Usage Report for Fiscal Year 2020

**Project Title:**

# Non-hermitian physics in photonic crystal cavity

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## 1. Background and purpose of the project, relationship of the project with other projects

Our group investigates the interaction between nanoscale light emitters and photonic structures. In this project, we focus on the H1-type 2D planar air-holes photonic crystal cavity. Based on non-Hermitian interactions between the cavity modes, we aim to design a symmetry broken H1 photonic crystal cavity with an intrinsic chirality by modifying the parameters of the air holes near the cavity. The cavity field of such a chiral structure is expected to support circular polarization. Such a structure will be useful for the investigation of chiral-light-matter coupling effects.

## 2. Specific usage status of the system and calculation method

Finite-difference time-domain (FDTD) simulations are performed on the supercomputer. The FDTD method is widely used for computational electromagnetics. In this method, space is divided into a discrete grid and the fields are evolved in time using discrete time steps when solving the Maxwell's equation. We make use of an open source FDTD package called MEEP [1]. The FDTD simulations can be split into a number of parts and the calculation for each part can be run in parallel, as such the supercomputer is ideal for performing fast parallel simulations.

## 3. Result

We performed FDTD simulations for 2D and 3D structures to explore the suitable air holes for modifications, as well as to optimize their parameter values in order to obtain chiral cavity modes. Furthermore, based on the simulation results, we confirmed that by careful modifications of selected air holes, we could control the chirality of the cavity.

## 4. Conclusion

By performing FDTD simulations, we explored a large number of parameter values and have successfully simulated photonic crystal cavity structures that could support chiral cavity modes. The chirality of the cavity is manifested as circular polarization.

## 5. Schedule and prospect for the future

We are currently preparing a manuscript based on the simulations. In addition, we are performing further simulations in preparations for sample fabrication in order to verify the chirality of the cavity experimentally.

## 6. Reference

[1] A.F. Oskooi, D. Roundy, M. Ibanescu, P. Bermel, J.D. Joannopoulos, and S.G. Johnson, MEEP: A flexible free-software package for electromagnetic simulations by the FDTD method, Comput. Phys. Commun. 181, 687 (2010).