# Institute Seminar

**14 September 2016** **4:00 p.m.** **Fermion**


**Speaker:**

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**Title:**

## A tale of three slits: From Superposition to Correlated qutrits

**Abstract:**


This talk will cover two very interesting but widely varying applications of triple slit based aperture systems. The first one deals with a foundational problem in quantum mechanics and classical optics; the second one deals with quantum computing and quantum communication. In a double slit interference experiment, the wave function at the screen with both slits open is not exactly equal to the sum of the wave functions with the slits individually open one at a time. The three scenarios represent three different boundary conditions and as such, the superposition principle should not be applicable. However, most well-known text books in quantum mechanics implicitly and/or explicitly use this assumption that is only approximately true. In this talk, I will discuss recent results [1] in which we have used the Feynman Path Integral formalism to quantify contributions from non-classical paths in quantum interference experiments that provide a measurable deviation from a naive application of the superposition principle. A direct experimental demonstration for the existence of these non-classical paths is difficult to present. We find that contributions from such paths can be significant and we propose simple three-slit interference experiments [2] to directly confirm their existence. I will also describe more recent work [3] in which we have gained an analytical handle on the problem. I will end the first part with showing some exciting new results from ongoing experiments in my lab which are aimed at testing these theories. While two dimensional quantum systems known as qubits are traditionally used for experiments in Quantum Computation, in our lab we are exploring higher dimensional quantum systems called qudits. Maximally entangled qudits are subjects of interest in many quantum information

protocols and fundamental tests of quantum mechanics. Transverse spatial correlation obtained from spontaneous parametric down converted photons is one of the simplest methods that could be readily implemented using slit based interferometric systems. Recently, it was shown that, the angular spectrum of the incident pump can be transferred to the signal-idler bi-photon pair in SPDC process. Tapping on to this, we attempt to harness qutrit- qutrit correlations in spatial degrees of freedom by making the pump have a profile of a triple slit. We study how the idler profile is correlated with a given signal and establish the qutrit-qutrit correlations for different experimentally viable parameters [4]. This principle of generating spatially entangled photon qutrits could be easily extended to n dimensional space and find wide applications, especially in Quantum Computing. Demonstrating spatial correlations between two qutrits paves the way for using the spatial degree of freedom in experiments based on long distance Quantum Communication. While our experiment is a proof of principle experiment which demonstrates that spatial correlations can be quantified between qutrits, the result will also be applicable when the photons are in larger physical separation than inside the lab domain.

[1] R.Sawant, J.Samuel, A.Sinha, S.Sinha, U.Sinha, Non classical paths in quantum interference experiments. Phys.Rev.Lett.113, 120406 (2014).

[2] U.Sinha, C.Couteau, T.Jennewein, R.Laflamme, G.Weihs, Ruling out multi-order interference in quantum mechanics. Science 329, 418-421 (2010).

[3] A.Sinha, Aravind H.V., U.Sinha, On the Superposition principle in interference experiments. Scientific Reports 5, 10304 (2015).

[4] Surya N. Sahoo, D.Ghosh, E.Kaur, T.Jennewein, P.Kolenderski and U.Sinha, Measuring Spatial Correlations in qutrits, to be submitted, (2016).

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