“Organized Brownian Motion in Freestanding Graphene: A New Thermal Force”

Paul M. Thibado, Ph.D.

Department of Physics
University of Arkansas

Abstract:

In his renowned 1964 lecture series, Richard Feynman argued that obtaining useful work from Brownian motion is impossible, citing detailed balance and the second law of thermodynamics. Effectively, his point was that connecting a resistor to a diode will not generate a direct current [1]. Considering the noise voltage of a resistor is at best 500 micro-volts, while forward bias requires a minimum of 0.7 volts, this is a reasonable inference. The question is, in the fifty years since Feynman’s talk, has a system been found that has a noise voltage *larger* than forward bias [2]?

In our current studies of the continuous motion of freestanding graphene, we have discovered such a system, with a noise voltage in excess of 50 volts. As a freestanding monolayer, graphene isn’t flat; instead, it features alternately concave and convex ripples, forming its characteristic “egg carton” contours. Interestingly, these ripples undergo spontaneous curvature inversion in response to the ambient temperature [3]. As each ripple flips from concave to convex, more than 10,000 atoms move coherently in the same direction, creating an extremely large force [4].We have converted this collective thermal motion into stored electrical charge using a variable-capacitance machine [5]. This brings to mind another well-known assertion by Feynman: he stated that there is “plenty of room at the bottom” as he challenged scientists to successfully develop tiny motors.

Bio:

Paul Thibado is a Professor of Physics at the University of Arkansas. He received a Ph.D. in Physics from the University of Pennsylvania in 1994 under the advisement of Professor E. Ward Plummer and Professor Dawn Bonnell in the fields of surface physics and built his own scanning tunneling microscope (STM). He then won a National Research Council post-doctoral fellowship and worked for 2 years at the Naval Research Laboratory in Washington, DC with Dr. Lloyd Whitman in the fields of combined molecular beam epitaxial (MBE) semiconductor growth and STM characterization. In 1996 he joined the Physics faculty at the University at Arkansas, and was awarded the Faculty Early Career award from the National Science Foundation in 1997. So far he has won 13 national awards totaling nearly $10 million in external support for his research, has published over 80 papers, and given numerous invited talks. He co-invented clickers for use in large lecture classrooms. His current research is focused on his discovery of a new thermal force that is present in freestanding two-dimensional materials and how to use this force to convert its kinetic energy into stored electrical charge.