Topological Insulator Lasers

Mordechai Segev, Miguel A. Bandres, Gal Harari
Technion – Israel Institute of Technology, Haifa, Israel
Steffen Wittek, Midya Parto, Demetrios N. Christodoulides and Mercedeh Khajavikhan
CREOL, College of Optics and Photonics, UCF, Orlando, FL., USA

Topological insulators are a new phase of matter with insulating bulk but robust edge conductance. These topological edge states are extremely robust, propagate in a unidirectional manner immune to imperfections, defects, or disorder, and as such they are promising unprecedented advantages in technological applications. Such topological protection is now known to be a ubiquitous phenomenon, occurring in many physical systems, ranging from photonics [1,2] and cold atoms to acoustic and mechanical systems. In recent years, research in topological photonics has flourished with numerous photonic platforms that support topologically-protected transport of light. Until recently research on topological systems in all fields of science was carried out in entirely passive, linear and conservative settings. However, the idea of introducing photonic properties (e.g., gain and nonlinearity) to topological systems has raised many challenges and fundamental questions, most importantly on the existence of topological protection in systems containing gain.

In two back-to-back papers last year, we demonstrated that topological protection can be combined with gain and loss to give rise to a new kind of laser whose lasing mode is a topologically protected edge mode – a topological insulator laser [3,4]. The topological insulator laser displays slope efficiency that is considerably higher than in the corresponding trivial realizations even in the presence of defects and disorder, and operates at a single lasing mode even considerably above threshold [3,4].

These results pave the way towards a new era of active topological photonics, where topological protection, nonlinearity, and gain combine in nontrivial ways to give rise to new active photonic devices such as lasers, sensors, and antennas.

REFERENCES