

*Ain-Shams University  
Faculty of Engineering*



# **COHERENT QUANTUM SPIN TRANSPORT IN NANOSCALE DEVICES**

A Thesis

Submitted in Partial Fulfillment

For the award of the Ph.D. Degree in Engineering Physics

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Cairo (2011)*

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**Subject:** *Coherent Quantum Spin Transport in  
Nanoscale Devices.*

**Degree:** Ph.D. thesis in Engineering Physics, Ain-Shams University, Faculty of Engineering, Engineering Physics and Math. Department (2011).

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## ***ACKNOWLEDGEMENT***

First of all, thanks and indebtedness are due to ***ALLAH*** who made this work possible.

I would like to express my deep thanks and gratitude to Prof. Dr. ***Adel Helmy Phillips***, Professor of ***Theoretical Solid State Physics***, Faculty of Engineering, Ain-Shams University, not only for suggesting the subject of this research work, but also for his close supervision, valuable guidance, help, encouragement, and kind criticism.

I would like to express my deep thanks and gratitude to Dr. ***Walid A. Zein***, Faculty of Engineering, Ain-Shams University, for their supervision, continuous useful discussion, encouragement and motivation.

My thanks and gratitude extends to all the members of the Higher Technological Institute, for their continuous support and assistance.

I owe great thanks and sincere love to my family who supported me during difficult and hard times

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**2011**

## **ABSTRACT**

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**Subject:** *Coherent Quantum Spin Transport in Nanoscale Devices.*

**Degree:** Ph.D. thesis in Engineering Physics, Ain-Shams University, Faculty of Engineering, Engineering Physics and Math. Department (2011).

Spintronics that utilizes the electron's spin degree of freedom rather than its charge for information processing and storage has been a subject of intense interest in recent decades. The practical realization of spin-based electronic circuits requires the development of efficient means to generate spin-polarized currents, and to manipulate and detect spins.

The present thesis is devoted to investigate the quantum spin transport through mesoscopic device. Two nanoscale devices are considered in thesis which are:

(i) Semiconducting Aharonov-Casher ring and a semiconducting quantum dot embedded in one arm of the ring. Two conducting leads are connected to such ring. The spin transport characteristics are conducted under the

effects of both electromagnetic field of wide range of frequencies and magnetic field.

**(ii)** The second spintronic device is a semiconducting quantum curved nanowire. The effects of both microwave and infrared radiations are taken into consideration.

For the first model of the investigated spintronic device, we deduce an expression for the conductance using Landauer formula. It is well known that shot noise and consequently Fano factor is powerful quantity to give information about controlling decoherence of spin dependent phenomena. So, we deduced an expression for both shot noise and Fano factor for the present investigated Aharonov-Casher ring. Numerical calculations are performed for both the conductance and Fano factor. The results show oscillatory behavior of the conductance. These oscillations might be due to the interplay of Rashba spin orbit coupling strength with the induced photons. Also, these oscillations are due to spin sensitive quantum interference effects caused by the difference in the Aharonov-Casher phase accumulated by the opposite spin states.

For spin transport induced by microwave and infrared radiations, a random oscillatory behavior of the Fano factor is observed. These oscillations are due to constructive and destructive spin interference effects. While for the case of ultraviolet radiation, the Fano factor becomes constant. This is due to that the oscillations have been washed out by phase averaging (i.e. ensemble dephasing) over the spin transport channels.

Our results are found concordant with those in the literature. The present spintronic device could find applications in quantum computing and quantum information processing (qubit).

Now, considering the second spintronic device: An expression for both the spin polarization for spin injection current in semiconducting curved nanowire and the corresponding tunneling magnetoresistance (TMR) are deduced under the effect of microwave and infrared radiations. Numerical calculations are performed for the spin polarization and the tunneling magnetoresistance. The results show an oscillatory behavior of both the investigated parameters. This is due to Fano-type resonance and the interplay between the strength of the

spin orbit coupling and the induced photons in the subbands of the one-dimensional nanowire. Our results are found concordant with those in the literature. The present spintronic device, that is, the quantum curved nanowire might be used to be as a sensor for small strain in semiconductor heterostructures and also photodetector.

**Keywords:** *Spintronic devices - Quantum spin transport through mesoscopic device - Semiconducting Aharonov-Casher ring - Semiconducting quantum curved nanowire - Spin orbit coupling (SOC), Conductance, Fano-factor, Spin polarization, Tunneling magnetoresistance.*

## ACKNOWLEDGEMENT

## ABSTRACT

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