MAGNETOTRANSPORT SPECTROSCOPY OF A DOUBLE QUANTUM DOT WITH ONE AND TWO HOLES: DIRECT MEASUREMENT OF THE ANISOTROPIC HOLE g FACTOR

NRC·CNRC

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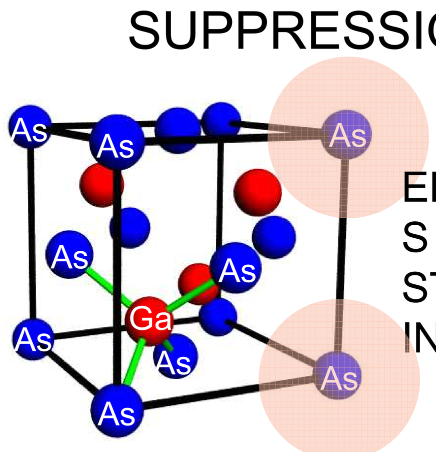
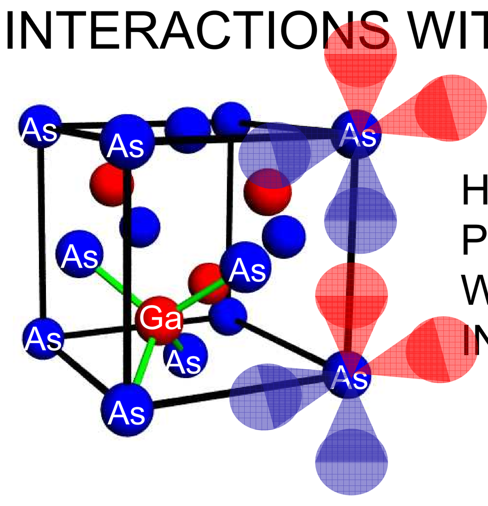
1. MOTIVATION

SUPPRESSION OF HYPERFINE INTERACTIONS WITH NUCLEI



ELECTRON:
S BLOCH FUNCTION
STRONG CONTACT
INTERACTION

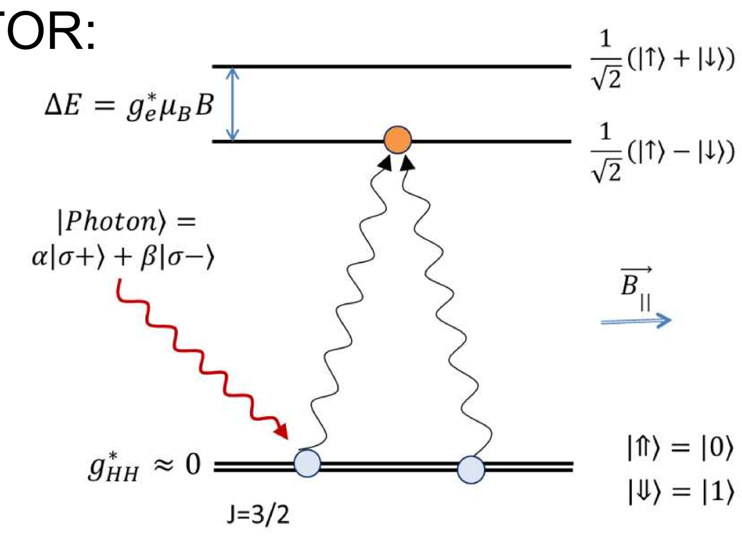


HOLE:
P BLOCH FUNCTION
WEAK CONTACT
INTERACTION

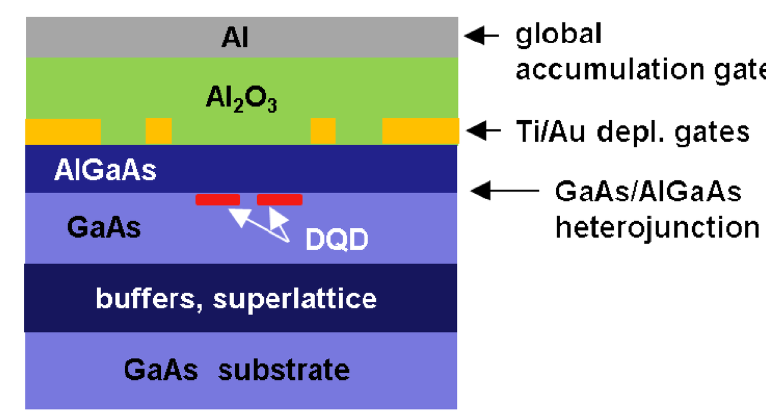
ANISOTROPY OF HEAVY HOLE g FACTOR:

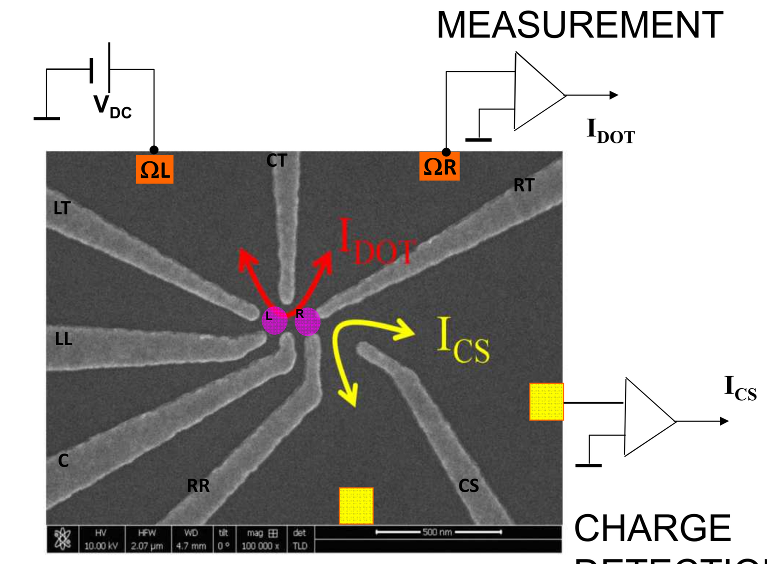
LARGE FOR PERPENDICULAR B FIELD
ZERO FOR IN-PLANE B FIELD

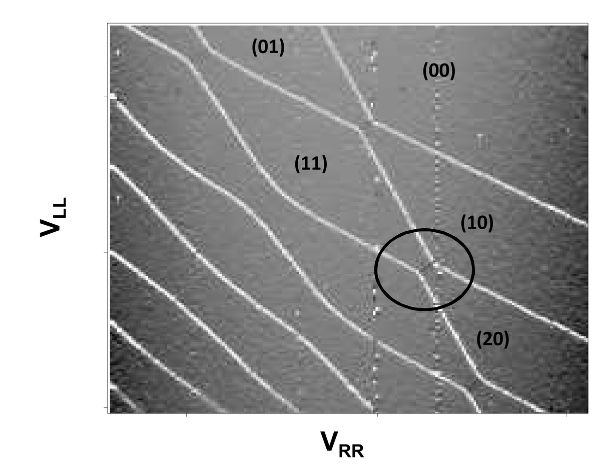
PHOTON-TO-SPIN INTERFACE:
PHOTON POLARIZATION TRANSLATED
INTO HEAVY HOLE SPIN STATE



2. THE p-GaAs DOUBLE QUANTUM DOT DEVICE





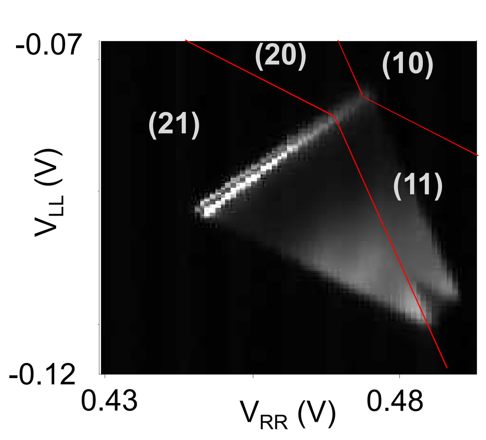


CHARGING DIAGRAM

L. A. Tracy et al., Appl. Phys. Lett. **104**, 123101 (2014)

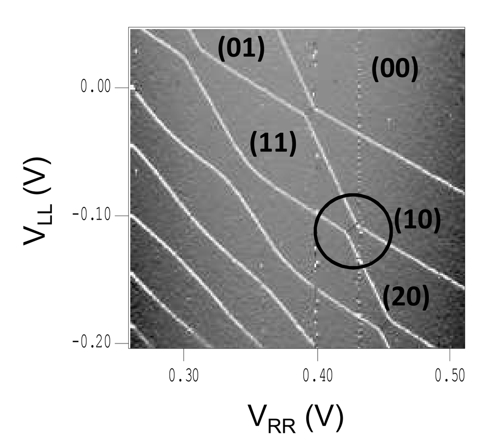
3. THE ONE HOLE PER DOT REGIME

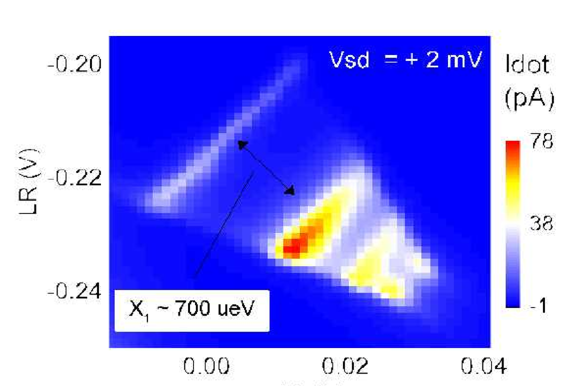
TRANSPORT MEASUREMENT (I_{DOT})



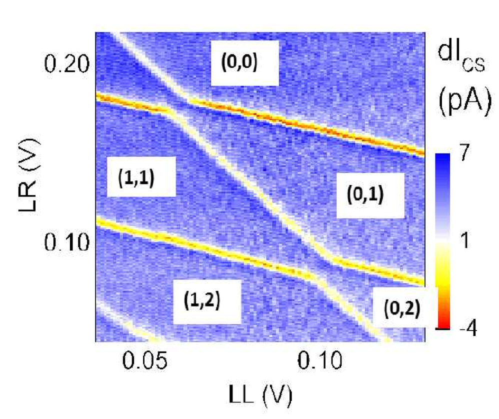
NRC

CHARGE MEASUREMENT (dI_{CS})



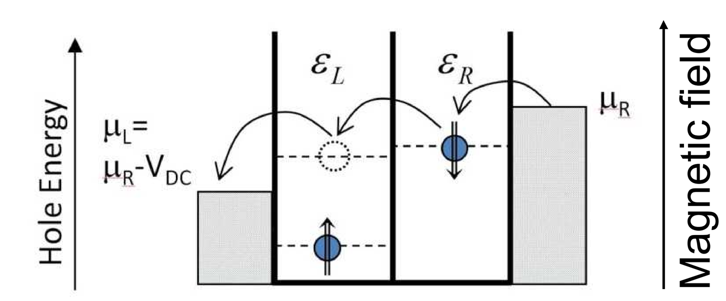


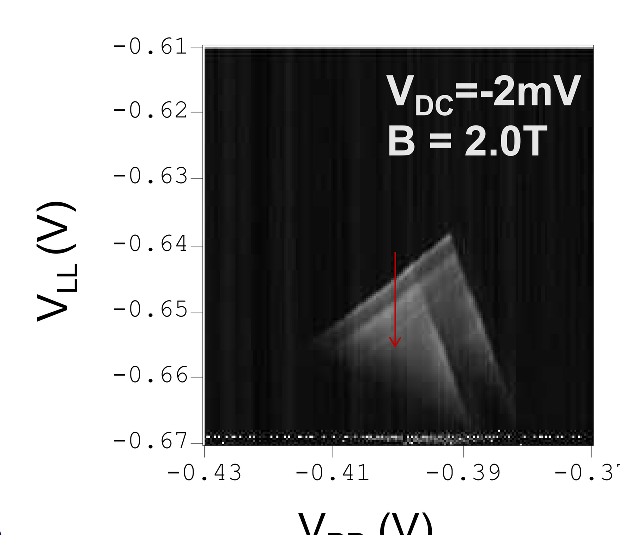
SANDIA

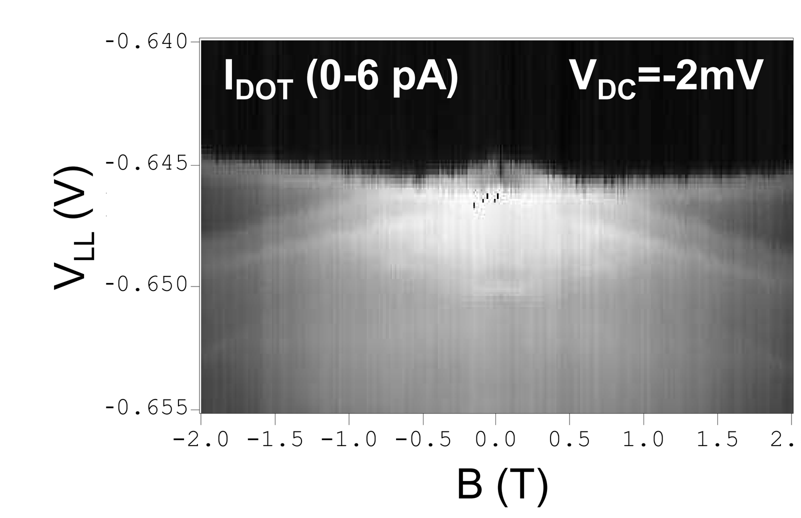


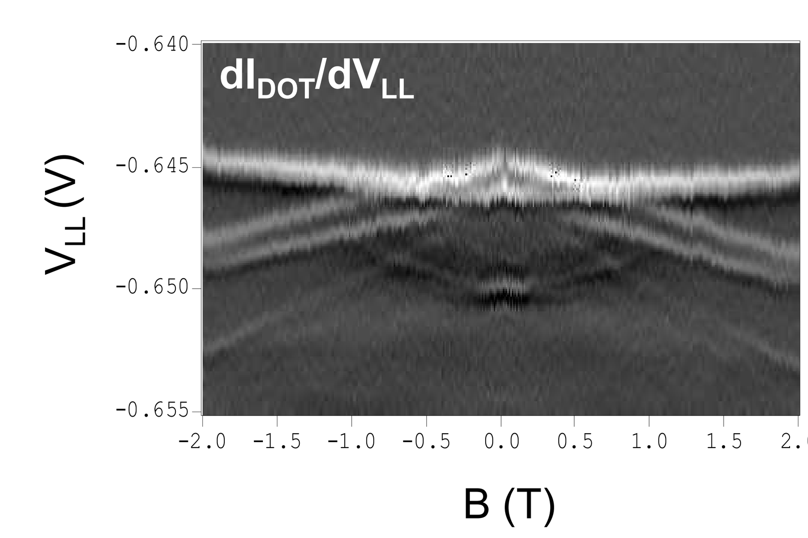
SANDIA REPORT SAND2015-8132 (October 2015)

4. MAGNETOTRANSPORT SPECTROSCOPY

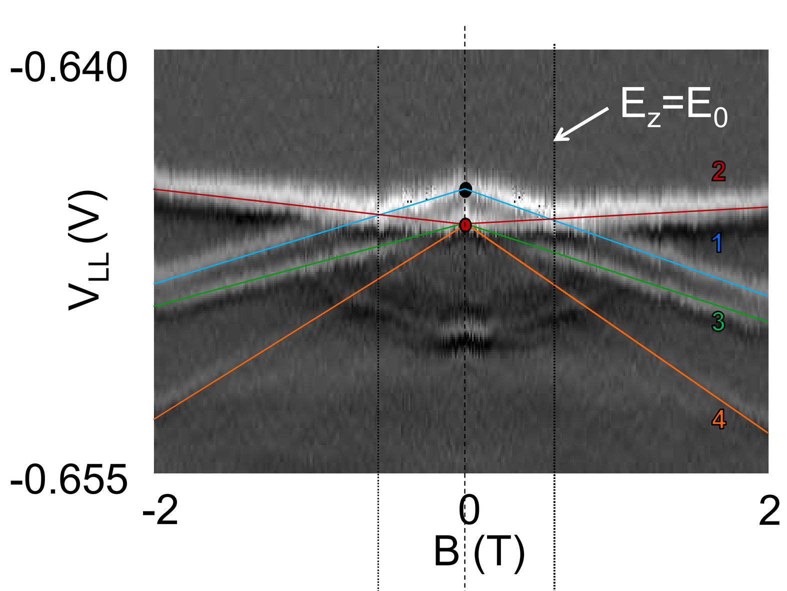


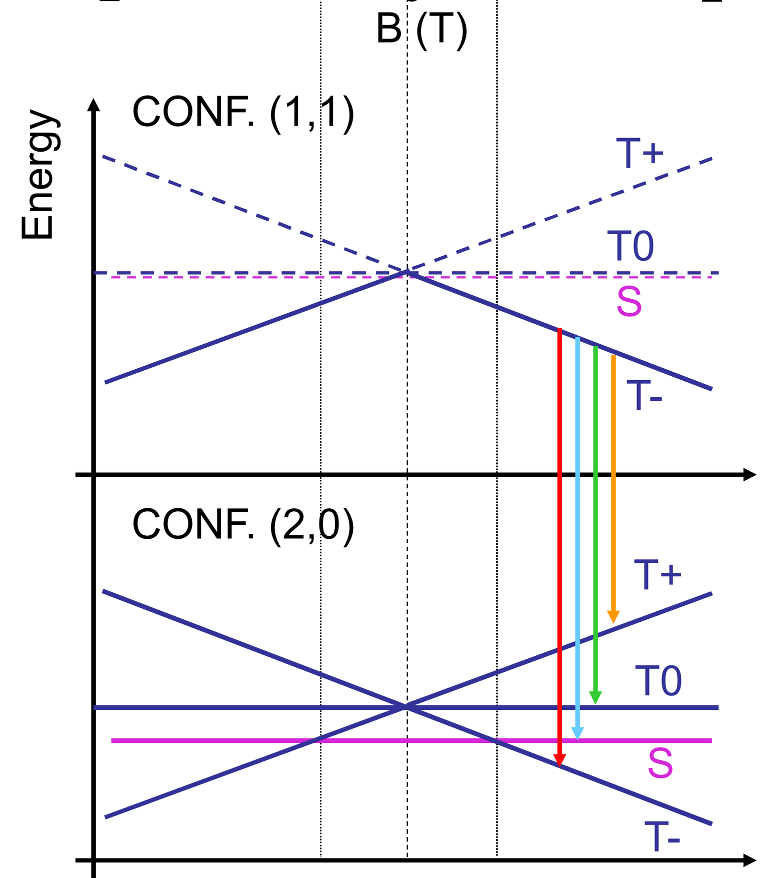






5. INTERPRETATION OF TRANSPORT SPECTRA





TRANSPORT SPECTRA REVEAL
NO CLEAR SPIN BLOCKADE

LUTTINGER-KOHN HAMILTONIAN

$$H_{LK} = \begin{bmatrix} P_+ & R & -S & 0 \\ R^* & P_- & 0 & S \\ -S^* & 0 & P_- & R \\ 0 & S^* & R^* & P_+ \end{bmatrix} \quad \begin{matrix} |3/2,3/2\rangle \\ |3/2,-1/2\rangle \\ |3/2,1/2\rangle \\ |3/2,-3/2\rangle \end{matrix}$$

$$P_+ = E_{HH} + \frac{\hbar^2}{2m_0}\left[(\gamma_1+\gamma_2)(k_x^2+k_y^2)+(\gamma_1-2\gamma_2)k_z^2\right]+V(z);$$

$$P_- = E_{LH} + \frac{\hbar^2}{2m_0}\left[(\gamma_1-\gamma_2)(k_x^2+k_y^2)+(\gamma_1+2\gamma_2)k_z^2\right]+V(z)$$

$$R = -\sqrt{3}\frac{\hbar^2}{2m_0}\gamma_{23}(k_x-ik_y)^2; \qquad S = 2\sqrt{3}\frac{\hbar^2}{2m_0}\gamma_3(k_x-ik_y)k_z$$

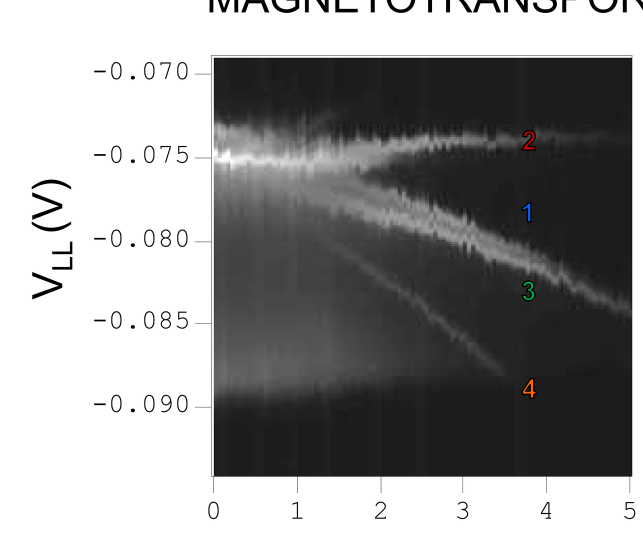
QUANTUM WELL CONFINEMENT:
HOLE STATES WITH CONSERVED
PSEUDOSPIN (CHIRALITY)

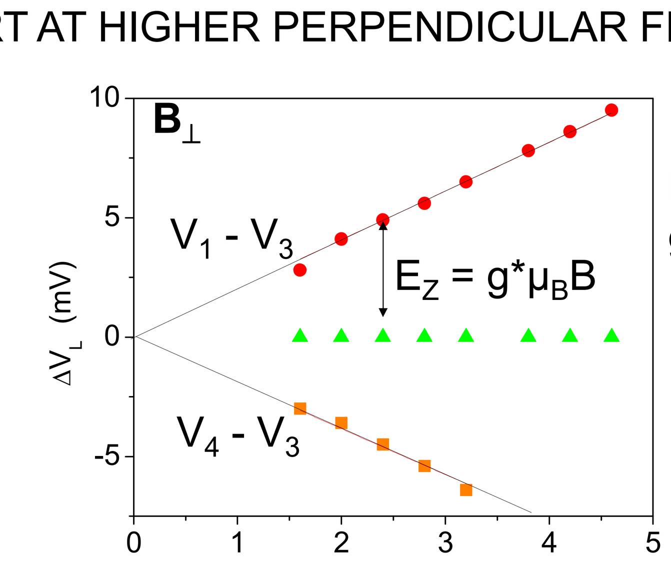
$$|\Uparrow\rangle = \begin{bmatrix} \varphi_{+3/2}(x,y)\cos(k_z z)\left|\frac{3}{2},+\frac{3}{2}\right\rangle \\ \varphi_{-1/2}(x,y)\cos(k_z z)\left|\frac{3}{2},-\frac{1}{2}\right\rangle \\ \varphi_{+1/2}(x,y)\sin(k_z z)\left|\frac{3}{2},+\frac{1}{2}\right\rangle \\ \varphi_{-3/2}(x,y)\sin(k_z z)\left|\frac{3}{2},-\frac{3}{2}\right\rangle \end{bmatrix} \qquad |\Downarrow\rangle = \begin{bmatrix} \varphi_{+3/2}(x,y)\sin(k_z z)\left|\frac{3}{2},+\frac{3}{2}\right\rangle \\ \varphi_{-1/2}(x,y)\sin(k_z z)\left|\frac{3}{2},-\frac{1}{2}\right\rangle \\ \varphi_{+1/2}(x,y)\cos(k_z z)\left|\frac{3}{2},+\frac{1}{2}\right\rangle \\ \varphi_{-3/2}(x,y)\cos(k_z z)\left|\frac{3}{2},-\frac{3}{2}\right\rangle \end{bmatrix}$$

TRIANGULAR CONFINEMENT OF
THE ACCUMULATION GATE:
CHIRALITY NOT CONSERVED

6. HEAVY HOLE EFFECTIVE g FACTOR

MAGNETOTRANSPORT AT HIGHER PERPENDICULAR FIELDS

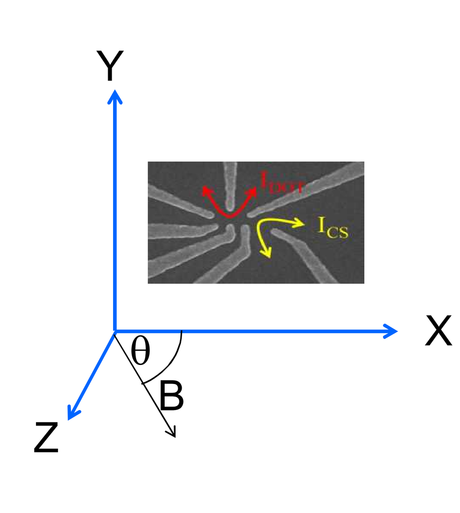


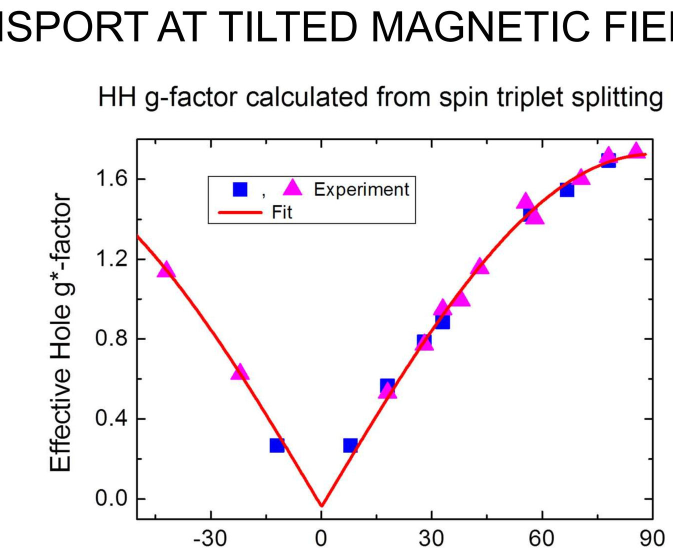


HEAVY HOLE EFFECTIVE
g FACTOR

g^* = 1.70

MAGNETOTRANSPORT AT TILTED MAGNETIC FIELDS





$$g^*(\theta) = g_0|\sin\theta| + g_{min}$$

$$g_0 = 1.7 \pm 0.1$$

$$g_{min} = -0.04 \pm 0.04$$

CONCLUSIONS:

•HEAVY HOLE g FACTOR HAS BEEN MEASURED IN A LATERAL GATED DOUBLE DOT
•THE g FACTOR IS ANISOTROPIC AND TUNABLE IN SITU BY THE TILT ANGLE OF THE MAGNETIC FIELD

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