# RESULTANTS/VECTORS

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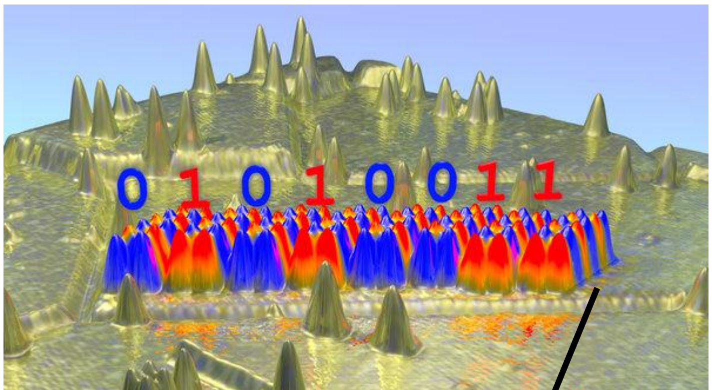
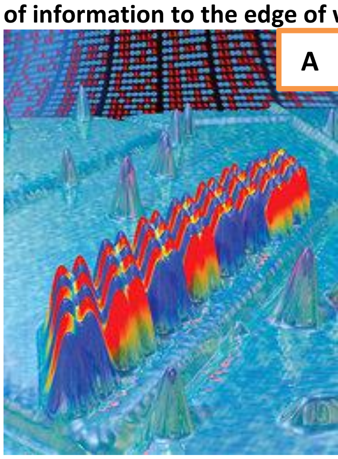
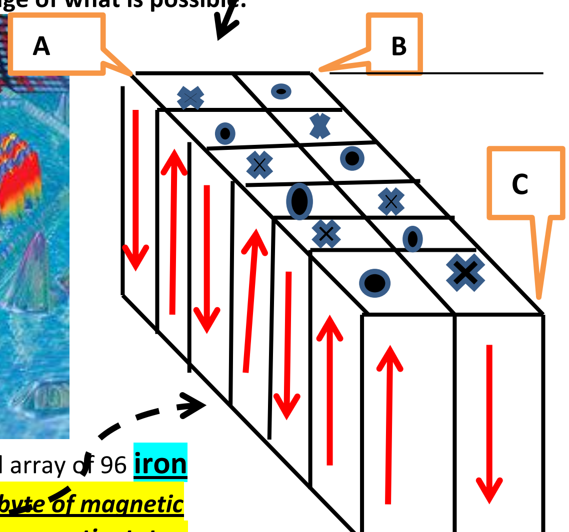
# New Storage Device Is Very Small, at 12 Atoms

New research findings at I.B.M. allow for miniaturized data storage in atomic-scale antiferromagnets. The binary representation of 'S' (01010011) was stored in eight iron atom arrays. See electron microscope image below.




**SAN JOSE, Calif. — Researchers at I.B.M. have stored and retrieved digital 1s and 0s from an *array of just 12 atoms, pushing the boundaries of the magnetic storage o* of information to the edge of what is possible.**



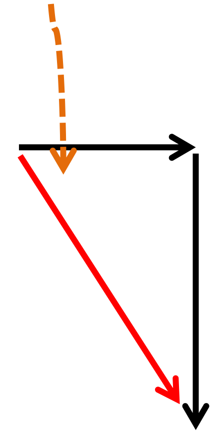



An atomically assembled array of 96 **iron atoms** *containing one byte of magnetic information in antiferromagnetic states.*

**INTRODUCTION: 12 IRON ATOMS are shown below in a antiferromagnetic state in the digital state of 1 or 0.** Iron atoms have a radius of 140 X $10^{-12}$ m. Thus iron atoms have a diameter of 2.8 X $10^{-10}$ m. The displacement magnitude from A to B is 5.6 X $10^{-10}$ m. The displacement magnitude from B to C is 16.8 X $10^{-10}$ m.

**QUESTIONS:** (a) Find the magnitude of resultant displacement vector from point A to point C? (b) Find angle of resultant displacement vector with respect to the horizontal direction X?

ANSWERS:
(a) 1.771 X $10^{-9}$ m
(b) $71.57^0$



, being reported Thursday in the journal Science, could help lead to a new class of nanomaterials for a generation of memory chips and disk drives that will not only have greater capabilities than the current silicon-based computers but **will consume significantly less power**. And they may offer a new direction for research in quantum computing. Until now, ***the most advanced magnetic storage systems have needed about one million atoms to store a digital 1 or 0.*** The new achievement is the product of a heated international race between elite physics laboratories to explore the properties of magnetic materials at a far smaller scale. ***The group at I.B.M.'s Almaden Research Center here, led by Andreas Heinrich, has now created the smallest possible unit of magnetic storage by painstakingly arranging (((two rows of six iron atoms)))) on a surface of copper nitride***. ***Such((( closeness is possible because the cluster of atoms is antiferromagnetic))) — a rare quality in which each atom in the array has an opposed magnetic orientation.*** (In common ferromagnetic materials like iron, nickel and cobalt, the atoms are magnetically aligned.) Although the research took place at a temperature near absolute zero, the scientists wrote that the same experiment could be done at room temperature with as few as 150 atoms. Antiferromagnetic materials are now instrumental in two types of data storage products. They are essential for the manufacture of recording heads, which resemble phonograph needles and are used in today's hard disk drives. They are also used in a new type of memory chip known as spin-transfer-torque RAM, or STT-RAM, which some view as a future competitor for DRAM and Flash memory chips.