Short Bio: Erez Hasman 2023

Erez Hasman is the Schlesinger chaired Professor at the Technion – Israel Institute of Technology, Russell Berrie Nanotechnology Institute & Helen Diller Quantum Center, Haifa, Israel and head of the Atomic-scale Photonics Laboratory. He received the B.Sc. degree in physics in 1981 from Tel Aviv University, the M.Sc. degree in 1985 from the Technion, Haifa, and the Ph.D. in 1992 from Weizmann Institute of Science, Rehovot. Before joining the Technion Erez was a senior project physicist and served as the chief physicist in high-Tech industries; Rafael, Optrotech (Orbotech) and Elop Electrooptics Industries. He was also a Visiting Professor at Stanford University, Stanford, CA. (2011-2012).

Erez initiated and demonstrated the first metasurface, pioneering the field of optical metasurfaces [the first *metallic* metasurface: Opt. Lett. **26**, 1424 (2001) *407 citations*; the first *dielectric* metasurface: Opt. Lett. **27**, 1141 (2002) *726 citations*; the first *orbital angular momentum* metasurface: Opt. Lett. **27** 1875 (2002) *338 citations*; the first *vectorial vortex* metasurface Opt. Lett. **27**, 285 (2002) *564 citations*]. In general, a metasurface can be described as an array of nanoantennas, serving as local phase shifters. Such nanopatterned structures are used for complex light manipulations, paving the route for the generation of multifunctional and quantum metasurfaces, and as a platform to study various physical phenomena.

His research group has made significant contributions in the field of nanophotonics, metasurfaces and radiative heat transfer from nanoscale structures, as well as the first to report on spin-valley Rashba monolayer laser. Among his most significant contributions are the discoveries of the Pancharatnam-Berry phase metasurfaces, (Geometric phase) utilizing the photonic spin orbit mechanism [Opt. Lett. **26**, 1424 (2001); Opt. Lett. **27**, 1141 (2002)], geometrodynamics of spinning light [**Nature Phot. 2**, 748 (2008) *569 citations*], spin Hall effect in plasmonics [Phys. Rev. Lett. **101**, 043903 (2008) *416 citations*; Phys. Rev. Lett. **101**, 030404 (2008) *329 citations*], photonic Rashba effect [**Science 340**, 724 (2013) *464 citations*] and the first proposing and demonstrating the shared-aperture multifunctional metasurfaces [**Science 352**, 1202 (2016) *438 citations*].

Moreover, Erez presented the first meta-lens [Appl. Phys. Lett. **82**, 328 (2003) *433 citations*], the first dielectric gradient metasurface for the visible spectrum [**Science 345**, 298 (2014) ***2117 citations***] (in collaboration with Prof. Mark Brongersma), and the first observation of optical transition from spin Hall to random Rashba effect induced by subwavelength-scale disordered geometric phase metasurface [**Science 358**, 1411 (2017)]. Erez presented the first experimental observation of quantum entanglement using metasurfaces – the use of a dielectric metasurface to generate entanglement between the spin and orbital angular momentum of photons (in collaboration with Prof. Mordechai Segev) [**Science 361**, 1101 (2018) *261 citations*]. These results show that metamaterials are suitable for the generation and manipulation of entangled photon states, introducing the area of quantum optics metamaterials, [selected by OSA as one of the "hottest" research in 2019, (Optics in 2019), OPN, Optics & Photonics News, December 2019, **30**, 46 (2019), "*Quantum Photonic Metamaterials*"].

Erez reported in Phys. Rev. Lett. (2019) on a topological mechanism for spin-dependent photonic transport – the first observation of photonic topological defects of bound vortex pairs and unbound vortices generated from a two-dimensional array of nanoantennas, The topological phenomena—creation of bound vortex pairs and unbound vortices—indicate the universality of the topological effect for particles of different natures, [Phys. Rev. Lett. **123**, 266101-1 266101-5(2019)]. Recently, Erez's group reported in Nature Nanotechnology the first stochastic photonic spin Hall effect arising from space-variant Berry–Zak phases, which are generated by disordered magneto-optical effects. This spin shift is observed from a spatially bounded lattice of ferromagnetic meta-atoms displaying nanoscale disorders, ["*Probing nanoscale fluctuation of ferromagnetic meta-atoms with* *a stochastic photonic spin Hall effect*", **Nature Nanotechnology 15**, 450 (2020)]. Erez's approach may be used for sensing deep-subwavelength disorders by actively breaking the photonic spin symmetry and may enable investigations of fluctuation effects in magnetic nanosystems.

Erez reported, in Nature Nanotechnology on discovery of the photonic Rashba effect from valley excitons in a WSe2 monolayer, which is incorporated in the Berry-phase defective Photonic crystal. This geometric-phase-induced valley separation establishes a multifunctional interface between valleytronics and photonics via all-silicon nanostructures, which may facilitate viable applications of valleytronics in semiconductor platforms [**Nature Nanotechnology** "*Photonic Rashba effect from quantum emitters mediated by Berry-phase defective photonic crystal*", **15,** 927-933 (2020)].

Recently, Erez discovered the *spin-valley Rashba monolayer laser* [accepted for publication in **Nature Materials,** March 2023]. He reported on a spin-optical monolayer laser by incorporating a WS_2 monolayer into a heterostructure microcavity supporting high-*Q* photonic spin-valley resonances. Inspired by the creation of valley pseudospins in monolayers, the spin-valley modes are generated from a photonic Rashba-type spin splitting of a bound state in the continuum, which gives rise to opposite spin-polarized ±K valleys due to emergent photonic spin-orbit interaction under inversion symmetry breaking. The Rashba monolayer laser shows intrinsic spin polarizations, high spatial and temporal coherence, and inherent symmetry-enabled robustness features, enabling valley coherence in the WS_2 monolayer upon arbitrary pump polarizations at room temperature. The monolayer-integrated spin-valley microcavities open avenues for further classical and non-classical coherent spin-optical light sources exploring both electron and photon spins.

The Pancharatnam-Berry phase metasurfaces have enabled Erez to discover new types of spin orbit interactions, *(i) Stochastic photonic spin Hall effect, (ii) Photonic Rashba effect, (iii) Quantum entanglement between the spin and the OAM of photons, (iv) spin-valley monolayer Rashba laser.* These show promising applications in novel photon transport control, such as entangled photons, atomic scale spinoptical light sources, and ultra-sensitive optical metrologies utilizing splits of non-degenerated spin modes distinguished by quantum weak measurements. The spin-controlled generation, manipulation, and detection of atomic-scale light sources of various statistical properties [*e.g.*, spontaneous emission (super-Poissonian), stimulated emission (Poissonian), and quantum emission (sub-Poissonian)] are promising fields, which foresee many possibilities in the coming future. In general, introducing spin-orbit coupling of electromagnetic waves into contemporary photonics and atomic-scale optics may result in the development of a new area of research, that is, atomic-scale spinoptics.

Erez was awarded the Fellow of OSA 2013, "for pioneering contributions in the field of nano-photonics, and specifically for developing a new branch in optics – Spinoptics: the symmetry breaking in nanostructures due to spin-orbit interaction". Spinoptics has opened a new avenue for controlling light in nanometric and atomic-scale optical devices. On the Technion level, he has won 2002 Salomon Simon Mani Award for Excellence in Teaching and the Henry Taub Prize for Research Excellence (2009). He has published over 130 journal papers, book chapters, and hundreds of conference papers. Erez served as an associate editor for Opt. Express (OSA), and was Co-Chair and member of program committees of several international conferences and workshops.

(Selected publication from 2008)

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