ON THE TUNNELLING OF WAVE-MATTER NEUTRON WAVEPACKETS, NEUTRON TRAPPING & NEUTRON LIFE-TIME

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•Neutrons are singular in that they are sensitive to the 4 basic interactions: strong, weak, electromagnetic, and gravitational which makes neutron wave-matter optics a particularly versatile tool for testing fundamental physics concepts in general & Quantum Mechanics specifically.

•While the existence of the neutron was postulated in 1920 [1] and confirmed by Chadwick in 1932 [2], its decay & hence its lifetime is pivotal to cosmology & the Standard Model itself. The recent theoretical predictions by physicists Berezhiani and Nesti from the University of l'Aquila, having re-analysed the experimental data obtained by Anatoly Serebrov at the Institut Laue-Langevin [3], showed that the loss rate of very slow free neutrons appeared to depend on the direction and strength of the magnetic field applied. This anomaly could not be explained by standard physics [4]. Berezhiani & Nesti suggest that it could be interpreted in the light of a hypothetical parallel world consisting of mirror particles. Each neutron would have the ability to transit into its invisible mirror twin, and back, oscillating from one world to the other. The probability of such a transition was predicted to be sensitive to the presence of magnetic fields, and could therefore be detected experimentally.

•In line with the recent trends in the investigations of Cold neutrons lifetime by trapping them in neutrons bottle-like traps, Thermal neutrons can be efficiently trapped in nanostructured Fabry-Pérot optical resonators. Correlated to the quantum mechanics wave-particle duality, the optical analogy between electromagnetic waves and cold neutrons manifests itself through several interference phenomena particularly the so called Frustrated Total Reflection i.e., the tunneling process in Fabry-Pérot nano-structured cavities. Prominent resonant situations offered by this configuration allow the attainment of numerous fundamental investigations and surface interface studies as well as to devise new kinds of neutron optics devices. This contribution reports on such possibilities in addition to the recently observed peculiar Goos–Hänshen longitudinal shift of neutron wave-particles which was predicted by Sir Isaac Newton as early as 1730. Likewise, these nanostructured Fabry-Pérot resonators allow the effective trapping of thermal neutrons, their lifetime within the cavity has been estimated via the Heinsenberg uncertainly principle both in unpolarized & polarized configurations [5-7].

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QUANTUM MECHANICS DRIVEN PHENOMENA AT THE NANOSCALE

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•It is well established that matter at nanoscale exhibits several size effects governed by size, shape, surface to volume ratio as well as by the breaking of the 3-D symmetry and spatial confinement. This contribution reports on Quantum Mechanic governed phenomena at room temperature in several nanoscaled systems. Due to the relativistic contraction in connection to the Dirac dynamics of the valence electrons of Mercury, this later is shown to be solid at room temperature for Nanoparticles of mercury with size below 5 nm in Ø. Owing to their large longitudinal to transversal anisotropy ratio & their multi-electronic properties, Carbon Nanotubes are ideal nanosystems to localize light and hence to observe the Anderson Localization at room temperature [1]. Likewise, due to the wave-particle duality, it is demonstrated that cold neutron wave-matter wavepackets can be trapped in the equivalent of Nanoscaled Fabry-Perot nanoresonators [2-4].

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TUNABILITY OF THE PHYSICAL PROPERTIES AT THE NANOSCALE OF OXIDES

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•The significance of metal oxides resides in their variety, their chemical stability, and their diverse chemical as well as their physical properties. Metal oxides display rich properties ranging from piezoelectricity, multiferroicity to super-conductivity, from negative thermal expansion to super-ionic conductivity. Yet, Metal oxides are in general multifunctional but lack in term of tenability except some. This seminar contribution exemplifies that it is possible to optically tune reversibly some physical properties of several nano-scaled oxides such as ZnO (Surface tension), α-Cr_2O_3 (Photo induced Magnetism), and VO_2 (Photo-induced optical dispersion).
•In addition, we report on the possibility of Green biosynthesis of high quality functional oxides nanoparticles using the bioactive compounds within natural extracts as chelating agents in replacement of standard oxido-reduction acids/bases [2-3].

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