

MPG No. 7.1.20  $mm2$  [ Type I, orthorhombic ] [Q tensor]

\* Rank 0 tensor.

$$[Q]$$

$$Q = Q_s^{(1)}$$

\* Rank 1 tensor.

$$[0 \ 0 \ Q_z]$$

$$Q_z = Q_{pz}^{(1)}$$

\* Rank 2 tensor (s).

$$\begin{bmatrix} Q_{xx} & 0 & 0 \\ 0 & Q_{yy} & 0 \\ 0 & 0 & Q_{zz} \end{bmatrix}$$

$$Q_{xx} = -Q_{du}^{(1)} + Q_{dv}^{(1)} + Q_s^{(1)}$$

$$Q_{yy} = -Q_{du}^{(1)} - Q_{dv}^{(1)} + Q_s^{(1)}$$

$$Q_{zz} = 2Q_{du}^{(1)} + Q_s^{(1)}$$

\* Rank 2 tensor (a). \* Rank 3 tensor (s).

$$\begin{bmatrix} 0 & 0 & Q_{xxz} \\ 0 & 0 & Q_{yyz} \\ 0 & 0 & Q_{zzz} \\ 0 & Q_{yzy} & 0 \\ Q_{zxx} & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$Q_{xxz} = -2G_{dxy}^{(1)} - Q_{faz}^{(1)} + Q_{fbz}^{(1)} + Q_{pz}^{(1)}$$

$$Q_{yyz} = 2G_{dxy}^{(1)} - Q_{faz}^{(1)} - Q_{fbz}^{(1)} + Q_{pz}^{(1)}$$

$$Q_{zzz} = 2Q_{faz}^{(1)} + Q_{pz}^{(1)} + 2Q_{pz}^{(2)}$$

$$Q_{yzy} = -G_{dxy}^{(1)} - Q_{faz}^{(1)} - Q_{fbz}^{(1)} + Q_{pz}^{(2)}$$

$$Q_{zxx} = G_{dxy}^{(1)} - Q_{faz}^{(1)} + Q_{fbz}^{(1)} + Q_{pz}^{(2)}$$

\* Rank 3 tensor (a).

$$\begin{bmatrix} 0 & Q_{yzy} & 0 \\ Q_{zxx} & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$Q_{yzy} = G_{dxy}^{(2)} + Q_{pz}^{(3)}$$

$$Q_{zxx} = G_{dxy}^{(2)} - Q_{pz}^{(3)}$$

\* Rank 4 tensor (sss).

$$\begin{bmatrix} Q_{xxxx} & Q_{xxyy} & Q_{xxzz} & 0 & 0 & 0 \\ Q_{xxyy} & Q_{yyyy} & Q_{yyzz} & 0 & 0 & 0 \\ Q_{xxzz} & Q_{yyzz} & Q_{zzzz} & 0 & 0 & 0 \\ 0 & 0 & 0 & Q_{yzyz} & 0 & 0 \\ 0 & 0 & 0 & 0 & Q_{zxxz} & 0 \\ 0 & 0 & 0 & 0 & 0 & Q_{xyxy} \end{bmatrix}$$

$$\begin{aligned}
Q_{xxxx} &= -2Q_{du}^{(1)} - 4Q_{du}^{(2)} + 2Q_{dv}^{(1)} + 4Q_{dv}^{(2)} - Q_{gu}^{(1)} + Q_{gv}^{(1)} + 2Q_g^{(1)} + Q_s^{(1)} + 2Q_s^{(2)} \\
Q_{xxyy} &= -2Q_{du}^{(1)} + 2Q_{gu}^{(1)} - Q_g^{(1)} + Q_s^{(1)} \\
Q_{xxzz} &= Q_{du}^{(1)} + Q_{dv}^{(1)} - Q_{gu}^{(1)} - Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(1)} \\
Q_{yyyy} &= -2Q_{du}^{(1)} - 4Q_{du}^{(2)} - 2Q_{dv}^{(1)} - 4Q_{dv}^{(2)} - Q_{gu}^{(1)} - Q_{gv}^{(1)} + 2Q_g^{(1)} + Q_s^{(1)} + 2Q_s^{(2)} \\
Q_{yyzz} &= Q_{du}^{(1)} - Q_{dv}^{(1)} - Q_{gu}^{(1)} + Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(1)} \\
Q_{zzzz} &= 4Q_{du}^{(1)} + 8Q_{du}^{(2)} + 2Q_{gu}^{(1)} + 2Q_g^{(1)} + Q_s^{(1)} + 2Q_s^{(2)} \\
Q_{yzyz} &= Q_{du}^{(2)} - Q_{dv}^{(2)} - Q_{gu}^{(1)} + Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(2)} \\
Q_{zxzx} &= Q_{du}^{(2)} + Q_{dv}^{(2)} - Q_{gu}^{(1)} - Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(2)} \\
Q_{xyxy} &= -2Q_{du}^{(2)} + 2Q_{gu}^{(1)} - Q_g^{(1)} + Q_s^{(2)}
\end{aligned}$$

\* Rank 4 tensor (ssa).

$$\begin{bmatrix} 0 & Q_{xxyy} & Q_{xxzz} & 0 & 0 & 0 \\ -Q_{xxyy} & 0 & Q_{yyzz} & 0 & 0 & 0 \\ -Q_{xxzz} & -Q_{yyzz} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\begin{aligned}
Q_{xxyy} &= 4G_{f3}^{(1)} - 2Q_{dv}^{(3)} \\
Q_{xxzz} &= -4G_{f3}^{(1)} + 3Q_{du}^{(3)} - Q_{dv}^{(3)} \\
Q_{yyzz} &= 4G_{f3}^{(1)} + 3Q_{du}^{(3)} + Q_{dv}^{(3)}
\end{aligned}$$

\* Rank 4 tensor (aas).

$$\begin{bmatrix} Q_{yzyz} & 0 & 0 \\ 0 & Q_{zxzx} & 0 \\ 0 & 0 & Q_{xyxy} \end{bmatrix}$$

$$\begin{aligned}
Q_{yzyz} &= -2Q_{du}^{(4)} + 2Q_{dv}^{(4)} + Q_s^{(3)} \\
Q_{zxzx} &= -2Q_{du}^{(4)} - 2Q_{dv}^{(4)} + Q_s^{(3)} \\
Q_{xyxy} &= 4Q_{du}^{(4)} + Q_s^{(3)}
\end{aligned}$$

\* Rank 4 tensor (aaa). \* Rank 4 tensor (sa).

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ Q_{yzyz} & 0 & 0 \\ 0 & Q_{zxzx} & 0 \\ 0 & 0 & Q_{xyxy} \end{bmatrix}$$

$$\begin{aligned}
Q_{yzyz} &= G_{f3}^{(2)} - 3Q_{du}^{(5)} - Q_{dv}^{(5)} \\
Q_{zxzx} &= G_{f3}^{(2)} + 3Q_{du}^{(5)} - Q_{dv}^{(5)} \\
Q_{xyxy} &= G_{f3}^{(2)} + 2Q_{dv}^{(5)}
\end{aligned}$$

\* Rank 4 tensor (as).

$$\begin{bmatrix} 0 & 0 & 0 & Q_{yzyz} & 0 & 0 \\ 0 & 0 & 0 & 0 & Q_{zxzx} & 0 \\ 0 & 0 & 0 & 0 & 0 & Q_{xyxy} \end{bmatrix}$$

$$Q_{yzyz} = G_{f3}^{(3)} - 3Q_{du}^{(6)} - Q_{dv}^{(6)}$$

$$Q_{zxzx} = G_{f3}^{(3)} + 3Q_{du}^{(6)} - Q_{dv}^{(6)}$$

$$Q_{xyxy} = G_{f3}^{(3)} + 2Q_{dv}^{(6)}$$

\* Rank 4 tensor (s).

$$\begin{bmatrix} Q_{xxxx} & Q_{xxyy} & Q_{xxzz} & 0 & 0 & 0 & 0 & 0 & 0 \\ Q_{yyxx} & Q_{yyyy} & Q_{yyzz} & 0 & 0 & 0 & 0 & 0 & 0 \\ Q_{zzxx} & Q_{zzyy} & Q_{zzzz} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & Q_{yzyz} & 0 & 0 & Q_{yzyy} & 0 & 0 \\ 0 & 0 & 0 & 0 & Q_{zxzx} & 0 & 0 & Q_{zxzx} & 0 \\ 0 & 0 & 0 & 0 & 0 & Q_{xyxy} & 0 & 0 & Q_{xyyx} \end{bmatrix}$$

$$Q_{xxxx} = -2Q_{du}^{(1)} - 4Q_{du}^{(2)} + 2Q_{dv}^{(1)} + 4Q_{dv}^{(2)} - Q_{gu}^{(1)} + Q_{gv}^{(1)} + 2Q_g^{(1)} + Q_s^{(1)} + 2Q_s^{(2)}$$

$$Q_{xxyy} = 4G_{f3}^{(1)} - 2Q_{du}^{(1)} - 2Q_{dv}^{(3)} + 2Q_{gu}^{(1)} - Q_g^{(1)} + Q_s^{(1)}$$

$$Q_{xxzz} = -4G_{f3}^{(1)} + Q_{du}^{(1)} + 3Q_{du}^{(3)} + Q_{dv}^{(1)} - Q_{dv}^{(3)} - Q_{gu}^{(1)} - Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(1)}$$

$$Q_{yyxx} = -4G_{f3}^{(1)} - 2Q_{du}^{(1)} + 2Q_{dv}^{(3)} + 2Q_{gu}^{(1)} - Q_g^{(1)} + Q_s^{(1)}$$

$$Q_{yyyy} = -2Q_{du}^{(1)} - 4Q_{du}^{(2)} - 2Q_{dv}^{(1)} - 4Q_{dv}^{(2)} - Q_{gu}^{(1)} - Q_{gv}^{(1)} + 2Q_g^{(1)} + Q_s^{(1)} + 2Q_s^{(2)}$$

$$Q_{yyzz} = 4G_{f3}^{(1)} + Q_{du}^{(1)} + 3Q_{du}^{(3)} - Q_{dv}^{(1)} + Q_{dv}^{(3)} - Q_{gu}^{(1)} + Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(1)}$$

$$Q_{zxzx} = 4G_{f3}^{(1)} + Q_{du}^{(1)} - 3Q_{du}^{(3)} + Q_{dv}^{(1)} + Q_{dv}^{(3)} - Q_{gu}^{(1)} - Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(1)}$$

$$Q_{zzyy} = -4G_{f3}^{(1)} + Q_{du}^{(1)} - 3Q_{du}^{(3)} - Q_{dv}^{(1)} - Q_{dv}^{(3)} - Q_{gu}^{(1)} + Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(1)}$$

$$Q_{zzzz} = 4Q_{du}^{(1)} + 8Q_{du}^{(2)} + 2Q_{gu}^{(1)} + 2Q_s^{(1)} + 2Q_s^{(2)}$$

$$Q_{yzyz} = G_{f3}^{(2)} + Q_{du}^{(2)} - 3Q_{du}^{(5)} - Q_{dv}^{(2)} - Q_{dv}^{(5)} - Q_{gu}^{(1)} + Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(2)}$$

$$Q_{yzyy} = -G_{f3}^{(2)} + Q_{du}^{(2)} + 3Q_{du}^{(5)} - Q_{dv}^{(2)} + Q_{dv}^{(5)} - Q_{gu}^{(1)} + Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(2)}$$

$$Q_{zxzx} = G_{f3}^{(2)} + Q_{du}^{(2)} + 3Q_{du}^{(5)} + Q_{dv}^{(2)} - Q_{dv}^{(5)} - Q_{gu}^{(1)} - Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(2)}$$

$$Q_{zzxz} = -G_{f3}^{(2)} + Q_{du}^{(2)} - 3Q_{du}^{(5)} + Q_{dv}^{(2)} + Q_{dv}^{(5)} - Q_{gu}^{(1)} - Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(2)}$$

$$Q_{xyxy} = G_{f3}^{(2)} - 2Q_{du}^{(2)} + 2Q_{dv}^{(5)} + 2Q_{gu}^{(1)} - Q_g^{(1)} + Q_s^{(2)}$$

$$Q_{xyyx} = -G_{f3}^{(2)} - 2Q_{du}^{(2)} - 2Q_{dv}^{(5)} + 2Q_{gu}^{(1)} - Q_g^{(1)} + Q_s^{(2)}$$

\* Rank 4 tensor (a).

$$\begin{bmatrix} 0 & 0 & 0 & Q_{yzyz} & 0 & 0 & Q_{yzyy} & 0 & 0 \\ 0 & 0 & 0 & 0 & Q_{zxzx} & 0 & 0 & Q_{zxzx} & 0 \\ 0 & 0 & 0 & 0 & 0 & Q_{xyxy} & 0 & 0 & Q_{xyyx} \end{bmatrix}$$

$$Q_{yzyz} = G_{f3}^{(3)} - 2Q_{du}^{(4)} - 3Q_{du}^{(6)} + 2Q_{dv}^{(4)} - Q_{dv}^{(6)} + Q_s^{(3)}$$

$$Q_{yzyy} = G_{f3}^{(3)} + 2Q_{du}^{(4)} - 3Q_{du}^{(6)} - 2Q_{dv}^{(4)} - Q_{dv}^{(6)} - Q_s^{(3)}$$

$$Q_{zxzx} = G_{f3}^{(3)} - 2Q_{du}^{(4)} + 3Q_{du}^{(6)} - 2Q_{dv}^{(4)} - Q_{dv}^{(6)} + Q_s^{(3)}$$

$$Q_{zzxz} = G_{f3}^{(3)} + 2Q_{du}^{(4)} + 3Q_{du}^{(6)} + 2Q_{dv}^{(4)} - Q_{dv}^{(6)} - Q_s^{(3)}$$

$$Q_{xyxy} = G_{f3}^{(3)} + 4Q_{du}^{(4)} + 2Q_{dv}^{(6)} + Q_s^{(3)}$$

$$Q_{xyyx} = G_{f3}^{(3)} - 4Q_{du}^{(4)} + 2Q_{dv}^{(6)} - Q_s^{(3)}$$

\* Rank 4 tensor (t).

$$\begin{bmatrix} Q_{xxxx} & 0 & 0 \\ 0 & Q_{yyyy} & 0 \\ 0 & 0 & Q_{zzzz} \\ 0 & 0 & Q_{yyzz} \\ Q_{zzxx} & 0 & 0 \\ 0 & Q_{xxyy} & 0 \\ 0 & Q_{yzzy} & 0 \\ 0 & 0 & Q_{zxxz} \\ Q_{xxyy} + Q_{yyzz} - Q_{yzzy} - Q_{zzxx} + Q_{zzxx} & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$Q_{xxxx} = -2Q_{du}^{(1)} - 4Q_{du}^{(2)} + 2Q_{dv}^{(1)} + 4Q_{dv}^{(2)} - Q_{gu}^{(1)} + Q_{gv}^{(1)} + 2Q_g^{(1)} + 3Q_s^{(1)}$$

$$Q_{yyyy} = -2Q_{du}^{(1)} - 4Q_{du}^{(2)} - 2Q_{dv}^{(1)} - 4Q_{dv}^{(2)} - Q_{gu}^{(1)} - Q_{gv}^{(1)} + 2Q_g^{(1)} + 3Q_s^{(1)}$$

$$Q_{zzzz} = 4Q_{du}^{(1)} + 8Q_{du}^{(2)} + 2Q_{gu}^{(1)} + 2Q_g^{(1)} + 3Q_s^{(1)}$$

$$Q_{yyzz} = Q_{du}^{(1)} + 3Q_{du}^{(3)} - Q_{dv}^{(1)} + Q_{dv}^{(3)} - Q_{gu}^{(1)} + Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(1)}$$

$$Q_{zzxx} = Q_{du}^{(1)} - 3Q_{du}^{(3)} + Q_{dv}^{(1)} + Q_{dv}^{(3)} - Q_{gu}^{(1)} - Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(1)}$$

$$Q_{xxyy} = -2Q_{du}^{(1)} - 2Q_{dv}^{(3)} + 2Q_{gu}^{(1)} - Q_g^{(1)} + Q_s^{(1)}$$

$$Q_{yzzy} = Q_{du}^{(2)} + 3Q_{du}^{(5)} - Q_{dv}^{(2)} + Q_{dv}^{(5)} - Q_{gu}^{(1)} + Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(1)}$$

$$Q_{zxxz} = Q_{du}^{(2)} - 3Q_{du}^{(5)} + Q_{dv}^{(2)} + Q_{dv}^{(5)} - Q_{gu}^{(1)} - Q_{gv}^{(1)} - Q_g^{(1)} + Q_s^{(1)}$$