x^6 - 15x^4z^2 + 15x^2z^4 + y^6 - 15y^4z^2 + 15y^2z^4 - 2z^6)}{8}$ |
| | | $\begin{bmatrix} -\frac{\sqrt{66}}{264} & 0 & 0 & 0 & \frac{\sqrt{110}}{88} & 0 & 0 \\ 0 & -\frac{\sqrt{66}}{264} & 0 & 0 & 0 & -\frac{\sqrt{110}}{88} & 0 \\ 0 & 0 & \frac{\sqrt{66}}{22} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{110}}{88} & 0 & 0 & 0 & -\frac{5\sqrt{66}}{88} & 0 & 0 \\ 0 & -\frac{\sqrt{110}}{88} & 0 & 0 & 0 & -\frac{5\sqrt{66}}{88} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{5\sqrt{66}}{66} \end{bmatrix}$ |
| 226 | $\mathbb{Q}_{6,1}^{(a)}(E)$ | $\frac{\sqrt{42}(x-y)(x+y)(x^4 - 9x^2y^2 - 5x^2z^2 + y^4 - 5y^2z^2 + 5z^4)}{8}$ |
| | | $\begin{bmatrix} \frac{\sqrt{22}}{8} & 0 & 0 & 0 & -\frac{\sqrt{330}}{264} & 0 & 0 \\ 0 & -\frac{\sqrt{22}}{8} & 0 & 0 & 0 & -\frac{\sqrt{330}}{264} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{330}}{66} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{330}}{264} & 0 & 0 & 0 & \frac{5\sqrt{22}}{88} & 0 & 0 \\ 0 & -\frac{\sqrt{330}}{264} & 0 & 0 & 0 & -\frac{5\sqrt{22}}{88} & 0 \\ 0 & 0 & \frac{\sqrt{330}}{66} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 227 | $\mathbb{Q}_{6,2}^{(a)}(E)$ | $\frac{3\sqrt{7}yz(y-z)(y+z)(10x^2 - y^2 - z^2)}{4}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & 0 & 0 & -\frac{3\sqrt{22}}{44} & 0 & 0 & 0 \\ 0 & 0 & -\frac{5\sqrt{22}}{88} & 0 & 0 & 0 & -\frac{\sqrt{330}}{88} \\ 0 & -\frac{5\sqrt{22}}{88} & 0 & 0 & 0 & -\frac{\sqrt{330}}{88} & 0 \\ -\frac{3\sqrt{22}}{44} & 0 & 0 & 0 & -\frac{\sqrt{330}}{44} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{330}}{44} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{330}}{88} & 0 & 0 & 0 & \frac{5\sqrt{22}}{88} \\ 0 & -\frac{\sqrt{330}}{88} & 0 & 0 & 0 & \frac{5\sqrt{22}}{88} & 0 \end{bmatrix}$ |
| 228 | symmetry | $\frac{3\sqrt{7}xz(x-z)(x+z)(x^2-10y^2+z^2)}{4}$ |
| | | $\begin{bmatrix} 0 & 0 & \frac{5\sqrt{22}}{88} & 0 & 0 & 0 & -\frac{\sqrt{330}}{88} \\ 0 & 0 & 0 & -\frac{3\sqrt{22}}{44} & 0 & 0 & 0 \\ \frac{5\sqrt{22}}{88} & 0 & 0 & 0 & -\frac{\sqrt{330}}{88} & 0 & 0 \\ 0 & -\frac{3\sqrt{22}}{44} & 0 & 0 & 0 & \frac{\sqrt{330}}{44} & 0 \\ 0 & 0 & -\frac{\sqrt{330}}{88} & 0 & 0 & 0 & -\frac{5\sqrt{22}}{88} \\ 0 & 0 & 0 & \frac{\sqrt{330}}{44} & 0 & 0 & 0 \\ -\frac{\sqrt{330}}{88} & 0 & 0 & 0 & -\frac{5\sqrt{22}}{88} & 0 & 0 \end{bmatrix}$ |
| 229 | symmetry | $-\frac{3\sqrt{7}xy(x-y)(x+y)(x^2+y^2-10z^2)}{4}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{55}}{22} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{55}}{22} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{33}}{11} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{33}}{11} & 0 & 0 & 0 & 0 \\ 0 & \frac{\sqrt{55}}{22} & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{55}}{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 230 | symmetry | $\frac{\sqrt{462}yz(y^2-3z^2)(3y^2-z^2)}{16}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|----------------------------------|---|
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{3}}{16} & 0 & 0 & 0 & \frac{\sqrt{5}}{16} \\ 0 & \frac{\sqrt{3}}{16} & 0 & 0 & 0 & \frac{3\sqrt{5}}{16} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{3\sqrt{5}}{16} & 0 & 0 & 0 & \frac{5\sqrt{3}}{16} \\ 0 & \frac{\sqrt{5}}{16} & 0 & 0 & 0 & \frac{5\sqrt{3}}{16} & 0 \end{bmatrix}$ |
| 231 | $\mathbb{Q}_{6,1}^{(a)}(T_2, 1)$ | $\frac{\sqrt{462}xz(x^2-3z^2)(3x^2-z^2)}{16}$ |
| | | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{3}}{16} & 0 & 0 & 0 & -\frac{\sqrt{5}}{16} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{3}}{16} & 0 & 0 & 0 & -\frac{3\sqrt{5}}{16} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{3\sqrt{5}}{16} & 0 & 0 & 0 & \frac{5\sqrt{3}}{16} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{5}}{16} & 0 & 0 & 0 & \frac{5\sqrt{3}}{16} & 0 & 0 \end{bmatrix}$ |
| 232 | $\mathbb{Q}_{6,2}^{(a)}(T_2, 1)$ | $\frac{\sqrt{462}xy(x^2-3y^2)(3x^2-y^2)}{16}$ |
| | | $\begin{bmatrix} 0 & \frac{\sqrt{2}}{2} & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{2}}{2} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 233 | $\mathbb{Q}_{6,3}^{(a)}(T_2, 1)$ | $\frac{\sqrt{210}yz(16x^4-16x^2y^2-16x^2z^2+y^4+2y^2z^2+z^4)}{16}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{165}}{33} & 0 & 0 & 0 \\ 0 & 0 & \frac{17\sqrt{165}}{528} & 0 & 0 & 0 & -\frac{9\sqrt{11}}{176} \\ 0 & \frac{17\sqrt{165}}{528} & 0 & 0 & 0 & -\frac{\sqrt{11}}{16} & 0 \\ \frac{\sqrt{165}}{33} & 0 & 0 & 0 & -\frac{\sqrt{11}}{11} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{11}}{11} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{11}}{16} & 0 & 0 & 0 & \frac{5\sqrt{165}}{528} \\ 0 & -\frac{9\sqrt{11}}{176} & 0 & 0 & 0 & \frac{5\sqrt{165}}{528} & 0 \end{bmatrix}$ |
| 234 | symmetry | $\frac{\sqrt{210}xz(x^4 - 16x^2y^2 + 2x^2z^2 + 16y^4 - 16y^2z^2 + z^4)}{16}$ $\begin{bmatrix} 0 & 0 & \frac{17\sqrt{165}}{528} & 0 & 0 & 0 & \frac{9\sqrt{11}}{176} \\ 0 & 0 & 0 & -\frac{\sqrt{165}}{33} & 0 & 0 & 0 \\ \frac{17\sqrt{165}}{528} & 0 & 0 & 0 & \frac{\sqrt{11}}{16} & 0 & 0 \\ 0 & -\frac{\sqrt{165}}{33} & 0 & 0 & 0 & -\frac{\sqrt{11}}{11} & 0 \\ 0 & 0 & \frac{\sqrt{11}}{16} & 0 & 0 & 0 & \frac{5\sqrt{165}}{528} \\ 0 & 0 & 0 & -\frac{\sqrt{11}}{11} & 0 & 0 & 0 \\ \frac{9\sqrt{11}}{176} & 0 & 0 & 0 & \frac{5\sqrt{165}}{528} & 0 & 0 \end{bmatrix}$ |
| 235 | symmetry | $\frac{\sqrt{210}xy(x^4 + 2x^2y^2 - 16x^2z^2 + y^4 - 16y^2z^2 + 16z^4)}{16}$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{66}}{66} & 0 \\ 0 & 0 & 0 & 0 & -\frac{\sqrt{66}}{66} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{2\sqrt{66}}{33} \\ 0 & -\frac{\sqrt{66}}{66} & 0 & 0 & 0 & \frac{\sqrt{110}}{22} & 0 \\ \frac{\sqrt{66}}{66} & 0 & 0 & 0 & \frac{\sqrt{110}}{22} & 0 & 0 \\ 0 & 0 & 0 & \frac{2\sqrt{66}}{33} & 0 & 0 & 0 \end{bmatrix}$ |
| 236 | symmetry | x |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{42}i}{28} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{42}i}{28} & 0 & 0 & 0 & 0 \\ 0 & \frac{\sqrt{42}i}{28} & 0 & 0 & 0 & \frac{\sqrt{70}i}{28} & 0 \\ -\frac{\sqrt{42}i}{28} & 0 & 0 & 0 & -\frac{\sqrt{70}i}{28} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{70}i}{28} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{70}i}{28} & 0 & 0 & 0 & -\frac{\sqrt{42}i}{14} \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{42}i}{14} & 0 \end{bmatrix}$ |
| 237 | symmetry | y $\begin{bmatrix} 0 & 0 & \frac{\sqrt{42}i}{28} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{42}i}{28} & 0 & 0 & 0 \\ -\frac{\sqrt{42}i}{28} & 0 & 0 & 0 & \frac{\sqrt{70}i}{28} & 0 & 0 \\ 0 & -\frac{\sqrt{42}i}{28} & 0 & 0 & 0 & \frac{\sqrt{70}i}{28} & 0 \\ 0 & 0 & -\frac{\sqrt{70}i}{28} & 0 & 0 & 0 & \frac{\sqrt{42}i}{14} \\ 0 & 0 & 0 & -\frac{\sqrt{70}i}{28} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\frac{\sqrt{42}i}{14} & 0 & 0 \end{bmatrix}$ |
| 238 | symmetry | z $\begin{bmatrix} 0 & -\frac{3\sqrt{7}i}{14} & 0 & 0 & 0 & 0 & 0 \\ \frac{3\sqrt{7}i}{14} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{7}i}{7} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{7}i}{7} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{7}i}{14} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{7}i}{14} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 239 | symmetry | $\sqrt{15}xyz$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & \frac{\sqrt{6}i}{6} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{6}i}{6} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{6}i}{6} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 240 | symmetry | $\frac{x(2x^2-3y^2-3z^2)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & \frac{i}{4} & 0 & 0 & 0 \\ 0 & 0 & -\frac{i}{4} & 0 & 0 & 0 & \frac{\sqrt{15}i}{12} \\ 0 & \frac{i}{4} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 \\ -\frac{i}{4} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{15}i}{12} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{15}i}{12} & 0 & 0 & 0 & \frac{i}{4} \\ 0 & -\frac{\sqrt{15}i}{12} & 0 & 0 & 0 & -\frac{i}{4} & 0 \end{bmatrix}$ |
| 241 | symmetry | $-\frac{y(3x^2-2y^2+3z^2)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & \frac{i}{4} & 0 & 0 & 0 & \frac{\sqrt{15}i}{12} \\ 0 & 0 & 0 & \frac{i}{4} & 0 & 0 & 0 \\ -\frac{i}{4} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 & 0 \\ 0 & -\frac{i}{4} & 0 & 0 & 0 & \frac{\sqrt{15}i}{12} & 0 \\ 0 & 0 & \frac{\sqrt{15}i}{12} & 0 & 0 & 0 & -\frac{i}{4} \\ 0 & 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 & 0 & 0 \\ -\frac{\sqrt{15}i}{12} & 0 & 0 & 0 & \frac{i}{4} & 0 & 0 \end{bmatrix}$ |
| 242 | symmetry | $-\frac{z(3x^2+3y^2-2z^2)}{2}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & \frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{6}i}{6} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 243 | symmetry | $\frac{\sqrt{15}x(y-z)(y+z)}{2}$ $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{15}i}{12} & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 & 0 & 0 & -\frac{i}{4} \\ 0 & \frac{\sqrt{15}i}{12} & 0 & 0 & 0 & \frac{i}{4} & 0 \\ -\frac{\sqrt{15}i}{12} & 0 & 0 & 0 & \frac{i}{4} & 0 & 0 \\ 0 & 0 & 0 & -\frac{i}{4} & 0 & 0 & 0 \\ 0 & 0 & -\frac{i}{4} & 0 & 0 & 0 & \frac{\sqrt{15}i}{12} \\ 0 & \frac{i}{4} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 \end{bmatrix}$ |
| 244 | symmetry | $-\frac{\sqrt{15}y(x-z)(x+z)}{2}$ $\begin{bmatrix} 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 & 0 & 0 & \frac{i}{4} \\ 0 & 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 & 0 & 0 \\ \frac{\sqrt{15}i}{12} & 0 & 0 & 0 & -\frac{i}{4} & 0 & 0 \\ 0 & \frac{\sqrt{15}i}{12} & 0 & 0 & 0 & \frac{i}{4} & 0 \\ 0 & 0 & \frac{i}{4} & 0 & 0 & 0 & \frac{\sqrt{15}i}{12} \\ 0 & 0 & 0 & -\frac{i}{4} & 0 & 0 & 0 \\ -\frac{i}{4} & 0 & 0 & 0 & -\frac{\sqrt{15}i}{12} & 0 & 0 \end{bmatrix}$ |
| 245 | symmetry | $\frac{\sqrt{15}z(x-y)(x+y)}{2}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|--|
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{6}i}{6} & 0 \\ 0 & 0 & 0 & 0 & -\frac{\sqrt{6}i}{6} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{6}i}{6} \\ 0 & \frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{6}i}{6} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{6}i}{6} & 0 & 0 & 0 \end{bmatrix}$ |
| 246 | symmetry | $\frac{3\sqrt{35}xyz(x-y)(x+y)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & \frac{i}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{i}{2} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{i}{2} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{i}{2} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 247 | symmetry | $\frac{\sqrt{105}xyz(x^2+y^2-2z^2)}{2}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & \frac{\sqrt{3}i}{6} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\sqrt{3}i}{6} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{3}i}{3} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{3}i}{6} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -\frac{\sqrt{3}i}{6} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{3}i}{3} & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 248 | symmetry | $\frac{x(8x^4-40x^2y^2-40x^2z^2+15y^4+30y^2z^2+15z^4)}{8}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & 0 & 0 & -\frac{\sqrt{14}i}{14} & 0 & 0 & 0 \\ 0 & 0 & -\frac{13\sqrt{14}i}{112} & 0 & 0 & 0 & \frac{\sqrt{210}i}{48} \\ 0 & \frac{13\sqrt{14}i}{112} & 0 & 0 & 0 & -\frac{\sqrt{210}i}{336} & 0 \\ \frac{\sqrt{14}i}{14} & 0 & 0 & 0 & \frac{\sqrt{210}i}{42} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{210}i}{42} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{210}i}{336} & 0 & 0 & 0 & -\frac{5\sqrt{14}i}{112} \\ 0 & -\frac{\sqrt{210}i}{48} & 0 & 0 & 0 & \frac{5\sqrt{14}i}{112} & 0 \end{bmatrix}$ |
| 249 | symmetry | $\frac{y(15x^4 - 40x^2y^2 + 30x^2z^2 + 8y^4 - 40y^2z^2 + 15z^4)}{8}$ |
| | | $\begin{bmatrix} 0 & 0 & \frac{13\sqrt{14}i}{112} & 0 & 0 & 0 & \frac{\sqrt{210}i}{48} \\ 0 & 0 & 0 & -\frac{\sqrt{14}i}{14} & 0 & 0 & 0 \\ -\frac{13\sqrt{14}i}{112} & 0 & 0 & 0 & -\frac{\sqrt{210}i}{336} & 0 & 0 \\ 0 & \frac{\sqrt{14}i}{14} & 0 & 0 & 0 & -\frac{\sqrt{210}i}{42} & 0 \\ 0 & 0 & \frac{\sqrt{210}i}{336} & 0 & 0 & 0 & \frac{5\sqrt{14}i}{112} \\ 0 & 0 & 0 & \frac{\sqrt{210}i}{42} & 0 & 0 & 0 \\ -\frac{\sqrt{210}i}{48} & 0 & 0 & 0 & -\frac{5\sqrt{14}i}{112} & 0 & 0 \end{bmatrix}$ |
| 250 | symmetry | $\frac{z(15x^4 + 30x^2y^2 - 40x^2z^2 + 15y^4 - 40y^2z^2 + 8z^4)}{8}$ |
| | | $\begin{bmatrix} 0 & -\frac{\sqrt{21}i}{42} & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{21}i}{42} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{2\sqrt{21}i}{21} & 0 & 0 & 0 \\ 0 & 0 & -\frac{2\sqrt{21}i}{21} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{5\sqrt{21}i}{42} & 0 \\ 0 & 0 & 0 & 0 & \frac{5\sqrt{21}i}{42} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 251 | symmetry | $\frac{3\sqrt{35}x(y^2 - 2yz - z^2)(y^2 + 2yz - z^2)}{8}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|----------------------------------|---|
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{10}i}{16} & 0 & 0 & 0 & -\frac{3\sqrt{6}i}{16} \\ 0 & \frac{\sqrt{10}i}{16} & 0 & 0 & 0 & -\frac{3\sqrt{6}i}{16} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{3\sqrt{6}i}{16} & 0 & 0 & 0 & -\frac{\sqrt{10}i}{16} \\ 0 & \frac{3\sqrt{6}i}{16} & 0 & 0 & 0 & \frac{\sqrt{10}i}{16} & 0 \end{bmatrix}$ |
| 252 | $\mathbb{M}_{5,1}^{(a)}(T_1, 2)$ | $\frac{3\sqrt{35}y(x^2 - 2xz - z^2)(x^2 + 2xz - z^2)}{8}$ |
| | | $\begin{bmatrix} 0 & 0 & \frac{\sqrt{10}i}{16} & 0 & 0 & 0 & -\frac{3\sqrt{6}i}{16} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{10}i}{16} & 0 & 0 & 0 & -\frac{3\sqrt{6}i}{16} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{3\sqrt{6}i}{16} & 0 & 0 & 0 & \frac{\sqrt{10}i}{16} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \frac{3\sqrt{6}i}{16} & 0 & 0 & 0 & -\frac{\sqrt{10}i}{16} & 0 & 0 \end{bmatrix}$ |
| 253 | $\mathbb{M}_{5,2}^{(a)}(T_1, 2)$ | $\frac{3\sqrt{35}z(x^2 - 2xy - y^2)(x^2 + 2xy - y^2)}{8}$ |
| | | $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -\frac{i}{2} & 0 \\ 0 & 0 & 0 & 0 & -\frac{i}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{i}{2} & 0 & 0 & 0 & 0 & 0 \\ \frac{i}{2} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$ |
| 254 | $\mathbb{M}_{5,3}^{(a)}(T_1, 2)$ | $\frac{\sqrt{105}x(y-z)(y+z)(2x^2 - y^2 - z^2)}{4}$ |

continued ...

Table 10

| No. | multipole | matrix |
|-----|-----------|---|
| | | $\begin{bmatrix} 0 & 0 & 0 & \frac{\sqrt{30}i}{12} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{30}i}{24} & 0 & 0 & 0 & \frac{\sqrt{2}i}{8} \\ 0 & -\frac{\sqrt{30}i}{24} & 0 & 0 & 0 & -\frac{\sqrt{2}i}{8} & 0 \\ -\frac{\sqrt{30}i}{12} & 0 & 0 & 0 & \frac{\sqrt{2}i}{4} & 0 & 0 \\ 0 & 0 & 0 & -\frac{\sqrt{2}i}{4} & 0 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{2}i}{8} & 0 & 0 & 0 & -\frac{\sqrt{30}i}{24} \\ 0 & -\frac{\sqrt{2}i}{8} & 0 & 0 & 0 & \frac{\sqrt{30}i}{24} & 0 \end{bmatrix}$ |
| 255 | symmetry | $\frac{\sqrt{105}y(x-z)(x+z)(x^2-2y^2+z^2)}{4}$ $\begin{bmatrix} 0 & 0 & \frac{\sqrt{30}i}{24} & 0 & 0 & 0 & -\frac{\sqrt{2}i}{8} \\ 0 & 0 & 0 & -\frac{\sqrt{30}i}{12} & 0 & 0 & 0 \\ -\frac{\sqrt{30}i}{24} & 0 & 0 & 0 & \frac{\sqrt{2}i}{8} & 0 & 0 \\ 0 & \frac{\sqrt{30}i}{12} & 0 & 0 & 0 & \frac{\sqrt{2}i}{4} & 0 \\ 0 & 0 & -\frac{\sqrt{2}i}{8} & 0 & 0 & 0 & -\frac{\sqrt{30}i}{24} \\ 0 & 0 & 0 & -\frac{\sqrt{2}i}{4} & 0 & 0 & 0 \\ \frac{\sqrt{2}i}{8} & 0 & 0 & 0 & \frac{\sqrt{30}i}{24} & 0 & 0 \end{bmatrix}$ |
| 256 | symmetry | $-\frac{\sqrt{105}z(x-y)(x+y)(x^2+y^2-2z^2)}{4}$ $\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{3}i}{6} & 0 \\ 0 & 0 & 0 & 0 & \frac{\sqrt{3}i}{6} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\sqrt{3}i}{3} \\ 0 & -\frac{\sqrt{3}i}{6} & 0 & 0 & 0 & 0 & 0 \\ \frac{\sqrt{3}i}{6} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{\sqrt{3}i}{3} & 0 & 0 & 0 \end{bmatrix}$ |