Effect of a tilted magnetic field on radiation-induced zero resistance states and resistance oscillations in a 2DEG

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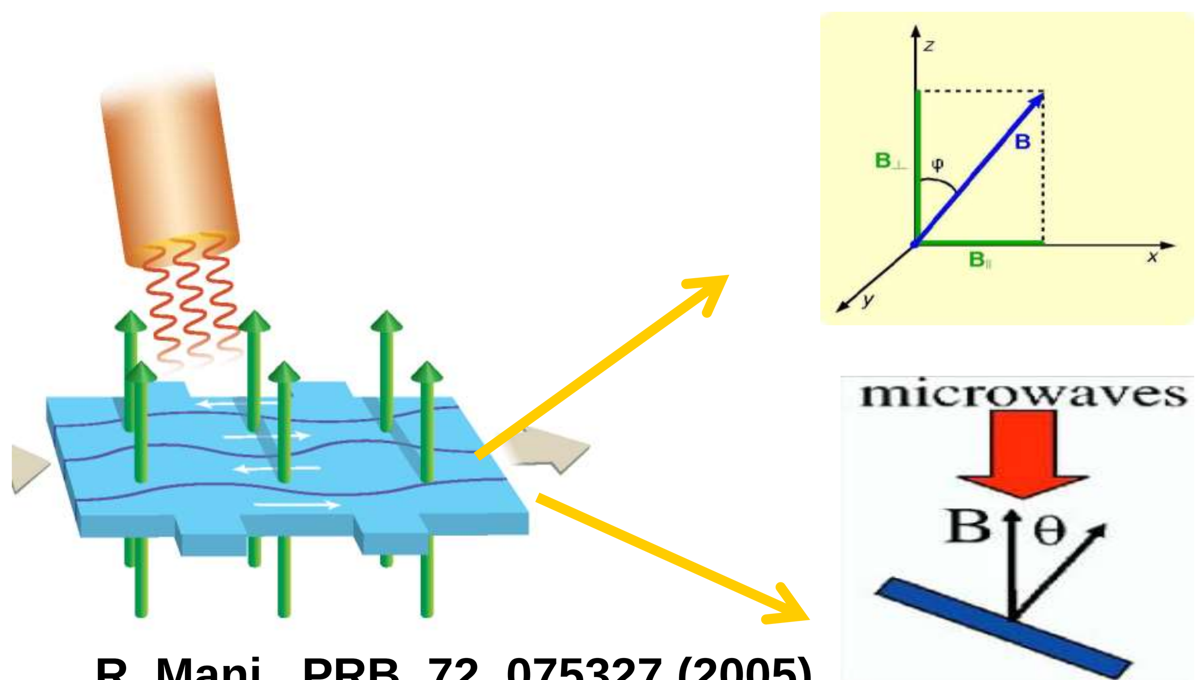
Introduction

In this work we present a theoretical approach to study the effect of a tilted magnetic field on the microwave-assisted transport properties of a two-dimensional electron system.

experimental evidences : oscillations displacement and unbalanced quenching of magnetoresistance oscillations with increasing tilted magnetic field.



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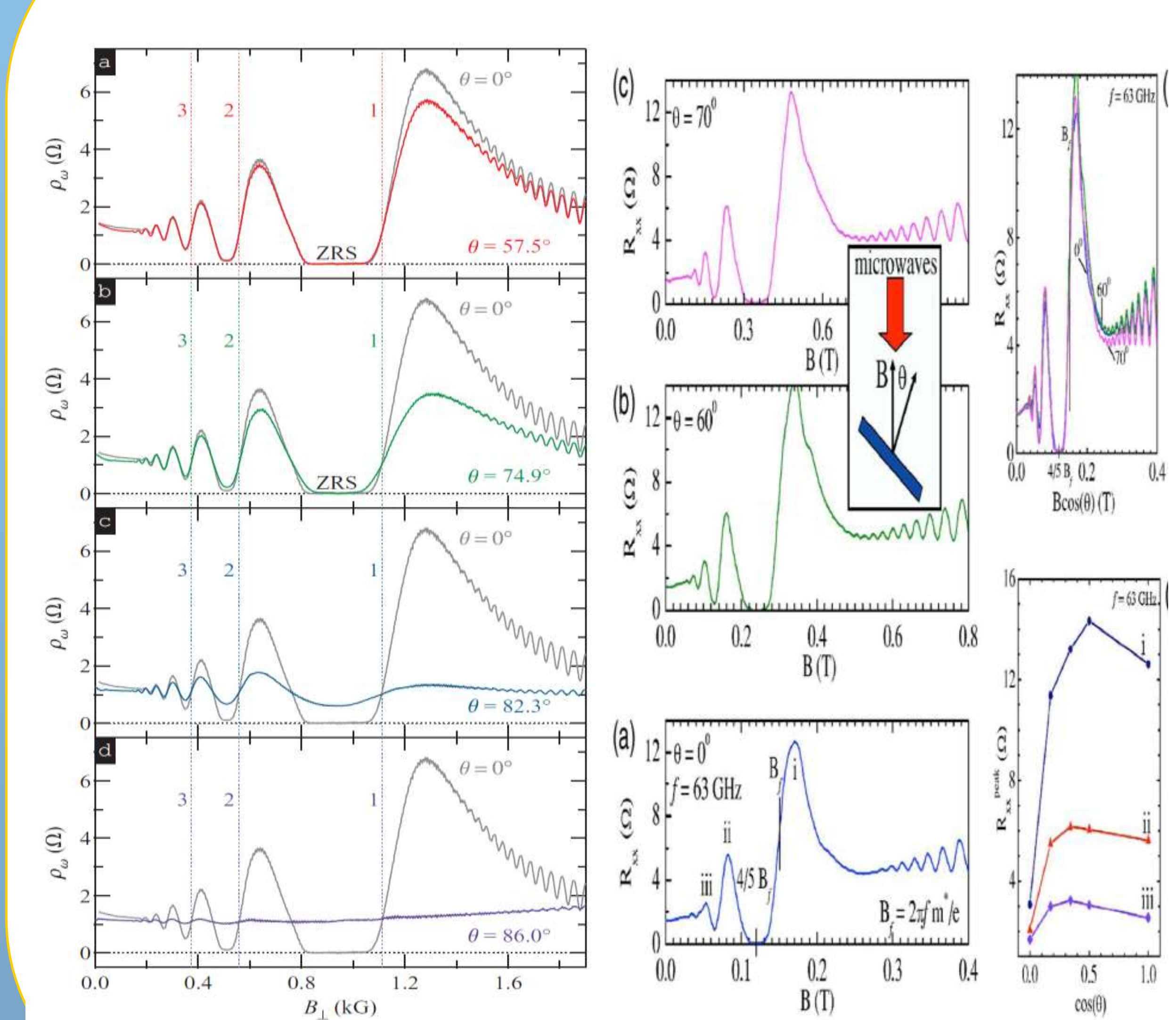
A. Bogan, PRB, (2012) R. Mani, PRB, (2005).



Theoretical Model

We first obtain an **exact expression of the electronic wave vector** for a 2DES in a perpendicular B, a dc electric field and a MW radiation.

$$\Psi(x,y,t)=\phi_N\left[(x-X-x_{cl}(t)),(y-y_{cl}(t)),t\right]$$
$$\times exp\frac{i}{\hbar}\left[m^*\left(\frac{dx_{cl}}{dt}x+\frac{dy_{cl}}{dt}y\right)+\frac{m^*w_c(x_{cl}x-y_{cl}y)}{2}-\int_0^t Ldt\right]$$
$$\times\sum_{p=-\infty}^{\infty}J_p(A_N)e^{ipwt} \qquad x_{cl}=\frac{eE_o}{m^*\sqrt{(w_c^2-w^2)^2+\gamma^4}}\cos wt$$

$$\Psi_m \qquad \tau=\frac{1}{W_{m,n}} \qquad \Psi_n$$

$$\Delta X^{MW}=\left(\Delta X^0+\frac{eE_o}{m^*\sqrt{(w_c^2-w^2)^2+\gamma^4}}\cos w\tau\right)$$

The longitudinal conductivity σ_{xx} can be calculated: $\sigma_{xx}\propto\int dE\frac{\Delta X^{MW}}{\tau}(f_i-f_f)$, being f_i and f_f the corresponding distribution functions for the initial and final states respectively and E energy. To obtain ρ_{xx} we use the relation $\rho_{xx}=\frac{\sigma_{xx}}{\sigma_{xx}^2+\sigma_{xy}^2}\simeq\frac{\sigma_{xx}}{\sigma_{xy}^2}$, where $\sigma_{xy}\simeq\frac{n_ie}{B}$ and σ_{xx}

$$\rho_{xx}\propto\frac{eE_o}{m^*\sqrt{(w_c^2-w^2)^2+\gamma^4}}\cos w\tau$$

γ = DAMPING FACTOR ➡ ACOUSTIC PHONONS

$$\frac{1}{\tau_{ac}}=\frac{m^*\Xi_{ac}^2k_BT_L}{\hbar^3\rho u_l^2<z>}$$

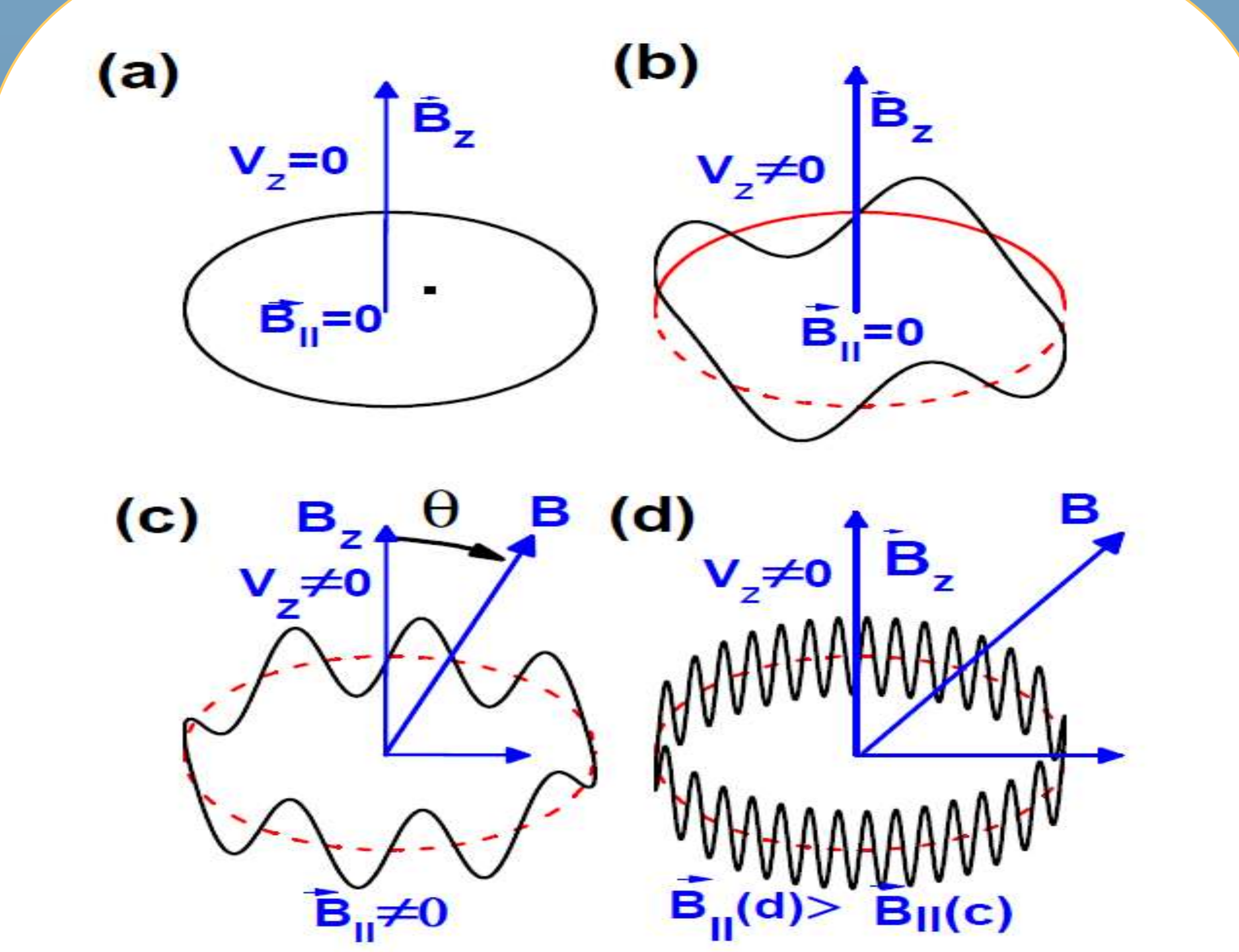
$$H_T=\frac{P_x^2+P_y^2}{2m^*}+\frac{w_z}{2}L_z+\frac{1}{2}m^*\left[\frac{w_z^2}{2}\right]\left[(x-X)^2+y^2\right]-\frac{1}{2}eE_{dc}X$$
$$-eE_0(x-X)\cos wt-eE_0X\cos wt+\frac{P_z^2}{2m^*}+\frac{1}{2}m^*\Omega^2z^2.$$

$$H_z=\frac{P_z^2}{2m^*}+\frac{1}{2}m^*\boxed{(w_x^2+w_0^2)}z^2=\frac{P_z^2}{2m^*}+\frac{1}{2}m^*\boxed{\Omega^2}z^2$$

B in-plane **Z-confinment**

$$\Psi_T(x,y,t)\propto\phi_N\{[x-X-a(t)],[y-b(t)],t\}\phi(z)$$

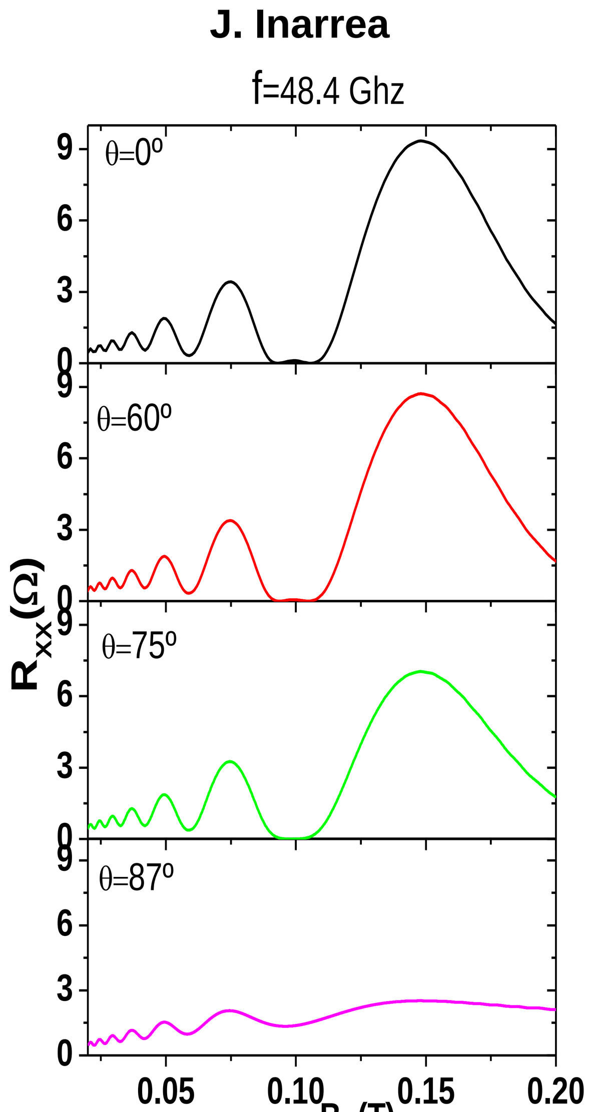
Harmonic Oscillator in Z



$$\gamma_f=\gamma\times\frac{\Omega}{w_0}=\gamma\times\sqrt{1+\left(\frac{w_x}{w_0}\right)^2}=\gamma\times\sqrt{1+\left(\frac{eB_x}{m^*w_0}\right)^2}$$

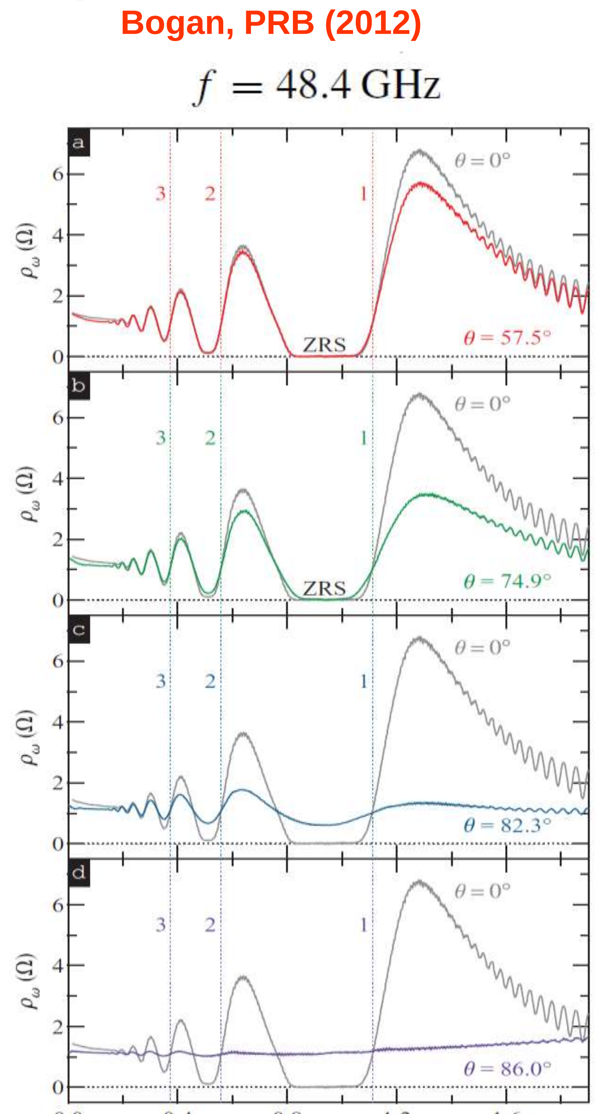
Calculated results

J. Inarrea



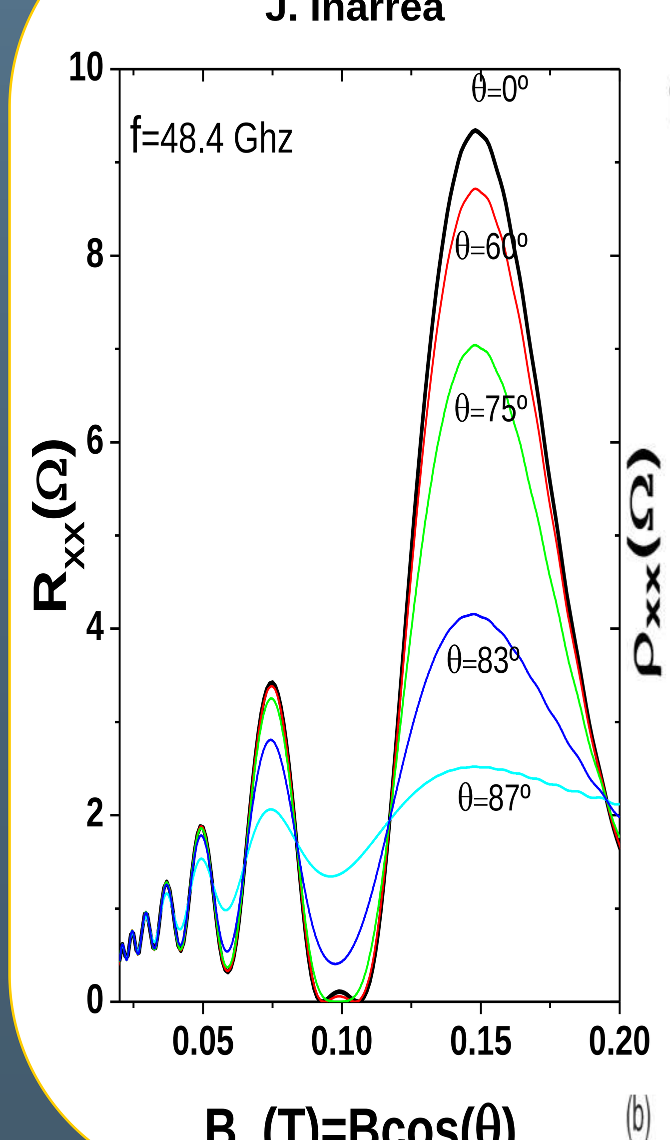
Experimental results

Bogan, PRB (2012)

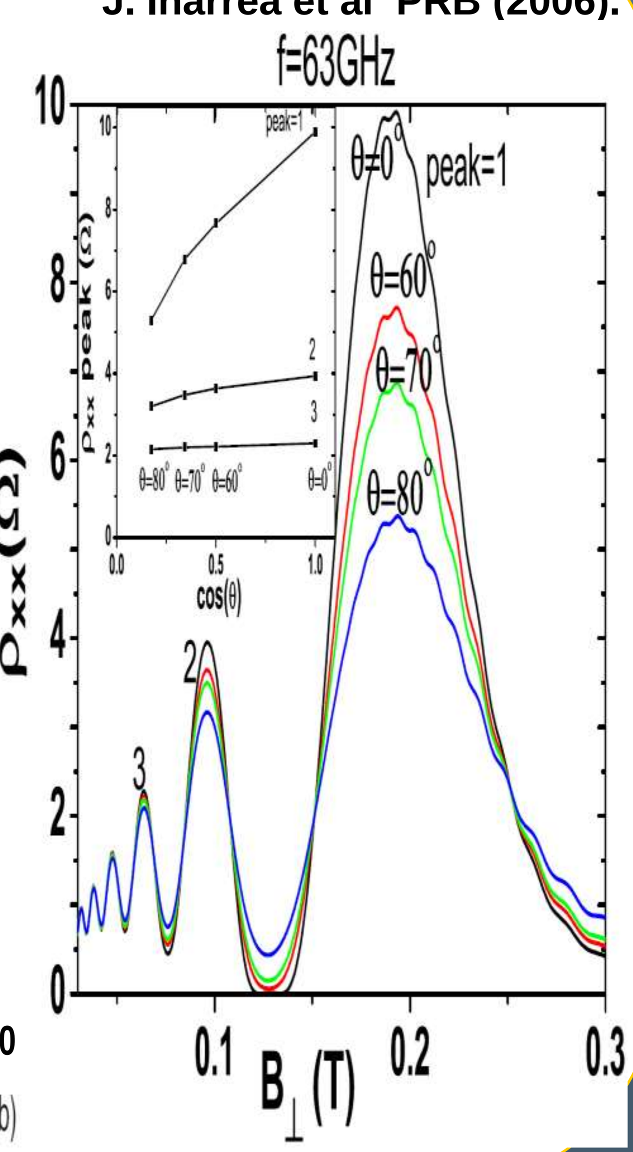


Calculated results, .

J. Inarrea



J. Inarrea et al PRB (2006).



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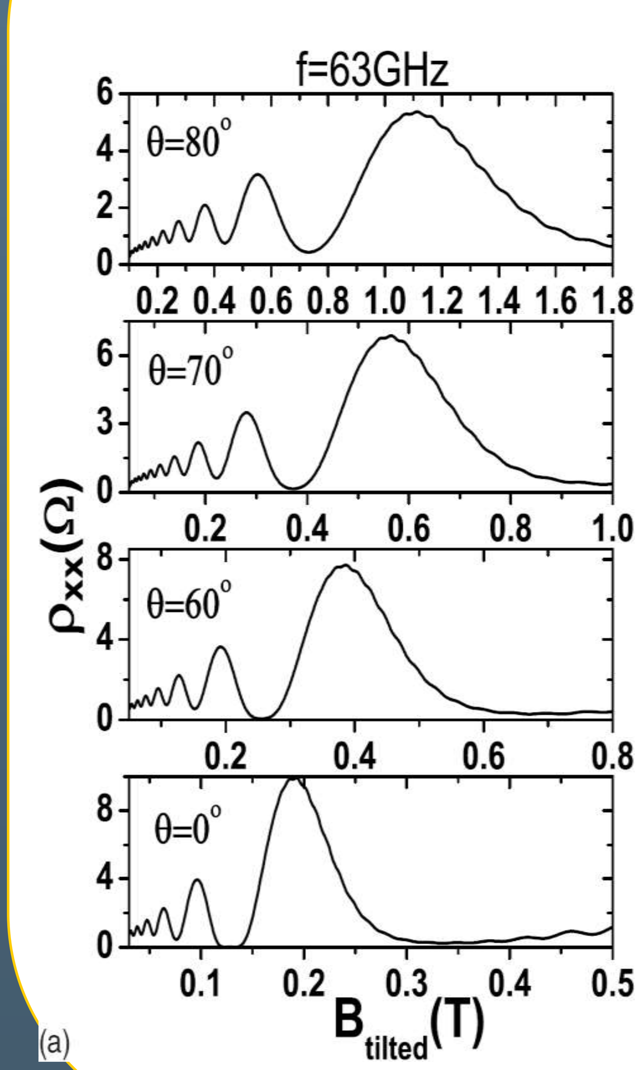

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