In-plane photocurrent in a quantum layer

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We study photocurrent in a quantum well illuminated by IR light with in-plane and out-of-plane polarization. Fig. 1 illustrates possible experimental scheme.Two models are examined. The first one is a quasiclassical parabolic well with inhomogeneous distribution of scatterers across the well providing vertical asymmetry of the system.

The photocurrent originates from the periodic vibration of electrons in a vertical direction caused by the normal component of the alternating electric field with simultaneous in-plane acceleration/deceleration by the in-plane component of electric field. The problem is considered assuming inhomogeneously-distributed friction. The current is described by a phenomenological expression

$$\mathbf{j} = \alpha_s(\mathbf{E} - \mathbf{n}(\mathbf{nE}))\mathbf{E}^* + c.c.) + i\alpha_s[\mathbf{n}[\mathbf{EE}^*]],$$

where **n** is the surface normal, **E** is the light electric field amplitude. The coefficients α_s and α_a describe responses to linear and circular polarization of light. The direction of the current are determined by the polarization of light. Photocurrent is found to have a resonance character (see Fig. 2). Resonance occurs at light frequency ω close to a characteristic well frequency Ω. The coefficients α_s and α_a behave like $\alpha_s + i\alpha_a \propto 1/(\omega - \Omega + i\gamma)$, where γ is a scattering rate. The effect of in-plane magnetic field is also studied.

The other system under consideration is an asymmetric double quantum well. The external alternating electric field with in- and out-of-plane components causes transitions between near-degenerate states located in different wells. The phototransitions are accompanied by the in-plane momentum non-conservation caused by the impurity scattering. We study the in-plane stationary current due to the lack of the in-plane symmetry of these indirect phototransitions. The linear and circular photogalvanic coefficients have the same dependence (shown in Fig.3) as in classical case: $\alpha_s + i\alpha_a \propto 1/(\omega - (\varepsilon_+ - \varepsilon_-) + i\gamma)$, where $(\varepsilon_+ - \varepsilon_-)$ is the small distance between parallel subbands of the double quantum well.

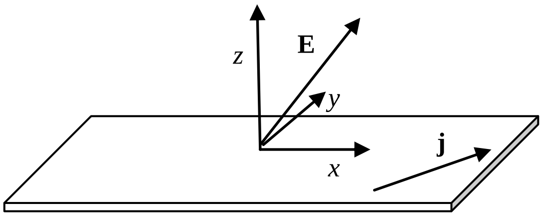

Fig.1. The sketch of the proposed experimental setup. The well confines electrons near the (*x,y*) plane. The electric field of light **E** is tilted to *z* axis. The stationary current flows in the (*x,y*) plane.

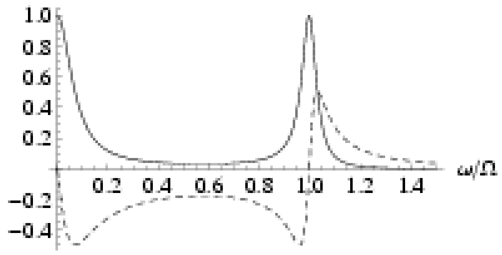

Fig.2. Photogalvanic coefficients α_s (solid) and α_a (dashed) versus frequency for parabolic well.

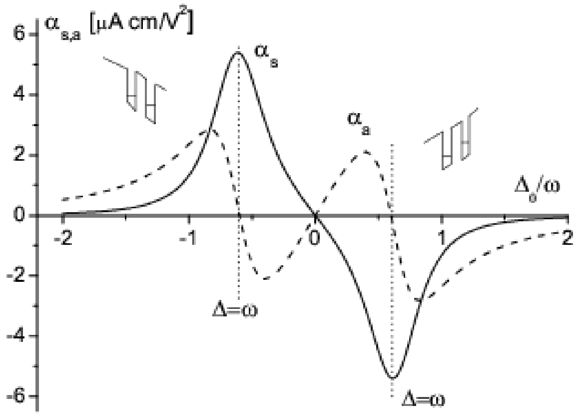

Fig.3. Dependence of the coefficients α_s (solid) and α_a (dashed) in a double quantum well on the bias voltage between individual wells (in arbitrary units).The dotted lines mark the exact resonance $\omega = |\varepsilon_+ - \varepsilon_-|$.