The Direct Product

- form the product $A_2 \otimes B_1$ for the C_{2v} point group explicitly by multiplying the characters, and check your answer by using the "rules" in your hand-out.

C_{2v}	E	C_2	σ_v	σ_v'
A_2	1	1	−1	−1
B_2	1	−1	−1	1
$A_2 \otimes B_2$	1	−1	1	$-1 \Rightarrow B_1$

  - $A_2 \otimes B_1 = B_2$ since $A \otimes B = B$ and $1 \otimes 2 = 2$

Using Symmetry to Determine Infrared Activity

- determine if excitation of the B_2 vibration of H_2O is allowed for IR spectra:
  - For Γ^f=A_1 we require the cross product below to contain the A_1 IR:

$$\left\{\Gamma^{\langle\chi_f|} \otimes \Gamma^{|\chi_i\rangle}\right\} \otimes \Gamma^{\lambda} = \left\{B_2 \otimes A_1\right\} \otimes \begin{bmatrix} B_1 \\ B_2 \\ A_1 \end{bmatrix} = B_2 \otimes \begin{bmatrix} B_1 \\ B_2 \\ A_1 \end{bmatrix} = \left\{A_2, A_1, B_1\right\}$$

  - A_1 is present and so the B_2 vibration is allowed => we will see a B_2 peak in the infrared spectrum of water

Using Symmetry to Determine Raman Activity

- determine if excitation of the B_2 vibration is allowed for RAMAN spectra:

$$\left\{\Gamma^{\langle\chi_f|} \otimes \Gamma^{|\chi_i\rangle}\right\} \otimes \Gamma^{\alpha} = \left\{B_2 \otimes A_1\right\} \otimes \begin{bmatrix} A_1 \\ B_1 \\ A_2 \\ B_2 \end{bmatrix} = B_2 \otimes \begin{bmatrix} A_1 \\ B_1 \\ A_2 \\ B_2 \end{bmatrix} = \left\{B_2, A_2, B_1, A_1\right\}$$

  - A_1 is present and so the B_2 vibration is allowed => we will see a B_2 peak in the infrared spectrum of water