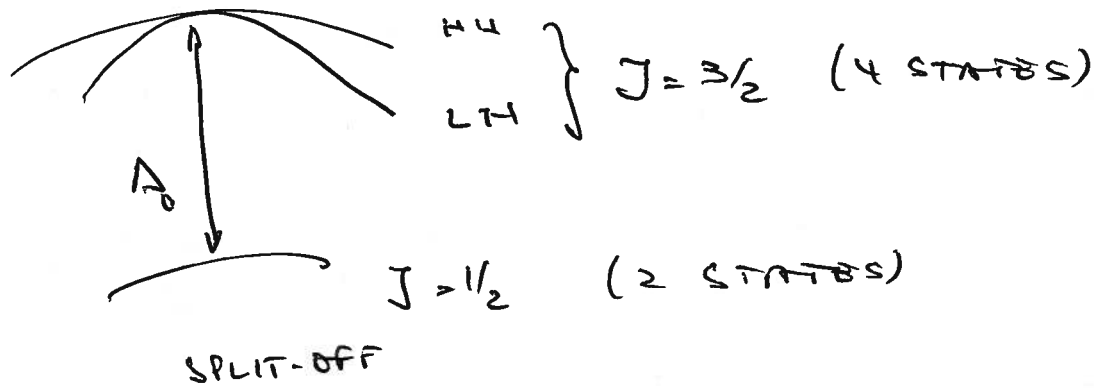


# SUMMARY

S-O COUPLING LIFTS THE DEGENERACY OF THE VALENCE BAND SO THAT



USING STRESS OR Q CONFINEMENT, IT'S POSSIBLE TO FURTHER SPLIT THE BANDS.

## EXAMPLE

STRESS // [001] (HW2, #5)

$$A_{\text{STRAIN}} = \text{CONSTANT} - 3 B_v \left[ (L_x^2 + L_y^2) S_{12} + L_z^2 S_{11} \right] \mathcal{P}$$

$$\equiv \text{CONSTANT}' - 3 B_v (S_{12} - S_{11}) L_z^2 \mathcal{P}$$

UNITS OF PRESSURE

THIS TERM LIFTS THE DEGENERACY

TAKE

NOTE: SPIN Q-AXIS IS "z"

$$\left\{ \begin{aligned} |3/2, 3/2\rangle &= \frac{1}{\sqrt{2}} |x+iy\rangle \uparrow \\ |3/2, 1/2\rangle &= \frac{1}{\sqrt{6}} (2|z\rangle \uparrow - |x+iy\rangle \downarrow) \\ |1/2, 1/2\rangle &= \frac{1}{\sqrt{3}} (|z\rangle \uparrow + |x+iy\rangle \downarrow) \end{aligned} \right.$$

(SAME FOR  $|3/2, -3/2\rangle, |3/2, -1/2\rangle, |1/2, -1/2\rangle$ )

$L_z |x+iy\rangle = |x+iy\rangle$   $L_z |z\rangle = 0$

$m_J = 1/2 \quad J = 3/2$

THEREFORE, STRESS <sup>ALSO</sup> MIXES WITH  $J = 1/2, m_J = 1/2$

$(a = -3B_V (s_{11} - s_{12}) J)$

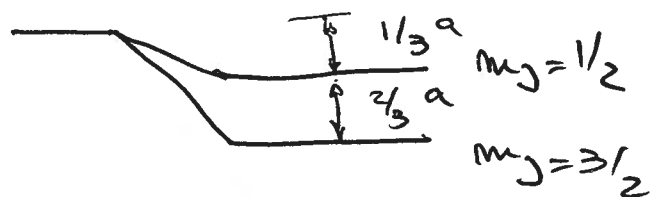
THE MATRIX IS:

$$\begin{vmatrix} E - a & 0 & 0 \\ 0 & E - \frac{1}{3}P & \frac{\sqrt{2}}{3}a \\ 0 & \frac{\sqrt{2}}{3}a & E - \frac{1}{3}P - \frac{2}{3}a \end{vmatrix} = 0$$

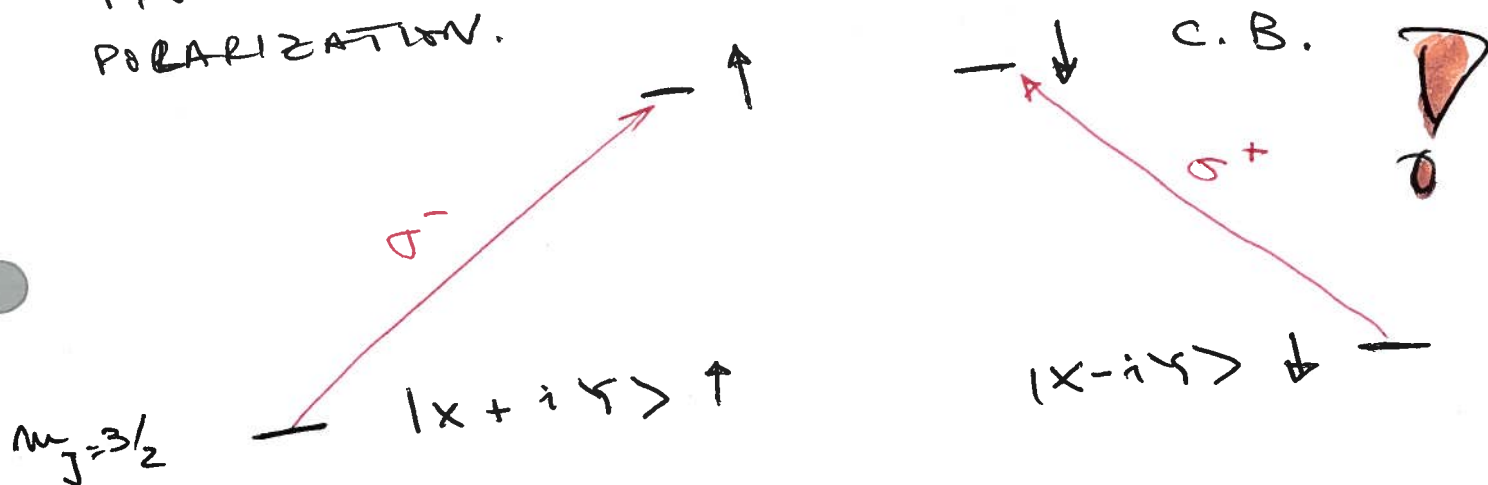
$|3/2, 3/2\rangle \quad |3/2, 1/2\rangle \quad |1/2, 1/2\rangle$

IGNORING THE COUPLING W/ SPLIT-OFF BAND:

COMPRESSIVE STRESS



SPIN-POLARIZED ELECTRONS CAN BE GENERATED BY PROMOTING CARRIERS FROM V.B TO C.B USING CIRCULAR POLARIZATION.



OR USING LIGHT POLARIZED ALONG Z-AXIS IN RESONANCE W/  $m_j = 1/2$  STATES ALL THIS, WITHOUT A B-FIELD

THE EFFECT OF A <sup>STATIC</sup> MAGNETIC-FIELD ON THESE STATES CAN BE EXPRESSED AS

$$-\mu^* \frac{\hbar}{g} \cdot \hat{B} \quad (\text{or } -\mu_B g \hat{S} \cdot \hat{B})$$

WHERE  $\mu^* \neq \mu_B \equiv \frac{e\hbar}{2mc}$

(4)



$g^* \neq 2$  !

GEOMAGNETIC FACTOR

REASON

THE STATIC FIELD ALSO ENTERS IN

$$\vec{p} + \frac{e}{c} \vec{A}_0 \rightarrow \frac{1}{2} \frac{e}{mc} (\vec{p} \cdot \vec{A}_0 + \vec{A}_0 \cdot \vec{p})$$

$$\vec{A} = \frac{1}{2} (\vec{B}_0 \times \vec{r})$$

WHICH MIXES BANDS

RESULT IS (KITTEL QTS, Ch. 14)

$$\frac{\mu^*}{\mu_B} = 1 + \frac{1}{2im} \sum_m \frac{\langle \chi | p_x | m \rangle \langle m | p_x | \chi \rangle}{E_\chi - E_m}$$

(FIELD ALONG Z-AXIS)

SIGNIFICANT DIFFERENCES

EXAMPLE

CONDUCTION ELECTRONS

$$\frac{\mu^*}{\mu_B} \approx -\frac{m}{m^*} \frac{\Delta}{3E_g + 2\Delta} + 1$$

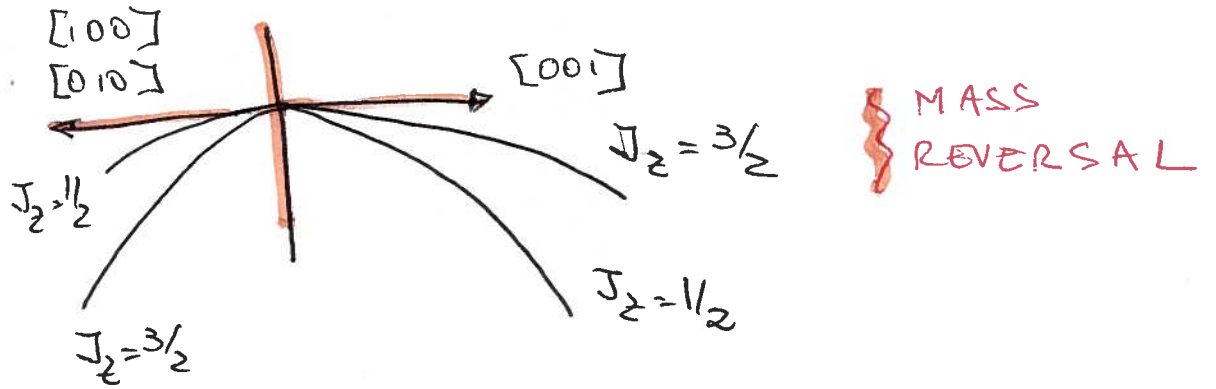
$g^* \approx 50$  (InSb)

$g^* \approx 0.03$  (GaAs)

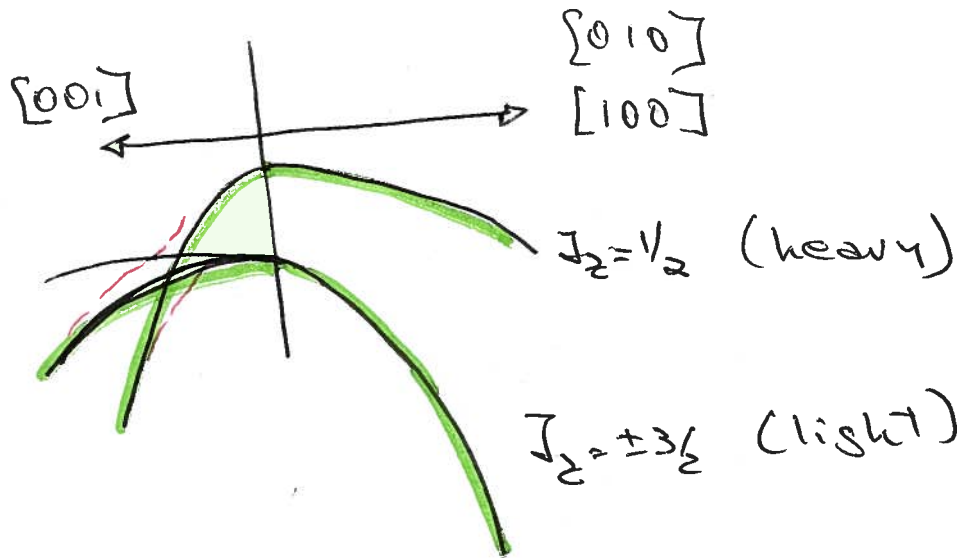
HEAVY VS LIGHT HOLE

5

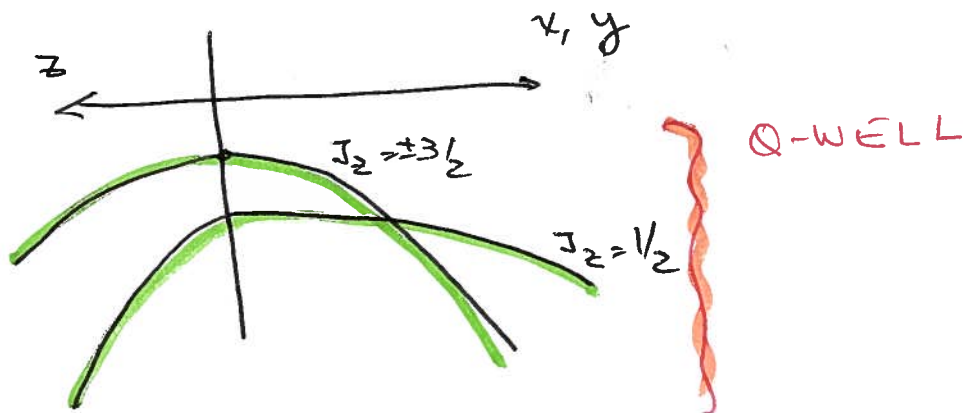
CHOOSE QUANTIZATION AXIS ALONG  $[001]$



UNDER COMPRESSIVE STRESS  $\parallel [001]$

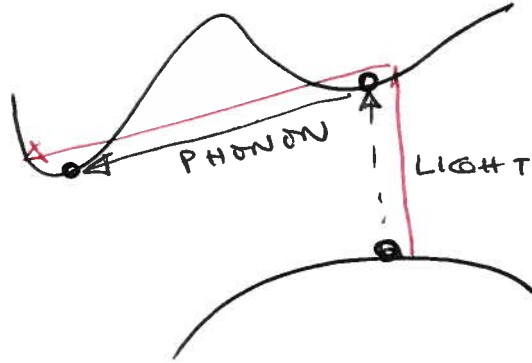


UNDER TENSILE STRESS



# INDIRECT GAPS

6



ELECTRON-PHONON INTERACTION

SECOND-ORDER PERTURBATION THEORY  
(1st order A.P + 1st order  $V_{ep}$ )

$$|\psi\rangle = |0\rangle + \text{FIRST-ORDER TERM} +$$

$$\sum_{\text{INTERM. STATES}} \frac{\langle \text{CB}_{\text{min}} | V_{ep} | \text{C.B.}_{k=0} \rangle \langle \text{CB}_{k=0} | A \cdot P | 0 \rangle}{-\hbar\omega + \bar{E}_{k=0} + i\gamma}$$

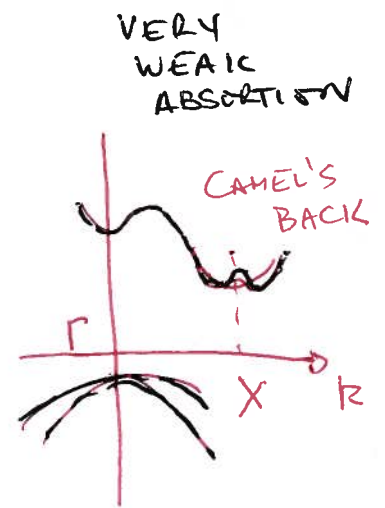
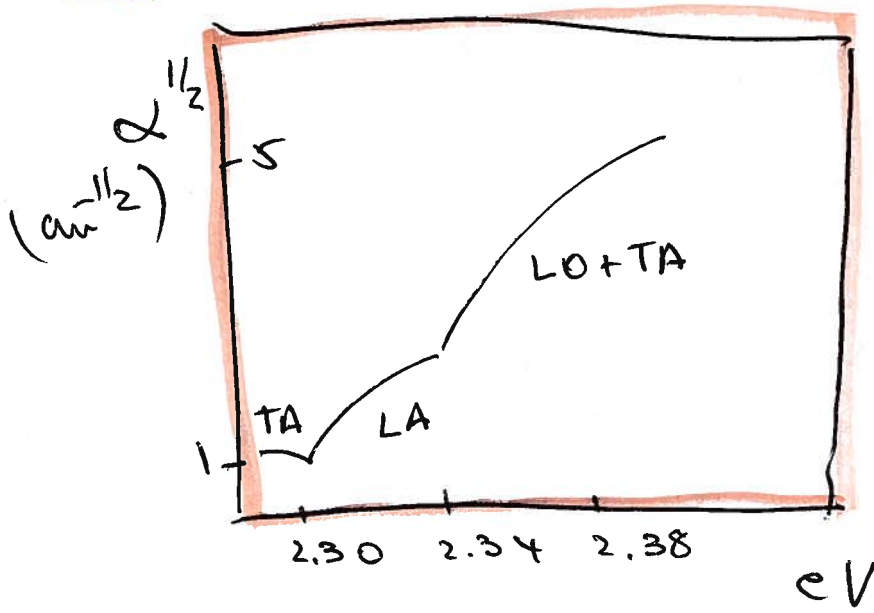
PHONON MEDIATED VERTICAL

$$\text{ABSORPTION} \propto \left| \sum_i \frac{\langle f | V_{ep} | i \rangle \langle i | A \cdot P | 0 \rangle}{E_{i0} - \hbar\omega} \right|^2 \delta(\hbar\omega \pm \hbar\Omega - E_c + E_v)$$

LIGHT FREQ  $\downarrow$   
PHONON FREQ  $\downarrow$

JOINT DENSITY OF STATES  
INTERBAND + PHONON

GAP



URBACH TAILS

(DIRECT GAP)

$$\alpha(E - E_0) / kT$$

$$\alpha = \alpha_0 e$$

PHONON-ASSISTED TRANSITIONS ?

ABSORPTION COEFF.  $\alpha$

