

H_{so}:

$$\begin{aligned} \langle N' \Lambda S J | H_{so} | N \Lambda S J \rangle &= A \Lambda (-1)^{N+S+J+N'-\Lambda} \sqrt{S(S+1)(2S+1)(2N+1)(2N'+1)} \\ &\times \begin{pmatrix} N' & 1 & N \\ -\Lambda & 0 & \Lambda \end{pmatrix} \begin{Bmatrix} S & N' & J \\ N & S & 1 \end{Bmatrix} \\ &+ \frac{A_D}{2} (N(N+1) + N'(N'+1)) \Lambda (-1)^{N+S+J+N'-\Lambda} \\ &\times \sqrt{S(S+1)(2S+1)(2N+1)(2N'+1)} \begin{pmatrix} N' & 1 & N \\ -\Lambda & 0 & \Lambda \end{pmatrix} \begin{Bmatrix} S & N' & J \\ N & S & 1 \end{Bmatrix} \end{aligned}$$