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**Short Communication**

# Background of Creation of New Memory Storage Unit of "Bit + Qubit" Type Based on Nanoscale Structural Inhomogeneities of Domain Walls Formed in Uniaxial Ferromagnetic Films

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It was proposed a new memory storage unit of "bit + qubit" type based on unipolar vertical Bloch lines located in the domain wall of a magnetic stripe domain formed in a uniaxial ferromagnetic film with strong magnetic anisotropy. This result opens up the prospects for creating memory storage devices with both the quantum and "classical" process of recording information.

**Keywords**: Uniaxial ferromagnetic film, Domain wall, Vertical Bloch line, Quantum oscillations, Memory storage "bit + qubit" unit.

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## 1. INTRODUCTION

The rapid development of modern technologies leads to increased requirements for the service characteristics of data storage devices. Memory storage devices (SDs) should possess radiation and mechanical stability, energy independence, and high density of logging large amounts of data. These qualities are largely matched by solid state drives, in which elementary bits of information are given stable states of physical storage media. For example, the hysteresis positions of the magnetization vectors of ferromagnetic clusters. In this case, $N$ bits of such memory SD can represent $N$ binary values. However, recently, intensive research has been conducted on the possibility of recording information using the superposition of stable quantum states (qubits). Using this approach will allow to increase qualitatively arrays of data recording. So, $N$ qubits can be represented by already $2^N$ binary values.

Summarizing the above, it is natural to pose the problem of the prospect of creating a memory SD with the properties inherent in both "classical" and quantum modes of recording information, i.e. hybrid memory "bit + qubit". Solving this problem opens a new direction in the development and manufacture of supercompacted memory SDs with a wide range of capabilities and high performance. This work is devoted to the results of the study of the physical basis of the operation of such a memory SD on a magnetic basis.

## 2. RESULTS AND DISCUSSION

To solve the above problem, using the WKB (Wentzel-Kramers-Brillouin) approximation, we investigated the quantum properties of nanoscale structural inhomogeneities of domain walls formed in uniaxial ferromagnetic films with strong magnetic anisotropy [1-4]. So, it was found that a pair of interacting topological nanostructures of a domain wall of a stripe magnetic domain in the form of unipolar vertical Bloch lines (BLs) (Fig. 1) can perform low-temperature quantum oscillations. As a result, the energy of a pair of interacting unipolar vertical BLs has equidistant type spectrum. The excitation of its quantum levels is carried out by an external magnetic field. The probability distribution of excitation quanta over discrete levels obeys a Poisson law.

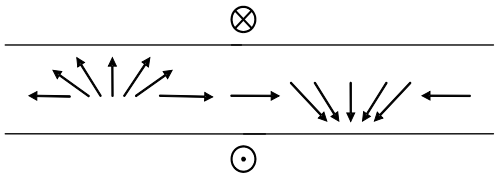

**Fig. 1** – Fragment of a domain wall (top view) of a stripe magnetic domain which contains a pair of unipolar vertical BLs. Magnetization vectors (shown by arrows) in both vertical BLs are rotated in the same directions. ⊗ and ⊙ indicate the magnetization vector directions along and against the normal to the upper surface of the film, respectively

It should be noted, that a pair of unipolar vertical BLs is already considered as a promising bit of information in the magnetic field-based memory storage [5], which is controlled by an external magnetic field. At the same time, by providing a quantum oscillation mode for vertical BLs, we will be able to form a qubit, in which a quantum system consisting of the basic (not excited) and assigned energy spectrum level of vertical BLs oscillations activated by an external magnetic field, is chosen as the base state.

It was established that the amplitudes of the fields that determine the control of vertical BLs and their quantum oscillations are in different numerical ranges, that is, there is a practical possibility of separate con-

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trol of the classical and quantum processes of information accumulation. As a consequence, we have the prerequisites for the implementation of the hybrid memory storage unit: "bit + qubit". In this case, it is especially important to emphasize that the realization of both bit and qubit of a hybrid memory unit is performed on a single physical medium − a pair of unipolar vertical BLs.

Meanwhile, it must be said that the practical implementation of the hybrid memory storage unit requires the solution, in addition to technical, of a series of scientific problems. One of which is the investigation of thermal fluctuations influence on the quantum oscillations of interacting unipolar vertical BLs. Solution of the given problem would increase the operating temperature of the memory SD.

## 3. CONCLUSIONS

Submitted result can stimulate the research and development of a new type of the memory SDs, which combine two recording media: specified stable states of physical memory element and quantum levels of its energy spectrum activated by external field.

## ACKNOWLEDGEMENTS

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## Передумови створення комірки пам'яті нового типу «біт + кубіт» на основі нанорозмірних структурних неоднорідностей доменних стінок, утворених в одновісних феромагнітних плівках

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Запропоновано комірку пам'яті нового типу «біт + кубіт» на основі вертикальних блохівськіх ліній, що знаходяться в доменній стінці смугового магнітного домену, утвореного в одновісній феромагнітній плівці із сильною магнітною анізотропією. Даний результат відкриває перспективи створення запам'ятовувальних пристроїв як з квантовим, так і «класичним» режимами запису інформації.

**Ключові слова**: Одновісна феромагнітна плівка, Доменна стінка, Вертикальна блохівська лінія, Квантові коливання, Комірка пам'яті «біт + кубіт».