# Longitudinal quantum oscillations of surface electrons over helium film on a structured substrate for quantum computer (proposition)

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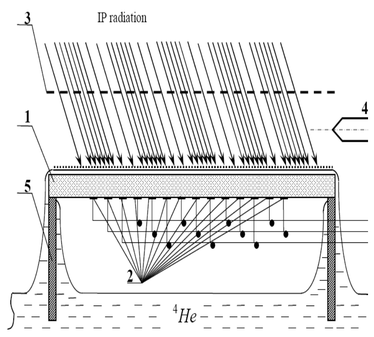
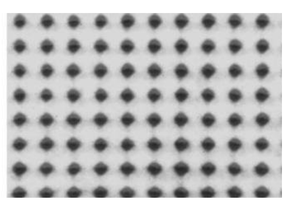
## Introduction

Modeling the micro-nano-objects and the complex physical processes revolutionize a quantum computers (QC). The quantum bit (QB) operates in superposition of two quantum states. The quantum entanglement of $n$ bits for some time is essence of QC with $2^n$ basis vector (in opposite to the classical logic with $n^2$ basis). The quantum dots for QBs are preferred. The concept of Platzman and Dykman (*Science., 284, p. 1967 (1999)*) considers for QC a hydrogen-like levels of the surface electrons (SEs) over set of microelectrodes helium coved. Using both the Stark's shift of Ridberg's levels into resonance with mkm-radiation and inner or out tunneling of SE the essence of QBs tuning and reading the result.

Here proposed the use of the longitudinal spectrum of SEs upper the lattice of governing microelectrodes coated with thin helium film on the dielectric plate.

## Setup



The proposed device can included the basis elements (the sketch on upper picture):

1- dielectric substrate with atomically smooth surface;

2 - the lattice of governing microelectrodes on opposite side of substrate (bits - on bottom picture) ;

3- the collector grid as a pressing electrode (it is transparent to the IR);

4- the source of free electrons;

5 – the support for substrate over helium.

## Relation for analyze

The longitudinal spectrum of SE depending on helium film thickness $d$ is

$$\omega_d^2 = e^2 / [(1 + \varepsilon_s)\, m\, d^3]$$

(here $e$ and $m$ are charge and mass of electron accordingly and $\varepsilon_s$ is the dielectric constant of plate).

The inter-level energy, $\Delta E$ [meV] dependence from $d$ [nm] is shown in the **graph** (inset shows SEs in potential wells)**:** the bottom curve on graph is smooth He film; He film with dimples under SEs is upper curve.

The localization size of electron in potential well is $L = (\hbar / m\omega_d)^{1/2}$.

The Wigner crystallization (WC) temperature at the electron density $n_s$ is

$$Tc < 0.226\, n_s^{1/2}.$$

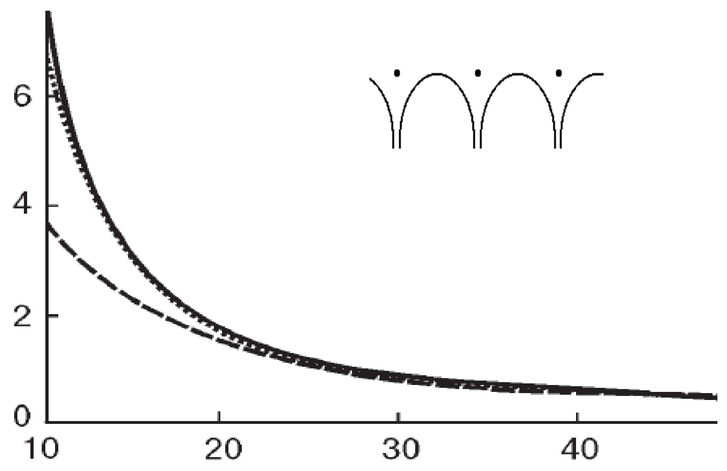
The quantum melting of WC and the overlapping of electron wave functions take a place at the energy

$$\varepsilon > (\pi\, n_s\, \hbar^2 / 2\, \mathrm{m}t).$$

Like zone theory is in the work [1].

Tuning of bits is using THz radiation at given the potentials of microelectrodes.

Reading of calculation results as superpositions of bits quantum states can be using SET.




## Conclusion

In conclusion some estimates and comments are given.

At $n_s = 10^{14} – 10^{15}$ m$^{-2}$ the interval of $Tc$ is 2.6 – 7.15 K and energy interval $\varepsilon$ is (0.14 – 1.4) K; the value of $L$~10nm at $d$ ~ 30nm.

For possible work QC with using longitudinal spectrum of SE need super-low temperatures (~ 10 mK).

Some advantage of this QC proposition are uniformity of helium film; absent loss of electrons; set of a bits is scalable.

The coherence time is essentially raise using at super-low temperature $^3$He film. The smoothly of plate surface is necessary requirement and this Is achievable with modern nanotechnology.

The corresponding of "check list DiVicenzo " is performed.

### *Reference*

1. *Ginzburg Vl.L., Monarkha Yu.P.* Surface electrons in helium over macroscopic structures // Fiz. Nizk. Temp. – 1978. – **4**. -P. 1236-1239.