IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Theory and Numerical Studies of SPASERs: A new class of nanoscale plasmonic lasers

Project number: IMURA0162

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Research Academy theme/s

List only the research academy theme/s that is relevant to the project

1. Advanced computational engineering, simulation and manufacture
2. Nanotechnology

The research problem

Diffraction barrier of conventional optics can be overcomed by using plasmons that have wavelengths in the nanometer range. Such plasmon fields provide excitation and imaging possibilities not available to researchers before. In such a device, the field is excited using surface plasmon which receives energy through stimulated emission of radiation. These devices are known as SPASERs (Surface Plasmon Amplification by Stimulated Emission of Radiation). It was previously thought that minimal dimension of a laser has be equal to one half the wavelength of light generated. However, further simplifications can be done if we change the optical wave to plasmonic wave in such a configuration and allow the plasmons attain stimulated emission through an external pump source. Generation of plasmons in such a device can be done using an active medium formed by two-level emitters, excited by an energy source, such as an optical, electrical, or chemical energy source. The active medium may be quantum dots, which transfer excitation energy by radiationless transitions to a resonant nanosystem that can play the same role as a laser cavity in a conventional laser. The transitions are stimulated by the surface plasmons in the nanostructure, causing the buildup of a macroscopic number of surface plasmons in a single mode. . We intend to carryout a detailed theoretical study on the possible configurations for creating SPASERs and use numerical simulations to simulate their behavior.

Project aims

- Develop new quantum dynamics theory on stimulated emission of plasmons and study plasmonic properties in high Q cavities and construct nanoscale SPASERs (i.e. laser equivalent in plasmonics)
- Study the various characteristics/dynamics of nanoscale SPASERs using numerical simulations.

Expected outcomes

A novel theory, software suite and optimized configuration capable of providing stimulated emission to plasmons (i.e. A nano scale SPASER)

Which of the above Theme does this project address?

This project is on developing nanotechnology (Theme 2) after carrying out numerical simulations in high performance computing environments (Theme 1).

How will the project address the Goals of the above Themes?

Describe how the project will address the goals of one or more of the 6 Themes listed above.