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Proposed Dark Energy Experiment Using Fullerenes.

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Abstract. A dark energy experiment is proposed, based on the dark energy research funded by the U.S. Department of Energy (DOE), Office of Science. The experiment would replicate the conditions of deep space; i.e., ultra-vacuum, isolation from the Earth's magnetic field, cryogenic temperatures, and an isotropic environment. The experiment may be able to detect whether the dark energy spectrum has a frequency-cubed distribution, the spectrum cutoff, and if there are any resonances. Such an experiment may be able to explain why the observed dark energy density is 122 orders of magnitude less than the theoretical prediction (which assumes a frequency cubed distribution and a cutoff at the Planck mass of 22 micrograms). The experiment might lead to a method for extracting dark energy for terrestrial and space-based uses.

Keywords: Dark Energy.

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1. INTRODUCTION

The "Scientific Background for the Noble Prize in Physics 2011" (Noble Prize Organization 2011) states that (1) dark energy "accounts for about 73% of the total energy density of the Universe", (2) dark energy is also "measurable (via) the Lamb Shift", (3) "quantum fluctuations (may be a) source" for dark energy within the Standard Model for Particle Physics, and (4) "the (theoretical) estimate is wrong by 122 orders of magnitude" (10^{124} keV/cc versus 5 keV/cc measured).

The DOE and NASA dark energy research programs on the accelerating expansion of the Universe have determined that the gravitational repulsion from dark energy is greater than the combined gravitational attraction from all of the normal matter and all of the dark matter of the Universe. The goal of dark energy research is to understand the fundamental physics involved regarding dark energy gravitational repulsion. DOE and NASA have proposed the Wide Field Infrared Survey (space) Telescope (WFIRST). Certain effects of dark energy can, however, be measured on Earth; e.g., the Lamb shift, the Casmir effect. The experiment described in this paper would be an Earth-based experiment.

2. CONCEPT

The theoretical overestimate of dark energy assumes a frequency cubed distribution and a cutoff at the Planck mass of 22 micrograms. If it is possible to measure the dark energy spectrum, it should be possible to determine if the dark energy spectrum has a frequency cubed distribution, a lower cutoff, and resonances.

The most dramatic effect that can be attributable to dark energy, the acceleration of the expansion of the Universe, is measured under the conditions found in deep space. Measuring the dark energy spectrum on Earth would require, as a minimum, eliminating the interferences on Earth by duplicating the conditions found in deep space.

It is known that the Earth's magnetic field can interfere with the generation of certain quantum physics effects. For example, an experiment proposed for the Oak Ridge research reactor required a Faraday Cage to minimize the effects of the Earth's magnetic field. In that case, the Earth's magnetic field would have reduced the antineutron "branching ratio" (quantum probability of producing antineutrons) to below the detection limit of the experiment. The use of Faraday Cages should eliminate this interference by reducing the effects of the Earth's magnetic field to nanoTeslas.

Duplicating the ultra-vacuum of deep space should eliminate interferences from particles absorbing the spectrum and dissipating the electromagnetic fields. Providing an ultra-vacuum ($< 10^{-12}$ Torr) should eliminate this source of interference.

Similarly, duplicating the cryogen temperature of space should eliminate interferences from particles absorbing the spectrum and dissipating the electromagnetic fields. Providing a cryogenic (liquid helium) temperature should eliminate this potential source of interference, in addition to substantially improving the sensitivity of the detector.

Providing an isotropic environment should eliminate this interference to measuring the dark energy spectrum.

3. PROPOSED EXPERIMENT

The Fullerene-based Carbon NanoTube Field Effect Transistors (CNTFETs) may be able to provide a dark energy detection system. Wrap-around gate CNTFETs, also known as gate-all-around CNTFETs, were recently developed (Chen 2008). As shown Figures 1 and 2 below, the entire circumference of the nanotube is gated.

Wrap-around CNTFET fabrication involves wrapping CNTs in a gate dielectric and gate contact, then deposition onto an insulating substrate (SiO), followed by partially etching off and exposing the ends of the CNTs, and then the source, drain, and gate contacts are deposited onto the CNT ends and the metallic outer gate wrapping applied (Farmer 2006).

A dark energy detector might be fabricated by substantially modifying this fabrication technique. Starting with grapheme sheets, the gate dielectric could be deposited onto the sheets and then the CNTs formed with the dielectric on the inside of the CNTFETs, the "source" ends of the CNTs left closed, the source material not deposited; i.e., dark energy would be the source. The CNTs should be able to conduct the voltages from the gate metal layer deposited on the exterior of the CNTs.

Although CNTs with internal diameters of > 10 nm are commercially available, transistors with dimensions of 32 nm are commercially available, and transistors with dimensions of 22 nm will soon be available, the use of grapheme sheets to form the CNTs will probably result in somewhat larger dimensions.

The CNTs would provide the Faraday Cages and the isotropic environments. The applications of ultra-vacuums and cryogenics to the CNTFETs would also improve the lifetime of the CNTs by eliminating exposure to oxygen,

The gate described above may be able to break the symmetry of dark energy. By using CNTFETs with varying gate voltages it may be possible to study the dark energy spectrum at different frequencies; i.e., detect whether the dark energy spectrum has a frequency cubed distribution, the spectrum cutoff, and if there are any resonances.

Recent encouraging research indicates that Ohm's Law Survives to the Atomic Scale (Weber 2012)

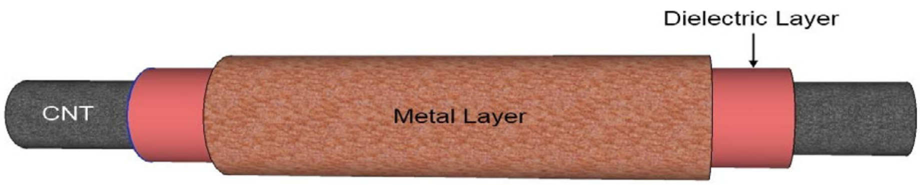

Figure 1. Sheathed CNT

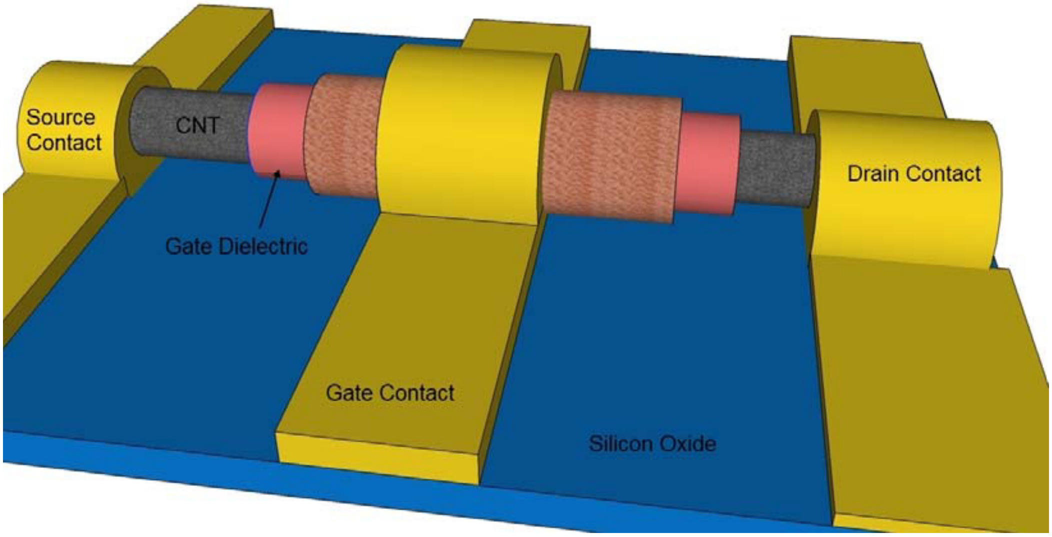

Figure 2. Gate all-around CNT Device

4. APPLICATION

Using the CNTFETs described above might allow extraction of dark energy. Although the energy extraction may be in the form of electricity and not heat, extractable dark energy can be estimated using the 100 watts/cm^2 of computing chips.

5. CONCLUSIONS

It may be possible to construct an experiment to measure the dark energy spectrum.

ACKNOWLEDGMENTS

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REFERENCES

[1] Chen, Zhihong; Farmer, Damon; Xu, Sheng; Gordon, Roy; Avouris, Phaedon; Appenzeller, Joerg (2008). "Externally Assembled Gate-All-Around Carbon Nanotube Field-Effect Transistor". *IEEE Electron Device Letters* **29** (2): 183. doi:10.1109/LED.2007.914069. http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1173&context=nanodocs.

[2]Department of Energy, “Exascale Challenges” (2011)

[3] http://science.energy.gov/ascr/research/computer-science/programming-challenges-workshop/

[4] Farmer, DB; Gordon, RG (2006). "Atomic layer deposition on suspended single-walled carbon nanotubes via gas-phase noncovalent functionalization". *Nano letters* **6** (4): 699–703. doi:10.1021/nl052453d. PMID 16608267.

[5] Nobel Prize Organization (2011) “Scientific Background for the Noble Prize in Physics 2011” (http://www.nobelprize.org/nobel_prizes/physics/laureates/2011/sciback_fy_en_11.pdf).

[6] Weber, et al (2012), “Ohm’s Law Survives to the Atomic Scale”, Scientific American, January 6, 2012 (pages 64 - 67).