Department of Electrical and Computer Engineering
North South University

Senior Design Project (EEE499)

Lateral Force on Atoms Using Quantum Metasurface

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Faculty Advisor:

Dr. Mahdy Rahman Chowdhury

Associate Professor

ECE Department

Summer, 2023

LETTER OF TRANSMITTAL

February, 2024

To

Dr. Rajesh Palit
Chairman,
Department of Electrical and Computer Engineering
North South University, Dhaka

Subject: **Submission of Capstone Project Report on "Lateral Force on Atoms Using Quantum Metasurface"**

Dear Sir,

With due respect, we would like to submit our **Capstone Project Report** on **"Lateral Force on Atoms Using Quantum Metasurface"** as a part of our BSc program. The report deals with achieving precise manipulation of atoms using quantum metasurfaces to result in lateral forces on atoms. This project was very much valuable to us as it helped us gain insight into the vast and growing field of quantum mechanics. We tried to the maximum competence to meet all the dimensions required from this report.

We will be highly obliged if you kindly receive this report and provide your valuable judgment. It would be our immense pleasure if you find this report useful and informative to have an apparent perspective on the issue.

Sincerely Yours,

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Ishmam Hossain
ECE Department
North South University, Bangladesh

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Mohammad Safi-Ul-Kaium
ECE Department
North South University, Bangladesh

APPROVAL

Ishmam Hossain (ID # 2011308043) and Mohammad Safi-Ul-Kaium (ID # 2013395643) from Electrical and Computer Engineering Department of North South University, have worked on the Senior Design Project titled "Lateral Force on Atoms Using Quantum Metasurface" under the supervision of Dr. Mahdy Rahman Chowdhury, partial fulfillment of the requirement for the degree of Bachelors of Science in Engineering and has been accepted as satisfactory.

Supervisor's Signature

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Dr. Mahdy Rahman Chowdhury

Associate Professor

Department of Electrical and Computer Engineering

North South University

Dhaka, Bangladesh.

Chairman's Signature

…….

Dr. Rajesh Palit

Professor

Department of Electrical and Computer Engineering

North South University

Dhaka, Bangladesh.

DECLARATION

This is to declare that this project is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. All project related information will remain confidential and shall not be disclosed without the formal consent of the project supervisor. Relevant previous works presented in this report have been properly acknowledged and cited. The plagiarism policy, as stated by the supervisor, has been maintained.

Students' names & Signatures

1. Ishmam Hossain

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2. Mohammad Safi-Ul-Kaium

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ACKNOWLEDGEMENTS

The authors would like to express their heartfelt gratitude towards their project and research supervisor, Dr. Mahdy Rahman Chowdhury, Associate Professor, Department of Electrical and Computer Engineering, North South University, Bangladesh, for his invaluable support, precise guidance and advice pertaining to the experiments, research and theoretical studies carried out during the course of the current project and also in the preparation of the current report.

Furthermore, the authors would like to thank the Department of Electrical and Computer Engineering, North South University, Bangladesh for facilitating the research. They would also like to thank their research assistants Sadia Humaira Salsabil and Prottay Saha for helping them in this project. The authors would also like to thank their loved ones for their countless sacrifices and continual support.

ABSTRACT

Lateral Force on Atoms Using Quantum Metasurface

This study represents an exploration, into the field of quantum metasurfaces, which use their characteristics to demonstrate how atoms move across surfaces. Scientists have been striving to manipulate atoms at the forefront of quantum research. This study represents a significant step towards understanding the mysteries of atomic scale quantum dynamics. The proposed quantum metasurface utilizes nanoscale engineering and special metamaterials to control the motion of atoms. By leveraging quantum superposition and entanglement principles the metasurface acts as a platform for orchestrating atom movement. To manipulate atoms on the metasurface, cutting edge techniques like scanning tunneling microscopy (STM) and laser cooling methods are employed in this research. The engineered properties of the metasurface create landscapes that guide atoms along paths showcasing its ability to direct motion with exceptional accuracy. This research not demonstrates progress in nanotechnology and quantum engineering. Also opens up new possibilities for applications in areas such as quantum computing, sensing and precise manipulation of materials. The ability to control the movement of atoms at the quantum level holds potential, for designing quantum devices and exploring fundamental principles governing quantum mechanics. Moreover the research showcases the potential of utilizing quantum metasurfaces as a means to investigate and comprehend quantum phenomena on a deeper level. This report showcases a quantum metasurface built using Zinc, Copper, and Nickel atoms, with a Helium atom adsorbate. Quantum ESPRESSO and COMSOL Multiphysics were the main software. The results obtained are less than ideal but do indicate it is possible to generate a lateral force using this quantum metasurface model. Insights gained from this research contribute to the growing body of knowledge aimed at harnessing the unique behaviors of quantum systems for practical applications, pushing the boundaries of what is achievable in the fascinating realm of quantum science.