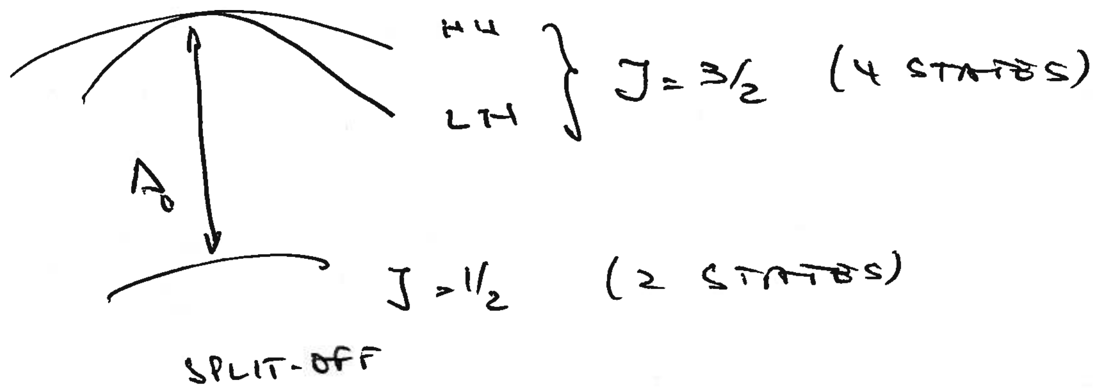
SUMMARY

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



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

EXAMPLE

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

UNITS OF PRESSURE

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

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

THIS TERM LIFTS THE DEGENERACY

TAKE NOTE: SPIN Q-AXIS IS "Z"

$$\left\{\begin{aligned} |\tfrac{3}{2},\tfrac{3}{2}\rangle &= \frac{1}{\sqrt{2}}\,|X+iY\rangle\uparrow \\ |\tfrac{3}{2},\tfrac{1}{2}\rangle &= \frac{1}{\sqrt{6}}\,\left(2|Z\rangle\uparrow - |X+iY\rangle\downarrow\right) \\ |\tfrac{1}{2},\tfrac{1}{2}\rangle &= \frac{1}{\sqrt{3}}\,\left(|Z\rangle\uparrow + |X+iY\rangle\downarrow\right) \end{aligned}\right.$$

(SAME FOR $|\tfrac{3}{2},-\tfrac{3}{2}\rangle$, $|\tfrac{3}{2},-\tfrac{1}{2}\rangle$, $|\tfrac{1}{2},-\tfrac{1}{2}\rangle$)

$$L_z|X+iY\rangle = |X+iY\rangle \qquad L_z|Z\rangle = 0$$

$m_J = \frac{1}{2}$ $J = 3/2$

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

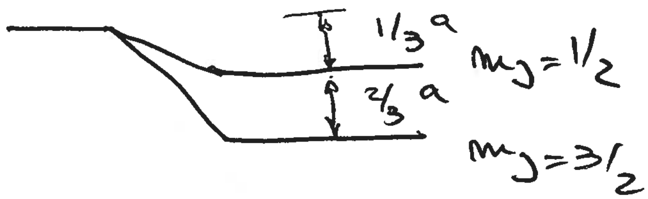
$(a = -3B_V(S_{11}-S_{12})T)$

THE MATRIX IS:

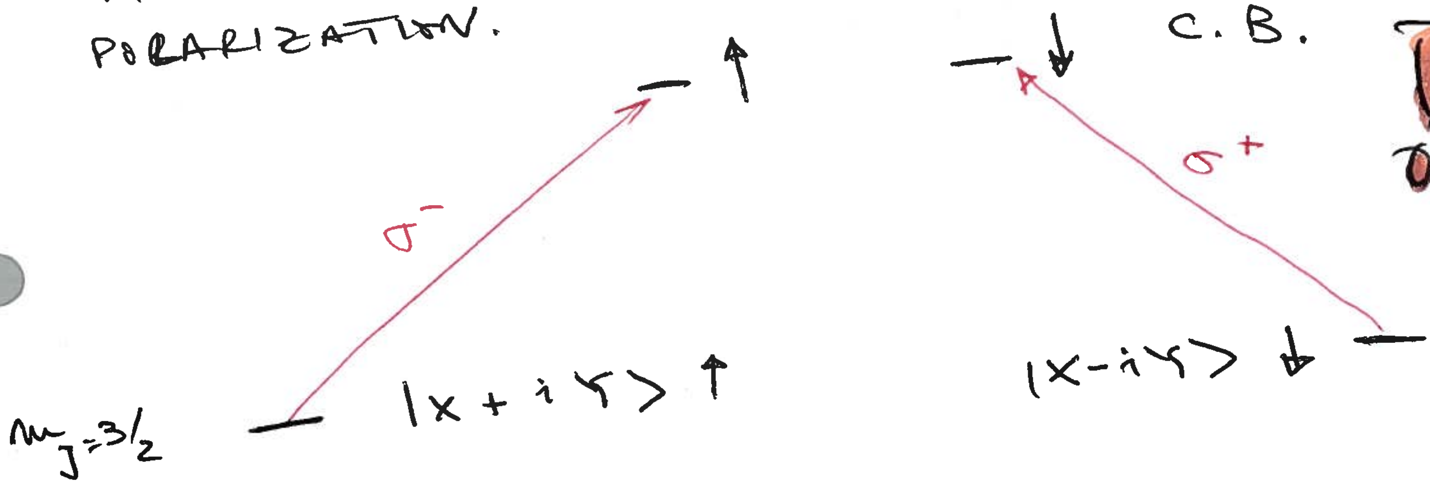
$$\begin{array}{c} \begin{vmatrix} E-a & 0 & 0 \\ 0 & E-\frac{a}{3} & \sqrt{\frac{2}{9}}\,a \\ 0 & \sqrt{\frac{2}{9}}\,a & E-\Delta_0-\frac{2a}{3} \end{vmatrix} = 0 \\ \begin{array}{ccc} |3/2,3/2\rangle & |\tfrac{3}{2},1/2\rangle & |\tfrac{1}{2},\tfrac{1}{2}\rangle \end{array} \end{array}$$

IGNORING THE COUPLING W/ SPLIT-OFF BAND:

COMPRESSIVE STRESS



SPIN-POLARIZED ELECTRONS CAN NOW 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 STATIC MAGNETIC-FIELD ON THESE STATES CAN BE EXPRESSED AS

$$-\mu^* \frac{\hat{\sigma}}{\sigma} \cdot \hat{B} \quad \left(\text{or } -\mu_0 g \, \hat{\sigma} \cdot \hat{B}\right)$$

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

$g^* \neq 2$!   GYROMAGNETIC FACTOR

REASON

THE STATIC FIELD ALSO ENTERS IN

$$\vec{p} + \frac{e}{c}\vec{A}_0 \Rightarrow \frac{1}{2}\frac{e}{mc}\left(\hat{\vec{p}} \cdot \vec{A}_0 + \vec{A}_0 \cdot \vec{p}\right)$$

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

WHICH MIXES BANDS

RESULT IS (KITTEL QTS, Ch. 14)

$$\frac{\mu^*_\gamma}{\mu_B} = 1 + \frac{1}{2im}\sum_m \frac{\langle\gamma|P_x|m\rangle\langle m|P_y|\gamma\rangle}{E_\gamma - E_m}$$

(FIELD ALONG Z-AXIS)

SIGNIFICANT DIFFERENCES

EXAMPLE

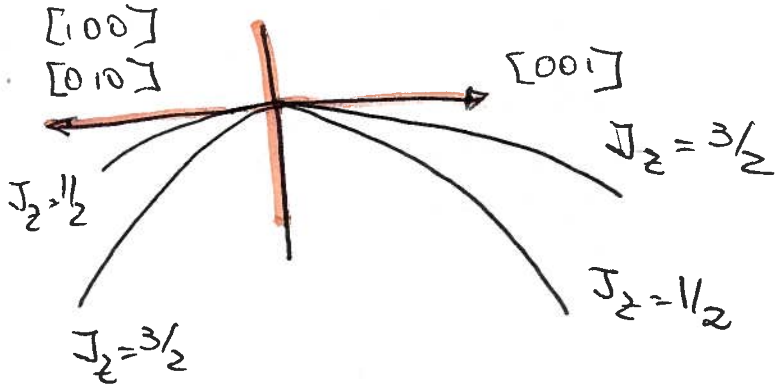
CONDUCTION ELECTRONS

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

$g \approx -50$ (InSb) $g \approx 0.03$ (GaAs)

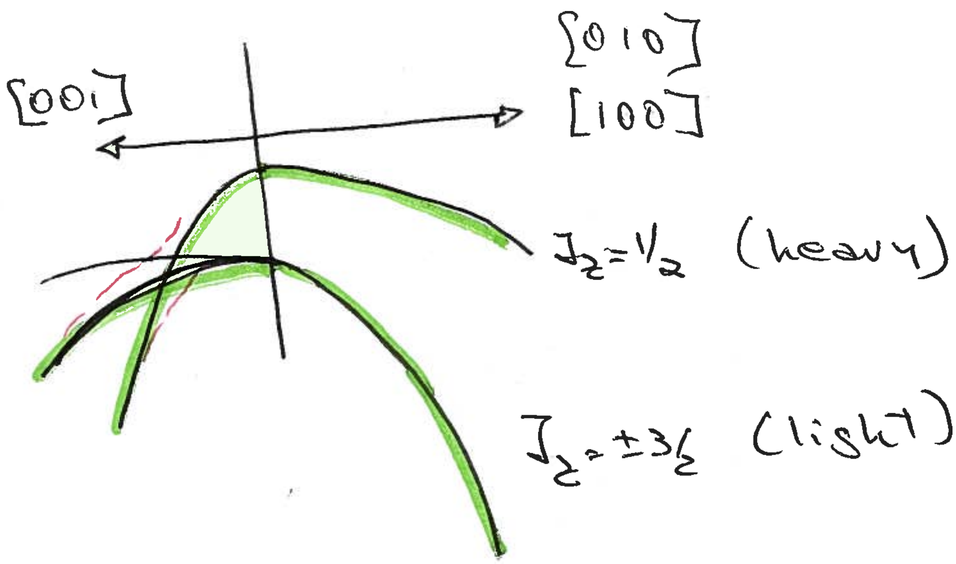
HEAVY VS LIGHT HOLE

CHOOSE QUANTIZATION AXIS ALONG [001]

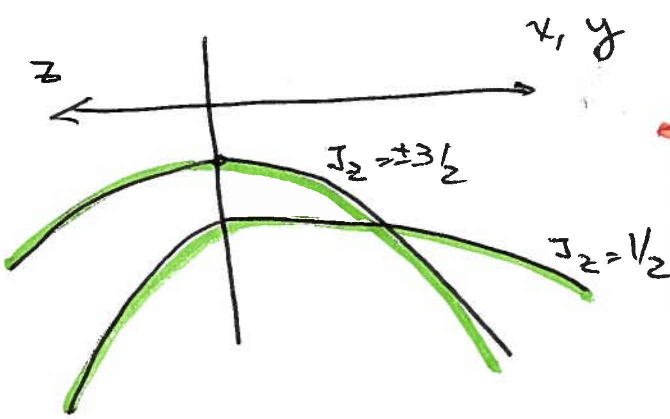


MASS REVERSAL

UNDER COMPRESSIVE STRESS || [001]

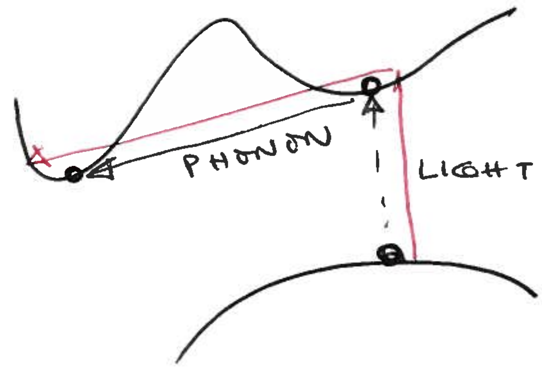


UNDER TENSILE STRES



Q-WELL

INDIRECT GAPS



ELECTRON-PHON. INTERACTION

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

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

PHONON MEDIATED   VERTICAL

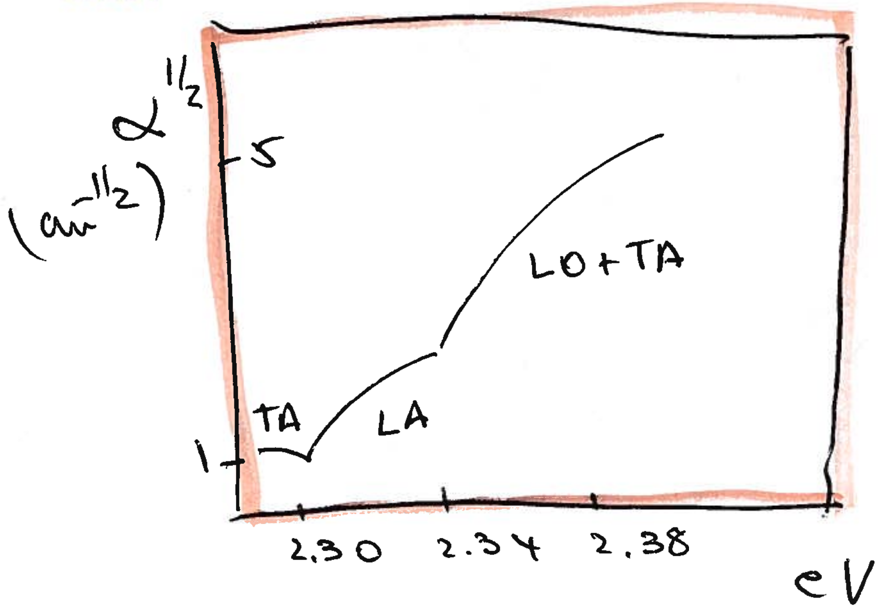
$$\sum_{\text{INTERM. STATES}} \frac{\underbrace{\langle CB_{min} | V_{ep} | CB_{k=0}\rangle}_{\text{PHONON MEDIATED}} \langle CB_{k=0} | A\cdot p | 0\rangle}{-\hbar\omega + E_{k=0} + i\gamma}$$

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

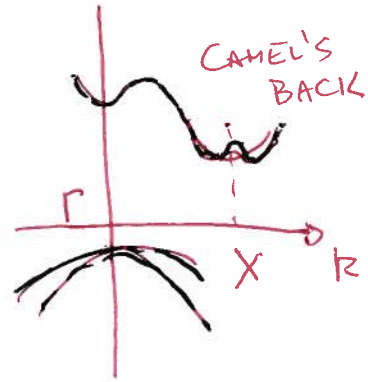
LIGHT FREQ   PHONON FREQ

JOINT. DENSITY OF STATES
INTERBAND + PHONON

GaP



VERY WEAK ABSORPTION



URBACH TAILS

(DIRECT GAP)

$$\alpha = \alpha_0 \, e^{\beta(E-E_0)/kT}$$

PHONON-ASSISTED TRANSITIONS ?