

**H<sub>rot</sub>:**

$$\langle \Lambda S \Sigma' J \Omega' | H_{rot} | \Lambda S \Sigma J \Omega \rangle = B \left\{ \begin{array}{l} \delta_{\Sigma \Sigma'} \delta_{\Omega \Omega'} [J(J+1) + S(S+1)] \\ - \left[ 2(-1)^{J-\Omega'+S-\Sigma'} \begin{pmatrix} J & 1 & J \\ -\Omega' & (\Omega' - \Omega) & \Omega \end{pmatrix} \begin{pmatrix} S & 1 & S \\ -\Sigma' & (\Sigma' - \Sigma) & \Sigma \end{pmatrix} \right] \\ \times \sqrt{J(J+1)(2J+1)S(S+1)(2S+1)} \end{array} \right\}$$

$$\langle \Lambda S \Sigma' J \Omega' | H_{rot-cd}^{(2)} | \Lambda S \Sigma J \Omega \rangle = -D \left\{ \begin{array}{l} - \delta_{\Sigma \Sigma'} \delta_{\Omega \Omega'} \left[ \begin{array}{l} J^2(J+1)^2 + S^2(S+1)^2 + \frac{10}{3} J(J+1)S(S+1) \\ - 4\Omega \Sigma (-1)^{J-\Omega'+S-\Sigma'} \left( J(J+1) + S(S+1) - \frac{1}{2} \right) \end{array} \right] \\ + (\delta_{\Omega, \Omega'+1} + \delta_{\Omega, \Omega'-1}) \left[ \begin{array}{l} 4(-1)^{J-\Omega'+S-\Sigma'} \begin{pmatrix} J & 1 & J \\ -\Omega' & (\Omega' - \Omega) & \Omega \end{pmatrix} \\ \times \begin{pmatrix} S & 1 & S \\ -\Sigma' & (\Sigma' - \Sigma) & \Sigma \end{pmatrix} \\ \times \sqrt{J(J+1)(2J+1)S(S+1)(2S+1)} \\ \times \left( J(J+1) + S(S+1) - \frac{1}{2} \right) \end{array} \right] \\ - \left[ \begin{array}{l} 4(-1)^{J-\Omega'+S-\Sigma'} \begin{pmatrix} J & 2 & J \\ -\Omega' & (\Omega' - \Omega) & \Omega \end{pmatrix} \begin{pmatrix} S & 2 & S \\ -\Sigma' & (\Sigma' - \Sigma) & \Sigma \end{pmatrix} \\ \times \prod_{k=0}^4 \sqrt{(2J+k-1)(2S+k-1)} \end{array} \right] \end{array} \right\}$$

$$\langle \Lambda S \Sigma' J \Omega' | H_{rot-cd}^{(6)} | \Lambda S \Sigma J \Omega \rangle = \frac{-H}{2BD} \langle \Lambda S \Sigma' J \Omega' | \{ H_{rot}, H_{rot-cd}^{(2)} \} | \Lambda S \Sigma J \Omega \rangle$$

$$= \frac{-H}{2BD} \left[ \begin{array}{l} \langle \Lambda S \Sigma' J \Omega' | H_{rot} \left( \sum_{\Sigma'' \Omega''} | \Lambda S \Sigma'' J \Omega'' \rangle \langle \Lambda S \Sigma'' J \Omega'' | \right) H_{rot-cd}^{(2)} | \Lambda S \Sigma J \Omega \rangle \\ + \langle \Lambda S \Sigma' J \Omega' | H_{rot-cd}^{(2)} \left( \sum_{\Sigma'' \Omega''} | \Lambda S \Sigma'' J \Omega'' \rangle \langle \Lambda S \Sigma'' J \Omega'' | \right) H_{rot} | \Lambda S \Sigma J \Omega \rangle \end{array} \right]$$