Microwave polarization dependence of magnetoresistance oscillations of 2DES

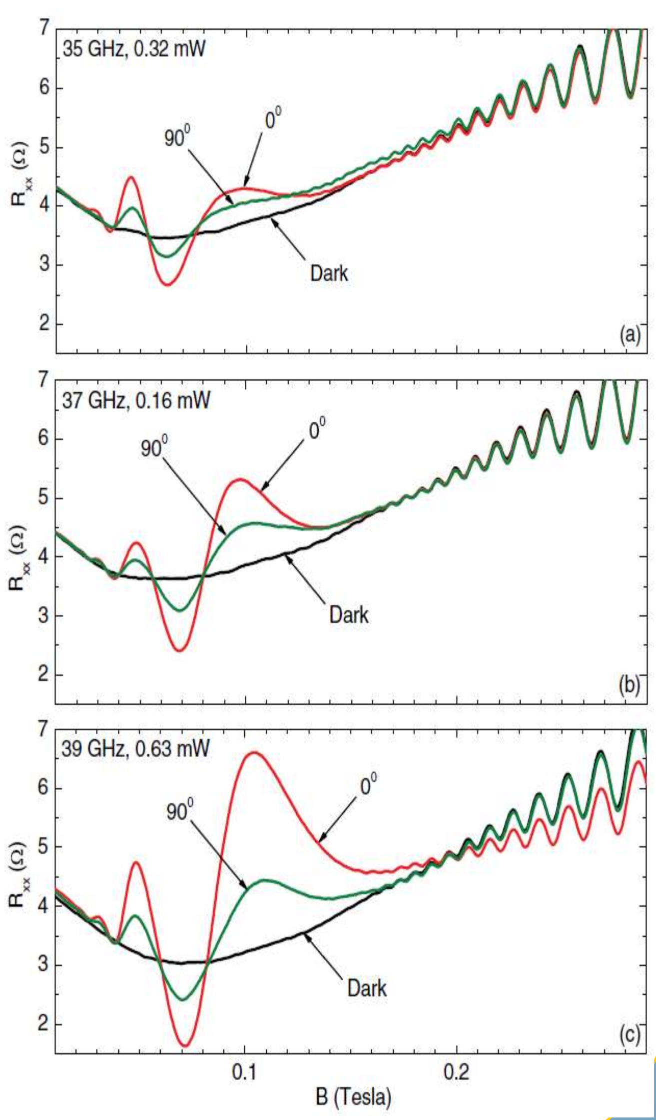
Jesús Iñarrea

Escuela Politécnica Superior, Universidad Carlos III, Leganés, Madrid, Spain

Introduction

We have studied the influence of the polarization angle of linear radiation on the radiation-induced magneto-resistance oscillations in 2DES.
We obtain, that resistance is sensitive to the orientation of the microwave electric field, in agreement with experimental results. We conclude that the sample shape is key to obtain sensitivity.
Previous experiments obtained however, immunity to the microwave polarization angle.

Experiments, by Mani et al. PRB 2011



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.

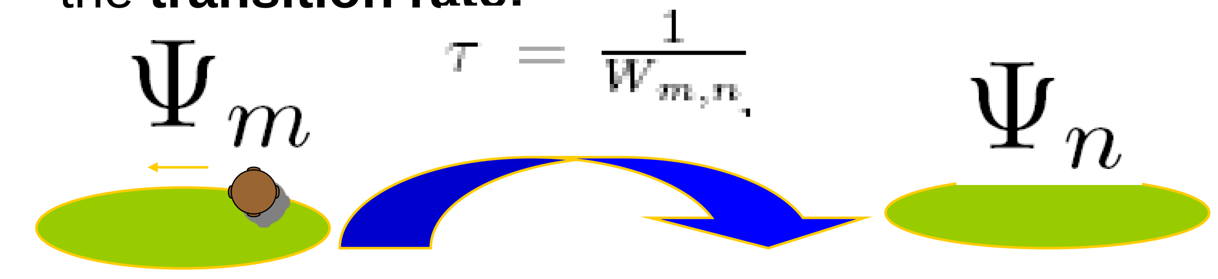
$$\Psi(x,y,t) \propto \phi_N[(x - X - a(t)), (y - b(t)), t]$$

where ϕ_N are analytical solutions for the Schrödinger equation with a two-dimensional (2D) parabolic confinement, known as Fock-Darwin states.

$$a(t) = \frac{eE_0 \cos wt}{m^* \sqrt{\frac{w^2(w_c^2 - w^2)^2}{w^2\cos^2\alpha + w_c^2 \sin^2\alpha} + \gamma^4}} = A_x \cos wt$$

$$b(t) = \frac{eE_0 \sin wt}{m^* \sqrt{\frac{w^2 w_c^2 (w_c^2 - w^2)^2}{\left(w\sqrt{w^2\cos^2\alpha + w_c^2\sin^2\alpha} + \cos\alpha(w_c^2 - w^2)\right)^2} + \gamma^4}} = A_y \sin wt.$$

Impurity scattering model based to calculate the **transition rate:**



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

With MW, all the electronic orbits centers oscillate back and forth in the x direction and when an electron scatters with probability ***Wn,m*** takes a time $\tau = \frac{1}{W_{m,n}}$ to complete the jump from an orbit to another, changing its average orbit center in:

$$\Delta X^{MW} = \Delta X^0 + A_x \cos w\tau$$

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 $\sigma_{xy} \simeq \frac{n_i e}{B}$ and $\sigma_{xx} \ll \sigma_{xy}$.

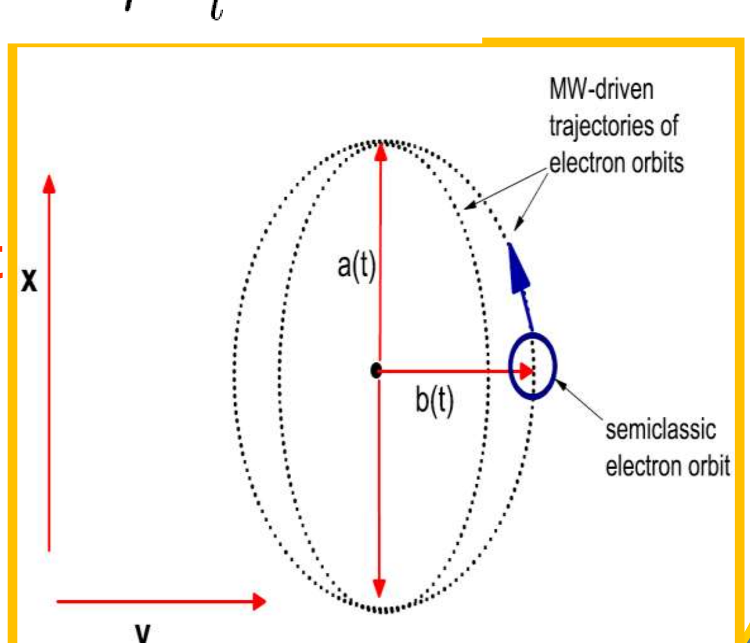
$$R_{xx} \propto A_x \cos w\tau$$

γ = DAMPING FACTOR → ACOUSTIC PHONONS

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

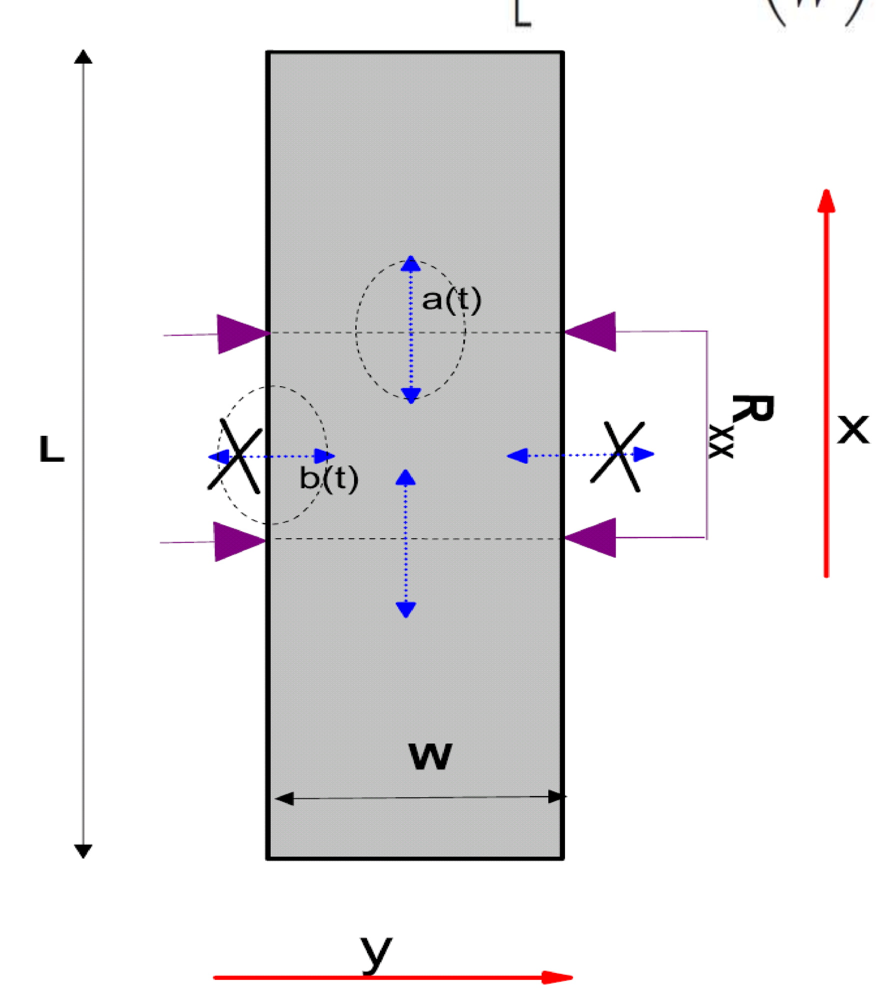
Trajectory of the guiding center of the electron orbit

$$\frac{a^2}{A_x^2} + \frac{b^2}{A_y^2} = 1.$$

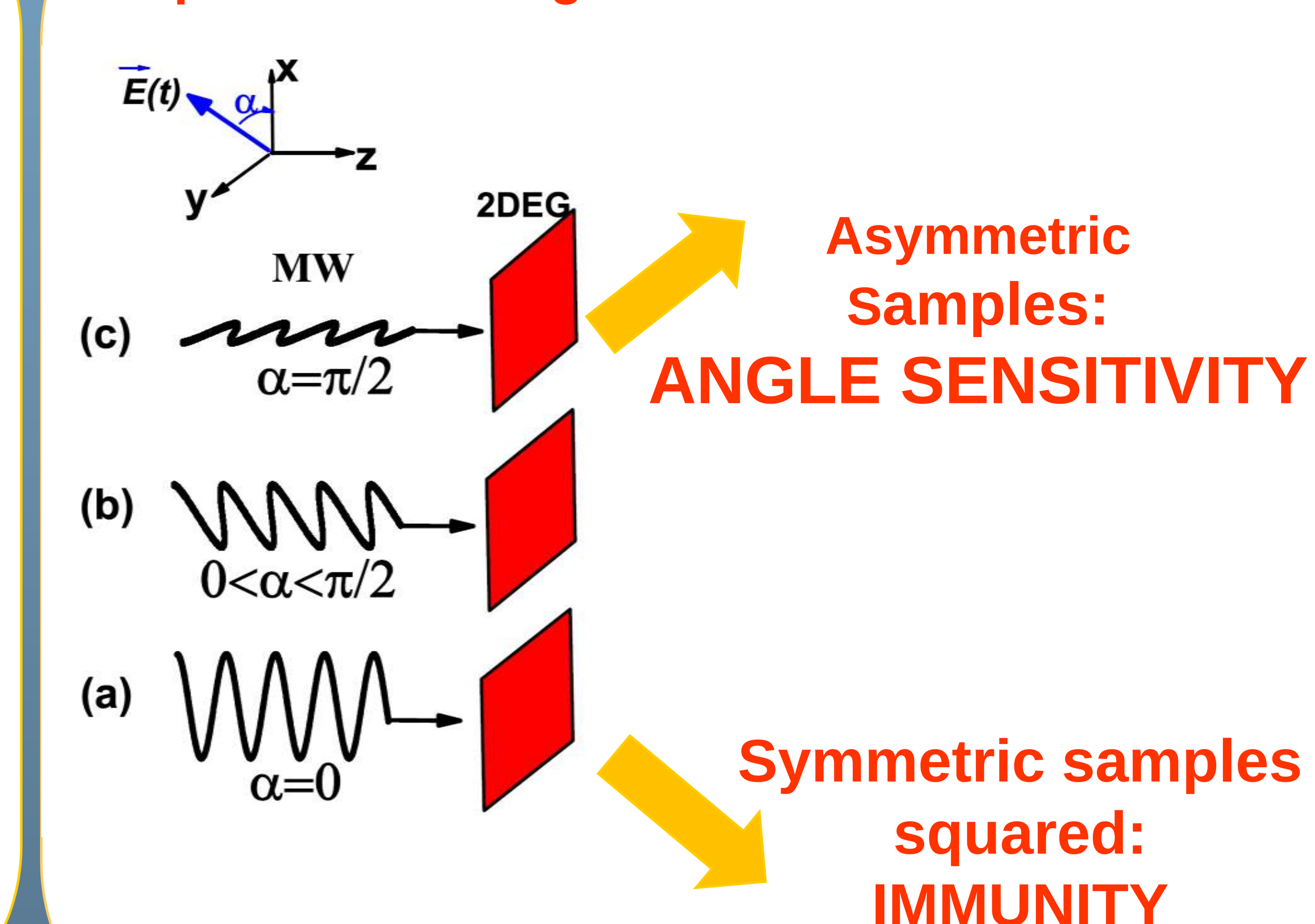


Asymmetric sample

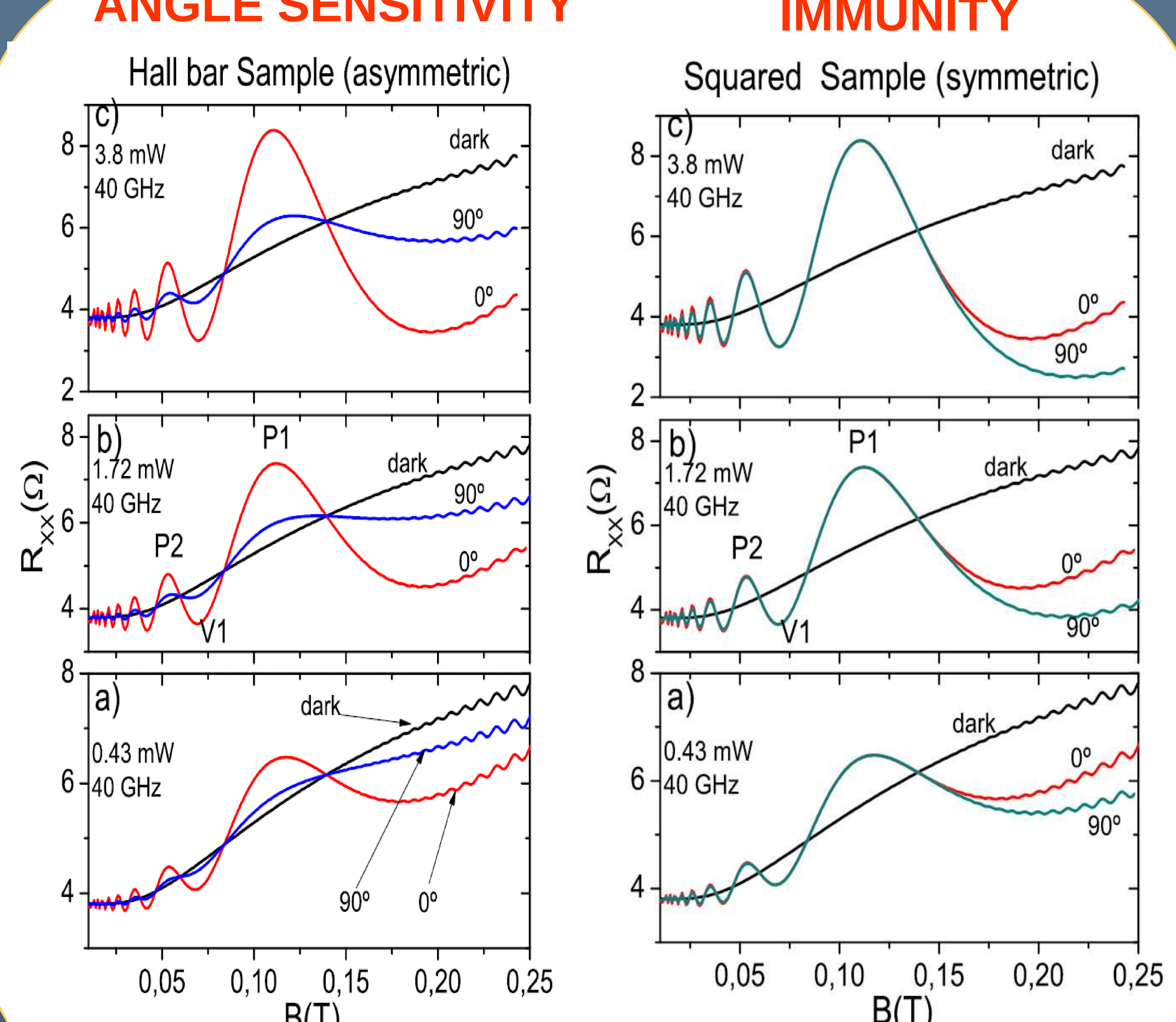
$$\gamma_t = \gamma \times \left[\cos^2\alpha + \left(\frac{L}{W}\right)\sin^2\alpha\right]$$



MW polarization angle

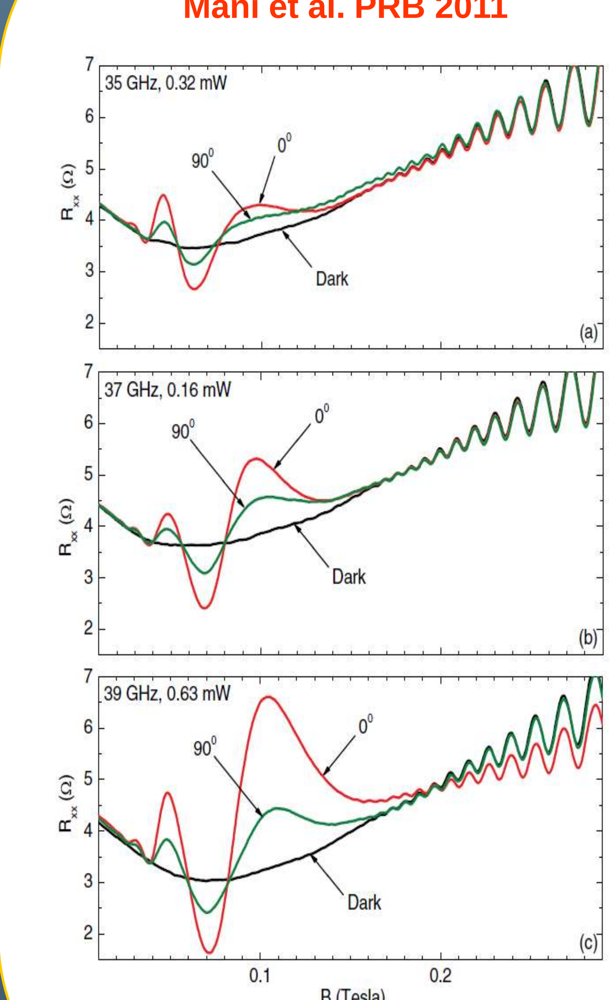


ANGLE SENSITIVITY / IMMUNITY

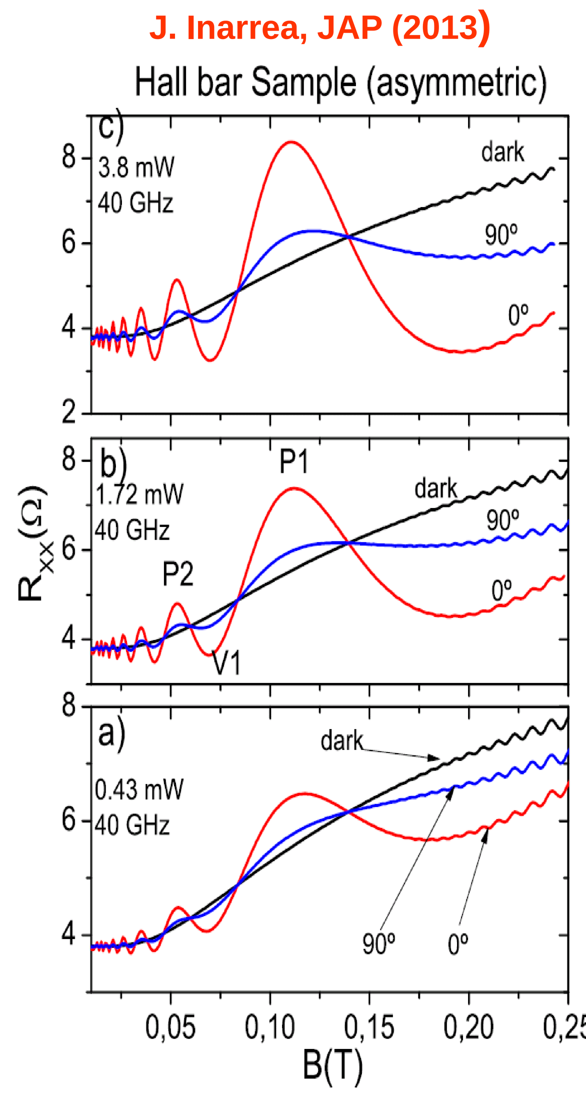


Calculated results J. Inarrea, JAP (2013)

Experimental results
Mani et al. PRB 2011



Calculated results
J. Inarrea, JAP (2013)



Calculated results
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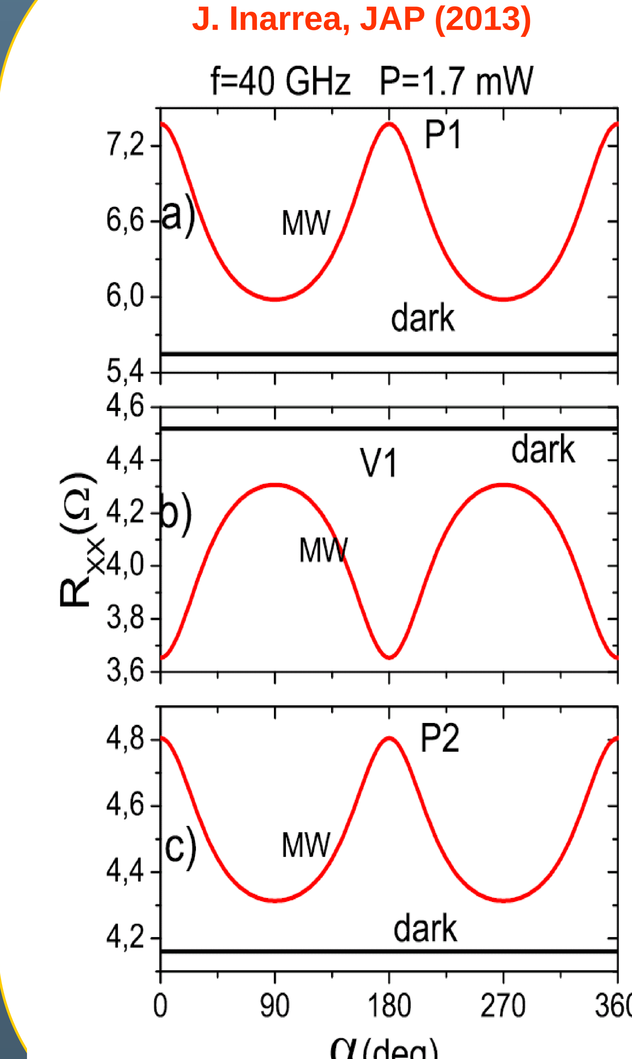

Experimental results
Mani et al. PRB 2012