-Nanoscale Physics –

About Possible Quantum Bits on Q1D-SE Vibration Levels over Helium Film

V. A. Nikolaenko[1], A. G. Pashchenko[2]

[1] *B. Verkin Institute for Low Temperature Physics and Engineering, National Academy of Sciences of Ukraine, 47 Nauka Ave., Kharkiv, 61103, Ukraine*

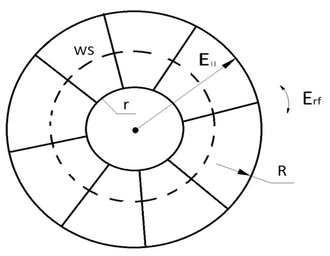
[2] *Kharkiv National University of Radio Engineering and Electronics, 14 Nauka Ave, Kharkiv, 61166, Ukraine*

E-mail: nikolaenko@ilt.kharkov.ua

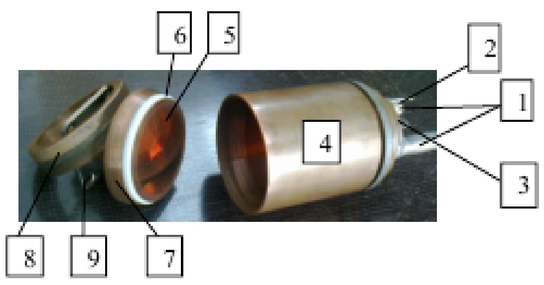
Introduction

The concept work [1] considers for QC realization a hydrogen-like levels of the surface electrons (SEs) over microelectrodes under helium using the Stark's shift of Ridberg's levels adjusted to resonance with mkm-radiation for superposition states. The QBs entanglement have a place at interaction QBs in electron Wigner solid (WS) regime. Here proposed quantum bits using vibration levels in a Q1D-SE potential well over helium film. Considered a set of 1D micro-channels or dielectric threads (δ in thickness) arranged as large and small coaxial rings coupled each other same radial lines. The system of channels is situated in a mkm-cavity with H_{011} mode working at super-low temperature. In begin the Q1D-SEs localized over the large ring nodes. The SE vibration states in well corresponding UHF is considered as a qubit basis |0> and |1>. The QB superposition state is defined by the Rabbi frequency pulses both either the UHF or the electric field. The SEs can move between rings at changing the radial electric field. The entanglement of states is possible at SEs WS in space between rings. Read out Q1D-SE state after reverse electric field can be performed with some probability at node by both the micro-capacity or the SET.

Setup



Set of micro-channels (upper picture)**.** Proposed a set of micro-channels or dielectric threads (δ in thickness) on dielectric plate and arranged as coaxial rings with *R* and *r* radius which is coupling each other same radial lines. Here *E* is the radial electric field; WS is region SE Wigner solid ; E_{rf} is a UHF wave.



The UFH resonator (bottom photo). 1 – the coaxial tubes coupling the microwave resonator with both the generator and the detector; 2 – the capillary He filling; 3 – the heat line connecting the resonator with the refrigerator; 4 – the resonator housing; 5 – the coplanar Corbino system; 6 – the high mode rf insulating ring; 7 – the vacuuming conical flange; 8 – the clamping potential ring; 9 – the power supply connector (DC and AC).

Expressions for analyze

The 1D basis wave function in potential well across channel (*y)* as $U(y) = m\omega_0^2 y^2 / 2$

is $\psi_o(y) = 1/(\pi^{1/2} y_0) \exp(-x^2 / 2y_0^2)$ and $y_0^2 = \hbar / (2\pi m \omega_0)$

The 1D energy spectrum is $\boldsymbol{\varepsilon_n = \hbar\omega_0 (n+1/2)}$ and the interenergy interval, $\boldsymbol{\Delta \varepsilon_n}$, is adjusted to the UHF resonance.

The vibration oscillations vs film thickness, *d* , is $\boldsymbol{\omega_d^2 = e^2 / [(1 + \varepsilon_s) m d^3]}$
(here *e* and *m* are charge and mass of electron accordingly and ε_s is the dielectric constant matter).

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

The WC temperature at the electron density n_s is $\boldsymbol{Tc < 0.226\, n_s^{1/2}}$.

The WC quantum melting take a place at the energy $\boldsymbol{\varepsilon > (\pi\, n_s\, \hbar^2 / 2m)}$. Like zone theory is in the work [2].

Conclusion

Many object have be proposed for QB of QC. One of them is the surface electron over helium using, for example, they quantum energy levels in normal to helium direction. Here proposed the SE vibration levels to concede for creating QB of QC. The original set of 1D micro-channels with SE over helium film performed in view coaxial rings coupling each other by radial channels. The system placed into UFH resonator on for QB superposition. The moving SEs by radial field to the system center leads to the WS regime and QBs entanglement. Near small diameter ring the WS goes to melt.

The "check list DiVicenzo " is corresponding for this system.

The system can consider a next condition: *R*~1mm; *r*~0.1mm; δ~ 1 - 10μm; the H_{011} mode cavity resonance is 10^{10} Hz, ΔE=0.5K and *T*~20mK. The linear electron density over nodes can be ~ 5 $10^4 m^{-1}$.

Reference

1. *Platzman, P.M. and Dykman, M.I.*, Quantum computing with electrons floating on liquid helium // Science.-1999, -**284**, -P.1967–1969.
2. *Ginzburg Vl.L., Monarkha Yu.P.* Surface electrons in helium over macroscopic structures // Fiz. Nizk. Temp. – 1978. – **4**. -P. 1236-1239.