Condensed Matter Physics Seminar

Topological properties of novel resonant states in nanophotonics

Thursday

December 8

4:00 P.M.

Rm 184 NSH

Dr. Bo Zhen

Physics Department and Research Laboratory of Electronics, MIT

Physics Department and Solid State Institute, Technion

Over the past decade, nanophotonics has achieved numerous successes in molding the flow of light, thanks to the rapid progress in experimental nanoscience capabilities. Recently, there has been great interest in utilizing these experimental tools in nanophotonics to demonstrate novel concepts in condensed matter physics, including but not limited to topological indices, quantum anomalous Hall effects, and non-Hermitian quantum mechanics. In this talk, I will focus on two topics as examples: bound states in the continuum and exceptional points.

Bound states in the continuum (BICs) are resonances but with theoretically infinitely long lifetimes. The existence of such states was first proposed back in 1929 [1], yet has never been clearly demonstrated in electronic systems until now. Here, I will present our experimental results in realizing such states in nanophotonic systems [2-4], and also our theoretical understanding of these states as being fundamentally topological defects [5], which are ultimately connected to Chern numbers and Weyl points [6].

In the second part, I will focus on an exotic type of degeneracy originating from non-Hermitian quantum mechanics – exceptional points: at these points, not only the eigenvalues of a system but also their corresponding eigenstates coalesce. Furthermore, eigenstates exhibit non-Abelian dynamics when the system adiabatically evolves around exceptional points, disclosing their nature being fractional topological charges. Here I will present our recent experimental results in spawning a ring of exceptional points out of a single Dirac point [7], as well as why the traditional Purcell factors fail at these points and how this failure leads to new opportunities in light-matter interactions [8,9].

At the end, I will discuss exciting future research directions in combining experimental tools in nanophotonics and theory from condensed matter physics.

References:

[1] J. von Neumann and E. Wigner, Phys. Z. 30, 465–467 (1929).

[2] C. W. Hsu*, B. Zhen*, et al., Nature Review Materials 1, 16048 (2016).

[3] J. Lee*, B. Zhen*, et al., Phys. Rev. Lett. 109, 067401 (2012).

[4] C. W. Hsu*, B. Zhen*, et al., Nature 499, 188, (2013),

[5] B. Zhen*, C. W. Hsu*, et al., Phys. Rev. Lett. 113, 257401 (2014).

[6] B. Zhen, et al., FIO/LS, LTh5H. 4 (2016).

[7] B. Zhen*, C. W. Hsu*, Y. Igarashi*, et al., Nature 525, 354 (2015).

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