NITheP Colloquium

Monday, 07 September 2020, 16h00

Prof Malik Maaza
UNESCO UNISA ITLABS-NRF Africa Chair in Nanosciences & Nanotech

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

Abstact: 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 Heisenberg uncertainly principle both in unpolarized & polarized configurations [5-7].

[1] E. Rutherford. Nuclear constitution of atoms, Proc.Roy.Soc., 97(686):374–400, 1920.
[2] J. Chadwick. Possible existence of a neutron, Nature, 129:312, 1932.
[3] A. Serebrov et al., UCN anomalous losses and the UCN capture cross-section on material defects. Phys. Lett. A335, 327 (2005)
[4] Z. Berezhiani, F. Nesti, Magnetic anomaly in UCN trapping: signal for neutron oscillations to parallel world? (2012), *European Physical Journal C* 72: 1974,
[5] M. Maaza, B. Pardo, J.P. Chauvineau, A. Raynal, F. Bridou, A. Menelle, Neutron tunneling and neutron lifetime in a Ni-V-Ni Fabry-Perot thin film resonator, Phys. Lett. A 223 (1996) 145

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[6] M. Maaza, B. Pardo, J.P. Chauvineau, F. Bridou, A. Menelle, Zeeman neutron tunneling in “Ni-Co-Ni thin film resonators, Phys. Lett. A 235 (1997) 19.
[7] M. Maaza, D. Hamidi, Nano-structured Fabry–Perot resonators in neutron optics & tunneling of neutron wave-particles, Physics Reports 514 (2012) 177–198

Prof Malik Maaza Short Bio:

- MSC in lasers & photonics 1988 (Paris-VI)
- PhD in Wave Matter Neutron Optics 1991(Paris-VI)
- Joint staff iThembaLABS-NRF & UNISA
- UNESCO UNISA ITLABS-NRF Africa Chair in Nanosciences & Nanotech
- Fellow of the African Academy of Sciences
- Fellow of the Royal Society of Chemistry-London
- Fellow of the National Academy of Sciences of India
- Fellow of the New York Academy of Sciences
- Fellow of the Islamic Academy of Sciences
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