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# RAYLEIGH SURFACE WAVE INTERACTION WITH THE 2D EXCITON BOSE–EINSTEIN CONDENSATE

***M. V. Boev, V. M. Kovalev****

*Institute of Semiconductor Physics, Siberian Branch, Russian Academy of Sciences*
*630090, Novosibirsk, Russia*

*Novosibirsk State Technical University*
*630073, Novosibirsk, Russia*

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We describe the interaction of a Rayleigh surface acoustic wave (SAW) traveling on the semiconductor substrate with the excitonic gas in a double quantum well located on the substrate surface. We study the SAW attenuation and its velocity renormalization due to the coupling to excitons. Both the deformation potential and piezoelectric mechanisms of the SAW–exciton interaction are considered. We focus on the frequency and excitonic density dependences of the SAW absorption coefficient and velocity renormalization at temperatures both above and well below the critical temperature of Bose–Einstein condensation of the excitonic gas. We demonstrate that the SAW attenuation and velocity renormalization are strongly different below and above the critical temperature.

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## 1. INTRODUCTION

The gas of bound electron–hole pairs, excitons, being a gas of Bose-like particles, can exhibit Bose–Einstein condensation (BEC) at extremely low temperatures. This phenomenon was theoretically predicted a long time ago [1–5] and was intensively studied in the $Cu_2O$ system (see recent review article [6]). Recently, BEC of excitons in low-dimensional systems was confirmed in various experiments [7–9].

The experimental evidence of the exciton BEC existence is mainly based on optical arguments. The general idea is the narrowing of the luminescence line when the exciton gas is cooled to below the critical temperature.

The main aim of this paper is to theoretically demonstrate that the SAW experimental technique widely used in earlier studies of the two-dimensional electron gas [10] may yield an alternative method for studying the exciton BEC. We show that the SAW velocity renormalization $\Delta c/c$ and the SAW attenuation coefficient behave differently above and below the critical BEC temperature, and this may be used as an experimental confirmation of exciton BEC.

*E-mail: vadimkovalev@isp.nsc.ru

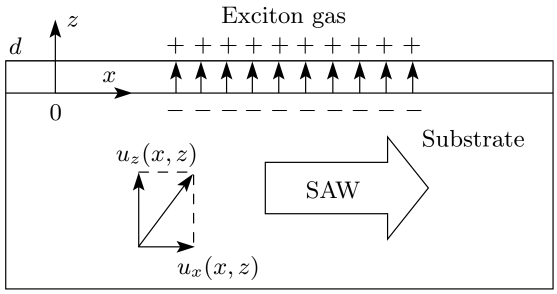


**Fig. 1.** A sketch of the system under study

We consider the double quantum well (DQW) structure depicted in Fig. 1. An electron and a hole are located in different QWs interacting via the Coulomb potential forming an exciton with the dipole moment $\mathbf{p}$ directed along the normal to the DQW plane. We consider the excitonic gas when the exciton Bohr radius $a_B$ and the distance between QWs $d$ satisfy the inequalities $na_B^2 \ll 1$ and $nd^2 \ll 1$. It was shown that the excitonic gas in the dilute limit $na_B^2 \ll 1$ has an excitation energy dispersion as in the Bogoliubov theory of weakly interacting Bose gas [4]. We use the Bogoliubov theory to calculate the SAW absorption and SAW velocity renormalization due to the interaction with excitons.