Measurements of longitudinal relaxation time of electrons in n-doped GaAs by means of spin noise spectroscopy

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The computational technologies development of the recent yearsraised a great interest to spin-based, rather than charge-based, logic elements implementations. This area of research is currently referred to as spintronics [1]. One of the prominent systems in this area is n-doped GaAs structures since the fabrication of high-quality GaAs heterostructures is available using the MBE technology. GaAs electronic subsystem is characterized by strong interaction with light, in particular, electron spin state can be controlled with circularly polarized light. Hence the GaAs heterostructures are widely studied, some simple properties, such as thermally equilibrated electrons longitudinal relaxation time remained beyond the scope of experimental investigations.

Noise spectroscopy is an elegant method to unravel properties of a system and was proven to be essentially nonperturbative [2]. Although spin noise spectroscopy (SNS) was firstly demonstrated on atomic systems [3,4], this method is highly applicable to semiconductor physics [5].

In most experimental cases SNS is realized using Voight geometry, when the external magnetic field $\mathbf{B}$ is applied orthogonally to the light propagation axis $\mathbf{L}$, $\boldsymbol{B} \perp \boldsymbol{L}$.Any spontaneous magnetization of the system will start to precess around the magnetic field direction. Noise spectrum of its projection on the light axis, which is detected in the experiment, will reveal a peak at the Larmor frequency with the characteristic transverse relaxation time T_2. To the contrary, the noise spectrum in Faraday geometry $\boldsymbol{B} \parallel \mathbf{L}$ will reveal a peak at zero frequency, which width is controlled by longitudinal relaxation time T_1. However, its direct measurement is technically hindered by the 1/f flicker-noise of the detection system. In this work we present a series of experiments devoted to investigation of the longitudinal relaxation time T_1 in the metallic GaAs ($n \approx 2 \cdot 10^{16} cm^{-3}$).

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