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PT-Symmetric Optical Materials and Structures

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14. ABSTRACT
The objective of this program was to pursue basic research that could potentially lead to new opportunities in science and engineering by harnessing parity-time (PT) symmetry concepts in optics and other fields of physics, engineering, and chemistry. As indicated in studies by our groups and others, PT symmetry and non-Hermiticity in general can provide a new avenue for molding the flow of light by judiciously incorporating both optical gain and loss in photonic structures and materials. In such settings, this non-Hermitian symmetry can lead to unusual and previously unattainable light propagation characteristics. Along these lines, optical active devices have been investigated that could respond with enhanced sensitivities to external signals, and strategies have been developed to exploit
non-Hermitian singularities-better known as exceptional points. One of the goals of this effort was to investigate optical materials that exhibit substantial amount of optical gain, needed to implement
PT-symmetric configurations. In this regard, special emphasis was given to polymeric materials and active semiconductor systems that in principle can exhibit very high optical amplification coefficients.

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Program Objective: The objective of this program was to pursue basic research that could potentially lead to new opportunities in science and engineering by harnessing parity-time (PT) symmetry concepts in optics and other fields of physics, engineering, and chemistry. As indicated in studies by our groups and others, PT symmetry and non-Hermiticity in general can provide a new avenue for molding the flow of light by judiciously incorporating both optical gain and loss in photonic structures and materials. In such settings, this non-Hermitian symmetry can lead to unusual and previously unattainable light propagation characteristics. Along these lines, optical active devices have been investigated that could respond with enhanced sensitivities to external signals, and strategies have been developed to exploit non-Hermitian singularities-better known as exceptional points. One of the goals of this effort was to investigate optical materials that exhibit substantial amount of optical gain, needed to implement PT-symmetric configurations. In this regard, special emphasis was given to polymeric materials and active semiconductor systems that in principle can exhibit very high optical amplification coefficients.

Executive Summary:

In the period between 2007 and 2010, the idea emerged that one could judiciously control the response of a photonic system, device or structure by allowing the optical absorption to antagonize optical amplification. Of course, within the optics community, loss is considered to be totally undesirable — something that a designer should avoid at all costs. Meanwhile, gain or amplification is a valuable commodity typically used to overcome losses. As a result, the prospect of using synergistically these two oppositely acting elements to achieve new behaviors and functionalities was never systematically pursued.

This MURI began in 2013 and was charged with the mission to carry out fundamental research in order to explore new possibilities in photonics based on such non-Hermitian concepts. From the very beginning the strategy was to pursue opportunities in the complex domain of the dielectric permittivity — something that is very natural in optics. To deploy these notions, methodologies like those associated with parity-time (PT) symmetry (ideas conceived within quantum field theories) were adopted, by means of which the spectrum of a device could be positioned in a

controllable manner in either the real or the fully complex plane. In the non-Hermitian domain, the vector space happens to be skewed (non-orthogonal) and as a result it is possible to produce a special class of degeneracies better known as exceptional points. At these singularities, not only the eigenvalues coalesce but also their corresponding eigenvectors collapse on each other. Consequently, the system's dimensionality is abruptly reduced and hence a structure or device can become extremely sensitive to external perturbations.

During the course of this MURI, a number of new effects have been successfully demonstrated based on these principles. At the same time, theoretical models have been developed in order to predict and describe these processes in non-Hermitian settings. In what follows we provide a sample of these research activities.

- Enhanced sensitivity was experimentally demonstrated for the first time in active InP microring optical resonator lasers using exceptional points. (Nature **548**, 187 (2017))
- Non-Hermiticity was employed to greatly enhance the sensitivity of a retrofitted He-Ne laser gyroscope operating around an exceptional point. By exploiting the increased rotational sensitivity of RLGs in the vicinity of an exceptional point, the resonance splitting was boosted by up to a factor of 20. (Nature **576**, 70 (2019))
- Parity-time symmetry was deployed to force coupled PT-symmetric microring lasers to operate stably in a single-longitudinal mode. This versatile methodology was found to be inherently self-adapting given that it facilitates mode selectivity over a broad bandwidth without the need for other additional intricate components. (Science **346**, 975 (2014))
- Active, nonmagnetic topological lasers were demonstrated exhibiting topologically protected transport in a laser array system. Its topological properties gave rise to single-mode lasing, robustness against defects, and considerably higher slope efficiencies compared to the topologically trivial counterparts. (Science **359**, eaar4005 (2018))
- Reflective optical limiters have been experimentally implemented in planar microcavities composed of alternating SiO_2 and Si_3N_4 layers with a single GaAs defect layer. At high intensities the resonant transmission was suppressed with the help of exceptional points. (Physical Review Applied **5**, 064010 (2016))
- By utilizing non-Hermitian concepts, coherent perfect absorption was achieved in polycrystalline silicon covered with aperiodic dielectric mirrors, across a spectrally flat, octave-spanning near-infrared spectrum, covering the range of 800-1600 nm. (Optics Letters **42**, 151 (2017))
- High optical gain from freestanding, optically stable, and mechanically robust films loaded with cross-linked $CdSe/Cd_{1-x}Zn_xSe_{1-y}S_y$ core/alloyed shell quantum dots (QD) was reported. These solid films displayed very high net optical gain as high as 650 cm^{-1} combined with a low pump excitation gain threshold. (ACS Photonics **3**,647 (2016))
- Large-area arrays of microdisk lasers based on all-inorganic perovskite quantum dots have been fabricated. (Advanced Optical Materials 6, 1800474, (2018))

During this MURI effort, the participating teams published 135 journal papers in journals like Science, Nature, Nature Physics, etc. According to the Institute of Scientific Information, these papers have attracted more than 7,000 citations. Throughout its run, the MURI supported 18 post-docs. Along the lines of research targeted by this effort, 24 graduate students completed their PhD studies and are now in academia, DOD, and industry in US and abroad. The transitions to DOD and industry, along with the issued patents will be highlighted in this report.

Even more importantly, this MURI was responsible for creating a scientific wave in non-Hermitian physics that these days impacts several areas in both science and technology. By now PT-symmetry and non-Hermiticity have permeated many fields beyond optics and represent an active research topic within many scientific communities. These include for example, topological physics, plasmonics, atomic physics, quantum information, applied mathematics, sensing technologies, wireless power transfer, and acoustics. PT-symmetry and non-Hermiticity have been discussed in numerous review articles in prominent journals and focus issues (https://www.nature.com/articles/s41566-017-0060-9; https://www.nature.com/articles/s41566-017-0067-2). An indication as to the impact this field is nowadays having is reflected in the October 2015 issue of Nature Physics, which highlighted "Parity-Time Symmetry in Optics" as one of the "Top 10 physics discoveries of the last 10 years", please see: http://www.nature.com/nphys/journal/v11/n10/full/nphys3500.html .

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Accomplishments to-date: In what follows we highlight some of the aforementioned research activities pertaining to parity-time symmetry and non-Hermitian physics in greater detail.

1. Experimental demonstration of a Non-Hermitian ring laser gyroscope with enhanced Sagnac sensitivity

Gyroscopes are essential to many diverse and applications associated with navigation, positioning and inertial sensing. In general, most optical gyroscopes rely on the Sagnac effect—a relativistically induced phase shift that scales linearly with the rotational velocity. In ring laser gyroscopes (RLGs), this shift manifests itself as a resonance splitting in the emission spectrum, which can be detected as a beat frequency. The need for ever more precise RLGs has fueled research activities aimed at boosting the sensitivity of RLGs beyond the limits dictated by geometrical constraints, including attempts to use either dispersive or nonlinear effects. During this MURI effort, we used the sensitivity associated with exceptional points, to demonstrate a non-Hermitian ring laser gyroscope with enhanced Sagnac sensitivity (Nature 576, 70-74 (2019)). This prospect was suggested in a theoretical study carried out by our team (Optics Letters 42, 1556-1559 (2017)).

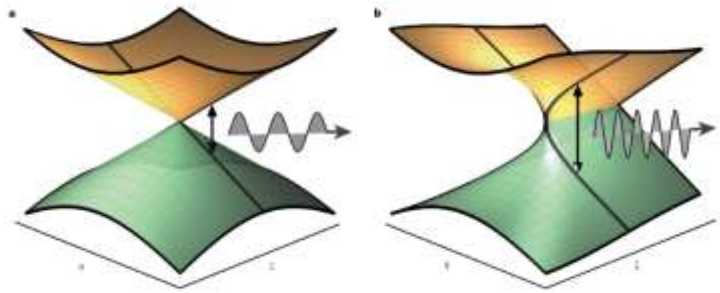

Figure 1. (a), The response of a Hermitian system to perturbations is considerably smaller than that of (b) a non-Hermitian arrangement when biased at an exceptional point.

In general, sensing involves the detection of the signature that a perturbing agent leaves on a system. In optics and other fields, resonant sensors are designed to be as lossless as possible so as to exhibit high quality factors. As a result, their response is governed by standard perturbation theory, suited for loss-free or Hermitian arrangements. In recent years, however, there has been a growing realization that non-Hermitian systems biased at exceptional points (EPs), can react much more drastically to external perturbations. This EP-enhanced sensitivity is a direct byproduct of Puiseux generalized expansions. In particular, for a system supporting an EP of order N, where N eigenvalues coalesce and their corresponding eigenvectors collapse on each other, the reaction to a perturbation (ε) is expected to follow an Nth-root behaviour ($\varepsilon^{1/N}$). This is in stark contrast to Hermitian systems, where the sensing response is at best of the order ε. Given that $\varepsilon^{1/N} \gg \varepsilon$ for $\varepsilon \ll 1$, this opens up new possibilities for designing ultrasensitive sensors based on such non-Hermitian spectral singularities. For illustration purposes, Fig. 1 provides a comparison between the eigenvalue surfaces associated with a Hermitian (Fig. 1a) two-level system (N = 2) and its corresponding non-Hermitian counterpart (Fig. 1b) when plotted in a two-parameter space around their corresponding spectral degeneracies.

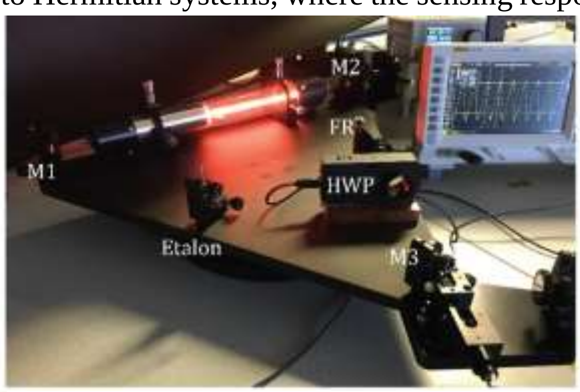

Figure 2. A photograph of the He-Ne ring laser gyroscope used in our experiments. This system was retrofitted with an etalon and with a non-reciprocal Faraday rotator (FR).

To experimentally demonstrate this enhanced Sagnac sensitivity, we used a custom-made, He–Ne RLG (purchased from Luhs; https://luhs.de/lm-0600-hene-laser-gyroscope.html) (Fig.2). The triangular cavity had a length of 138 cm and supported a free spectral range of about 216 MHz at 632.8 nm. The maximum loss that can be afforded in this system was approximately 3.6%. This resonator was then retrofitted with a terbium gallium garnet (TGG) Faraday element in order to provide a differential loss between the clockwise (CW) and counterclockwise (CCW) modes. This was used in conjunction with a half-wave plate (HWP) with a rotation angle that can vary in a controlled manner. An etalon in the cavity promoted lasing in a specific longitudinal mode while providing some level of coupling between the CW and CCW modes. Overall, the system was designed to allow maximum tunability in establishing an exceptional point (EP). Once an EP was established in the cavity, the Sagnac frequency splitting varied as $\sqrt{\Omega}$ as opposed to Ω in a Hermitian cavity. Figure 3a depicts experimental results obtained by our group (Nature **576**, 70 (2019)) from the non-Hermitian RLG system tested when biased at an EP. The figure provides data corresponding to three different coupling strengths, along with data from the standard unmodified RLG arrangement. These results are plotted in a log–log scale as a function of the rotation rate Ω for κ = 65 kHz, 150 kHz, 425 kHz. Whereas the response of the standard configuration is linear with respect to Ω (slope of 1), the same is not true for its non-Hermitian embodiment. In the latter case, the response is found to vary as the square-root of the rotation rate Ω, as is evident from the slope of the accompanying three Log-Log curves, which is very close to 1/2—a clear indication that an EP is at play. Our experimental observations clearly showed that the scale factor of the Sagnac effect is substantially boosted by exploiting the very properties of EPs. The resulting Sagnac enhancement factors (with respect to the standard arrangement) are also plotted in Fig. 3b for the same three cases.

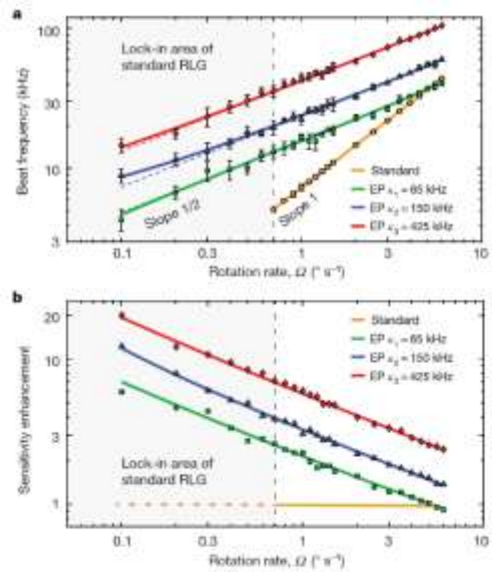

Figure 3. (a) Enhanced Sagnac sensitivity in a He-Ne RLG system due to the presence of an exceptional point (b) Sensitivity enhancement as a function of the rotation rate.

2. PT-symmetric microring lasers

The ability to control the modes oscillating within a laser resonator is of fundamental importance. In general, the presence of competing modes can be detrimental to beam quality and spectral purity, leading to spatial as well as temporal fluctuations in the emitted radiation. Over the years, several techniques have been developed to control the modal content of cavities. These techniques range from employing intra-cavity apertures for controlling the spatial modes to external cavity dispersive elements to control the longitudinal modes. However, each solution comes at a price and can only be successfully applied to certain classes of lasers. In 2014 our team has shown that by utilizing concepts from parity-time symmetry, stable single–longitudinal mode operation can be readily enforced in a system of coupled microring lasers (Science **346**, 975 (2014)). The selective breaking of PT symmetry was used to systematically enhance the maximum attainable output power in the desired mode. This was accomplished in a coupled arrangement of two structurally identical ring resonators; one experiencing gain, and the other one an equal amount of loss (Fig. 4). Once PT-symmetry was established by withholding the pump from one of the resonators lasing occured exclusively in the active ring, where single-mode operation is now achieved. The presence of the lossy ring only served to suppress the unwanted

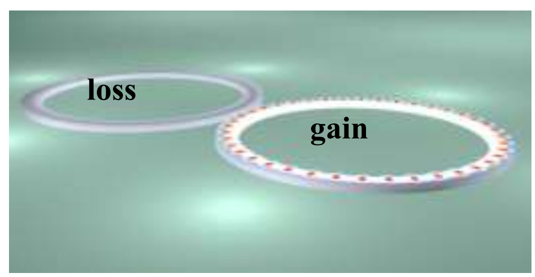

Figure 4**.** A PT-symmetric microring laser arrangement operating in single-mode.

longitudinal modes with a contrast exceeding 20 dB. This versatile concept is inherently self-adapting and facilitates mode selectivity over a broad bandwidth without the need for other additional intricate components in such microcavities.

3. Reflective optical limiters

Optical limiters are essential devices for the protection of the human eye, optical sensors, and other devices from high-power laser radiation. Existing passive optical limiters utilize certain properties of nonlinear optical materials, such as two-photon absorption, reverse saturable absorption, and other nonlinear effects. A common problem with such passive optical limiters is that the nonlinear optical material is directly exposed to high-level radiation, often causing overheating or other irreversible damage. To address this problem, the concept of a photonic reflective optical limiter was recently introduced by our team based on non-Hermitian notions. This proposed reflective limiter does not absorb the radiation, but instead reflects it back within a broad frequency range for an arbitrary incident direction. More importantly, only a small portion of the high-level input radiation reaches the nonlinear layer, which prevents the nonlinear optical material from being damaged.

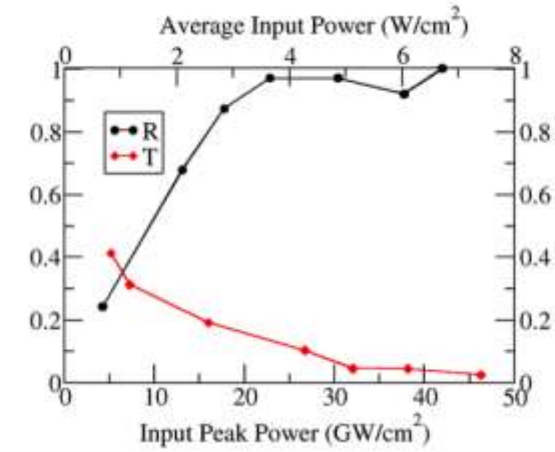

Figure 5. Transmission and reflection coefficients of a reflective limiter versus peak input power.. The laser pulse duration is 150 fs at a repetition rate of 1 KHz.

This type of a reflective optical limiter was first demonstrated by our team in collaboration with AFRL (Physical Review Applied **5**, 064010 (2016)).The design was based on a periodic layered structure comprising alternating SiO_2 and Si_3N_4 layers with a single GaAs defect layer in the middle. At low intensities, this limiter displayed a strong resonant transmission via a localized defect mode. On the other hand, at high intensities, two-photon absorption in the GaAs layer suppressed the localized mode along with the resonant transmission; hence the entire layered structure became highly reflective on resonance. By contrast, a stand-alone GaAs layer would have absorbed most of the high-level radiation, thus acting as a basic absorptive optical limiter-an aspect that is known to lead to radiation damage. The reflection and transmission characteristics at high incident powers of this limiter (tested at AFRL) are depicted in Fig. 5. The device was designed to perform at a wavelength of 1.5μm, where GaAs displays negligible linear absorption and very strong nonlinear two-photon absorption. With judicious choice of optical materials, the same principle can be replicated in the visible spectral range after replacing the GaAs layer with an appropriate polymeric film that exhibits a high two-photon absorption.

4. Coherent perfect absorption in resonant organic materials

The optimal conditions for achieving coherent perfect absorption (CPA) in a thin polymeric or semiconductor layer placed in an optical cavity were theoretically established by our team based on non-Hermitian arguments. These results indicated that the required cavity-mirror reflectivity is in inverse proportion to the intrinsic single-pass absorption in the thin film – according to a well-defined mathematical relationship. As such, in materials in which intrinsic absorption is wavelength-dependent, the mirror spectral reflectivity must also be wavelength dependent. Judiciously designing aperiodic multilayer dielectric mirrors can then help produce 100 % absorption in a thin film of any material at any wavelength regardless of its intrinsic absorption. In this respect, an experiment was carried out to verify these predictions (Optics Letters **42**, 151 (2017)). By employing thin aperiodic dielectric mirrors, we demonstrated coherent perfect absorption in a 2 μm thick film of polycrystalline silicon using a single incoherent beam of light at all the resonances across a spectrally flat, octave-spanning near-infrared spectrum, ranging from 800 to 1600 nm. Critically, these mirrors had a wavelength-dependent reflectivity devised to counterbalance the decline in silicon's intrinsic absorption at long wavelengths. These results could pave the way to efficient optical detectors and potentially improved solar collectors in inorganic or organic materials.

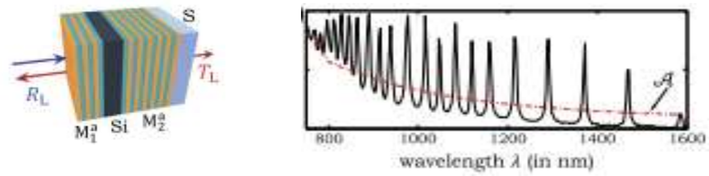

Figure 6**.** Coherent perfect absorption in a Si film, embedded in suitably designed cavity. The system is used with incoherent light and absorbs over a broad spectral band.

5. Development of polymeric materials with high optical gain coefficients

During the course of this effort, our team has successfully developed a high-yield synthesis process for stable $CdSe/Cd_{1-x}Zn_xSe_{1-y}S_y/ZnS$ quantum dots (QDs) needed for high optical gain (ACS Photonics **3**,647 (2016)). The emission stability of these quantum dots was addressed by switching from a traditional CdSe/ZnS core-shell composition to a more complex $CdSe/Cd_{1-x}Zn_xSe_{1-y}S_y$ composition. The resulting $CdSe/Cd_{1-x}Zn_xSe_{1-y}S_y/ZnS$ quantum dots exhibited an improved optical stability and very high quantum yield (~70%). Similarly, CdSe and CdS/CdSe/CdS quantum nanobars were synthesized. Such nanostructures could potentially exhibit high gain with exceptionally narrow emission peaks. The size of the QD and nanobar synthesis batch sizes was also scaled up in order to increase the number, size, and consistency of the gain systems being considered. Importantly, an approach was developed that increased the size of the batches nearly 10 times (from 15 mL to 150 mL). The optical gain of networked QD films was measured at two different participating institutions (Georgia Tech, Utah). These films exhibited gains up to a net gain value of 650 cm^{-1} which is one of the highset gain values known in the literature. In addition, the team used soft lithography to pattern strips with widths down to 2 microns-approaching the dimensions needed for the proposed PT systems. Photolithography was also employed to fabricate single and coupled disks consisting of crosslinked quantum dot solids, which have coupling distances down to 600 nm, appropriate for coupled lasing systems (Fig. 7). These configurations displayed localized emission from the disks, proving that the photolithography procedure is suitable to fabricate optically active systems with high fidelity.

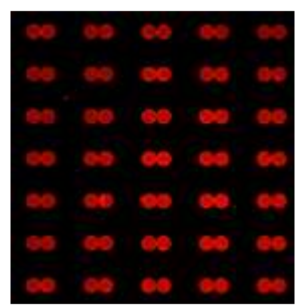

Figure 7. An array of microdisc PT symmetric laser emitters.

Photopatterning approaches were established in single QD-polymer films and mixed QD-polymer films that can be later used to pattern the gain-loss contrast. In all cases, the optical gain of these materials was measured using various techniques performed with three different laser pumping sources. The materials investigated included thin films of π-conjugated polymers, such as DOO-PPV; several organic/inorganic hybrid perovskites that were grown mainly by an evaporation process; and semiconductor quantum dots embedded in benign polymers. The most reliable material system found so far (for laser action) has been that involving quantum dots in benign polymers. These films have exceptionally large gain of ~ 600 cm^{-1}, relatively low threshold for lasing, and a loss coefficient of below 100 cm^{-1} at the lasing wavelength. Laser action in PbI_2 films, a precursor material for the $MAPbI_3$ perovskite was also measured.

6. Experimental demonstration of an all-dielectric topological laser

Physical systems that exhibit topological invariants are naturally endowed with robustness against perturbations, as was recently demonstrated in many physical settings like condensed matter, photonics, cold atoms, and acoustics. The most prominent manifestations of topological systems are topological insulators, which exhibit scatter-free edge-state transport, immune to perturbations and disorder. Recent years have witnessed intense efforts toward exploiting these physical phenomena in the optical domain, with new ideas ranging from topology-driven unidirectional devices to topological protection of path entanglement. But perhaps more technologically relevant than all topological photonic arrangements studied thus far is the prospect for an all-dielectric magnet-free topological insulator laser, with desirable properties stemming from the topological transport of light in the laser cavity. Lasers, in particular, could directly benefit from such topological attributes given that in general, their cavities are prone to disorder, which inevitably arises from fabrication imperfections, operational degradation, and malfunction. Specifically, the presence of disorder in a laser gives rise to spatial light localization within the cavity, ultimately resulting in a degraded overlap of the lasing mode with the gain profile. This implies lower output coupling, multimode lasing, and reduced slope efficiency-especially in laser arrays.

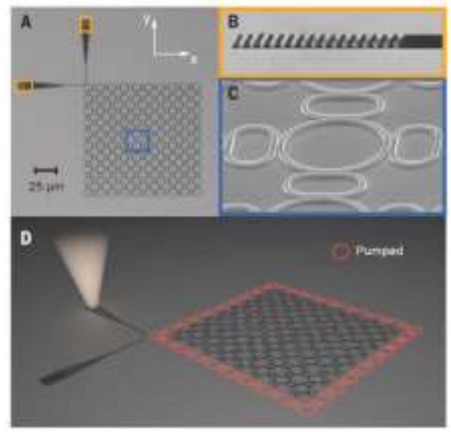

Figure 8. (a,b,c) Microscope images of an active InGaAsP topological array with 100 unit-cells of microresonators. (d) A schematic of the topological array when pumped along the perimeter to promote lasing of the topological edge mode.

During this MURI, our team demonstrated a nonmagnetic, non-Hermitian topological insulator laser (Science 359, eaar 4005 (2018)). The topological properties of this laser system gave rise to single-mode lasing, robustness against fabrication defects, and notably higher slope efficiencies compared to those of its topologically trivial counterpart. These properties were bestowed on the system using concepts from non-Hermiticity and exceptional points, as they applied to the S-chiral microresonators that enforced predetermined unidirectional lasing in these topological cavities even in the absence of magnetic fields. The topological insulator laser system fabricated involved an aperiodic array of 10x10 unit cells of coupled ring resonators on

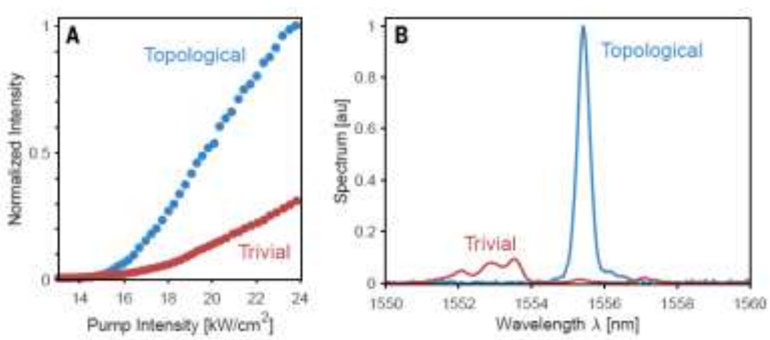

Figure 9. Slope efficiencies (a) and associated spectra of topological and trivial laser arrays (b).

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an InGaAsP quantum-well platform. The active lattice used for implementing the topological architecture is shown in Fig. 8 (a,b,c). To promote lasing of the topologically protected edge modes, we pumped the outer perimeter of the array while leaving the interior lossy, Fig. 8 d. We found that this topological insulator laser operates in single mode even considerably above threshold, whereas the corresponding topologically trivial realizations lased in multiple modes. The light-light curves measured for the topological and the trivial arrays (Fig. 9a) clearly show that the topological system lases with a higher efficiency than its trivial counterpart. From their measured spectra (Fig. 9 b, we observed that the topological arrays remained single-moded over a wide range of pumping densities, whereas the trivial arrays (tested over multiple samples) always emitted in multiple wavelengths with considerably broader linewidths. This difference in performance was attributed to the physical properties of the topological edge modes. The robustness of this lasers against defects was also demonstrated in this study.

Transitions

As indicated above, the scientific objective of the MURI program was to develop from first-principles a rigorous understanding of light transport in linear and non-linear non-Hermitian photonics. While pursuing this fundamental objective, the MURI groups have contacted candidate users of the resulting outcomes in the Department of Defense and in the civilian industrial sector.

There has been transition planning and substantial scientific interaction with The Sensors Directorate and the Aerospace Systems Directorate, at Wright Patterson AFB. The MURI effort in collaboration with researchers at Wright Patterson (Sensors Directorate) has suggested a new type of optical limiter. Optical limiters were designed to transmit low-intensity light, while blocking the light with excessively high intensity. A prototype was realized at Wright Patterson. The design was based on a periodic layered structure composed of alternating SiO2 and Si3N4 layers with a single GaAs non-Hermitian defect layer in the middle. Following this effort, the AFRL at Wright Patterson has issued an STTR [AF17A-T029: Fast Optical Limiters with Enhanced Dynamic Range: https://www.sbir.gov/sbirsearch/detail/1206545] which was influenced by the MURI investigations

Our group was actively working closely with the Materials and Manufacturing Directorate (AFRL/RX) at Wright Patterson AFB in order to explore possibilities for prospective technology transition and materials transfer. By utilizing the expertise of subject matter experts Dr. Timothy White and Dr. Timothy Bunning (optical metamaterials), various UV polymerization schemes have been developed in order to encapsulate quantum dots (QD) into polymer matrices in an effort to produce transparent, robust, and flexible polymer hosts, for producing large quantities of gain medium. The MURI research groups involved provided the expertise in the area of thin film and pattern fabrication while AFRL/RX pursued a wide variety of spectroscopy techniques complementary to the optical materials being developed by the MURI effort. Regular telecoms were held with AFRL/RX researchers as well as student visits were conducted at RX to perform research onsite.

The effort for developing compact and sensitive ring-laser-gyroscopes on active wafers of indium phosphide is currently pursued and supported in kind (wafers and device fabrication) by Infinera Corporation. The performance of the integrated RLG devices are now tested at USC by Prof. Khajavikhan.

One of the graduated students of Prof. Abouraddy (Massimo Villinger) is in the process of incorporating a startup company that aims at commercializing the solar-energy related non-Hermitian technology patents developed during this MURI effort. In addition, UCF is now negotiating with MultiCore Photonics in order to acquire the patent of the circulator design developed at UCF.

Transitions of PhD students supported by this MURI to DOD

Dr. Matthew Mills joined AFRL (University of Central Florida)
Dr. M. Smith transitioned to AFRL (Georgia Tech)

Patents

Integrated Optical Circulator Apparatus, Method, and Applications PRV-33471; 62/352,218

Coherently enhanced near-infrared quantum efficiency of a solar cell integrated into a planar omni-resonant cavity PRV-34141; 62/842,787

Solar-Energy Apparatus, Methods, and Applications NPR-34405; 16/865,486

Ultrasensitive Ring Laser Gyroscope Using Non-Hermitian Degeneracies PRV-33563; 62,415,792

Omniresonant Broadband Coherent Perfect Absorption (CPA) Apparatus, Method and Applications PRV-33751; 62/552,544

Sensors based on Wigner Cusp Anomaly, Provisional patent. Patent number 63/193,449

Conference and Workshop Organization:

D. N. Christodoulides, co-organizer of the special session "Wave propagation in complex media", The Ninth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, Georgia-Athens, Session 31. 2015.

E. Thomas, "Second workshop on PT-symmetric systems", one day workshop for PhD and post-doc associates of the MURI group, Rice, June 12, 2015

V. Tsukruk, Z. Lin, "First workshop on PT-symmetric systems", one day workshop for PhD and post-doc associates of the MURI group, GTech, August 26, 2014

T. Kottos, Synthetic Non-Hermitian Photonic Structures: Recent Results and Future Challenges, International Conference Organization; MPI-PKS Dresden, Germany, August 13-17 (2018).

Editorial activities and book publications:

1. D. Christodoulides and Jianke Yang, *Parity-time Symmetry and its Applications*, Springer 2018, ISBN 978-981-13-1246-5
2. D. N. Christodoulides; co-Guest Editor of "Focus on Parity-Time Symmetry in Optics and Photonics", New Journals of Physics (2016)
3. D. N. Christodoulides; co-Guest Editor of "Parity-Time Photonics", IEEE Journal of Selected Topics in Quantum Electronics (JSTQE).
4. V. Vardeny, "Organic Spintronics" World Scientific (2016).

AWARDS:

- Dr. D. Christodoulides, 2018 Max Born Award of the Optical Society of America.
- Dr. Ayman Abouraddy, OSA Fellow 2017
- Dr. Mercedeh Khajavikhan, OSA Fellow 2020
- Dr. Tsampikos Kottos, awarded an endowed chair “Lauren B. Dachs Endowed Professor of Science”, Wesleyan 2019
- Dr. Tsampikos Kottos, awarded the Wesleyan Prize for Excellence in Research (2019)
- Dr. E. L. Thomas Hagler Fellow, Hagler Institute for Advanced Study, Texas A&M University
- Dr. E. L. Thomas, Degree Doctorate Honoris Causa from the Technion, Haifa, Israel (2016)
- Dr. Zhiqun Lin, Fellow of the American Association for the Advancement of Science (2018)
- Dr. Zhiqun Lin, ACS PMSE Fellow (2019)
- Dr. Vladimir Tsukruk, Fulbright Award (2019)
- Dr. Vladimir Tsukruk, Regents Professor (2016)

Education and Promotion of younger participants

PhD students graduated (under the support of this MURI)

1. Soroush Shabahang (University of Central Florida)
2. Felix Tan (University of Central Florida)
3. Ahmed El Halawany (University of Central Florida)
4. William Hayenga (University of Central Florida)
5. Nicholas Nye (University of Central Florida)
6. Guangming Tao (University of Central Florida)
7. Absar Ulhassan (University of Central Florida)
8. Fan Wu (University of Central Florida)
9. Parinaz Aleahmad (University of Central Florida)
10. Joshua Kaufman (University of Central Florida)
11. Ali Kazemi Jahromi (University of Central Florida)
12. Matthew Mills (University of Central Florida)
13. Lane Martin (University of Central Florida)
14. Helena Lopez Aviles (University of Central Florida)
15. Chi Xu (University of Central Florida)
16. Midya Parto (University of Central Florida)
17. E. Makri (Wesleyan)
18. Michael Zeng (University of Utah)
19. Ashish Chanana, (University of Utah)
20. Jacky Liu, (University of Utah)
21. S. Malak (Georgia Tech)
22. C. Lin (Georgia Tech)
23. M. Smith (Georgia Tech)
24. Y. Yoon (Georgia Tech)

Post-doctoral Fellows supported by this MURI:

1. Dr. Mohammad Hokmabadi (University of Central Florida)
2. Dr. R. Kononchuk (Wesleyan)
3. Dr. A. Kurnosov (Wesleyan)
4. Dr. H. Li (Wesleyan)
5. Dr. V. Dominguez-Rocha (Wesleyan)
6. Dr. R. Thomas (Wesleyan)
7. Dr. Lucas Fernandez-Alcazar (Wesleyan)
8. Dr. M. Nafari (Wesleyan)
9. Dr. Ramathasan Thevamaran (Rice University)
10. Dr. Dr. Joshua Kauffman (University of Central Florida)
11. Dr. Soroush Shabahang (University of Central Florida)
12. Dr. Guangming Tao (University of Central Florida)
13. Dr. M. Zhuo (Rice University)
14. Dr. G. Liang (Rice University)
15. Dr. Dr. E. Lafalce (University of Utah)
16. Dr. Dr. H. Liu (University of Utah)
17. Dr. J. Jun (Georgia Tech)
18. Dr. X. Pang (Georgia Tech)

Masters Students supported under this MURI:

- A. Basiri (Wesleyan)
- Massimo Villenger (University of Central Florida)
- N. Bender (Wesleyan University)

Undergraduate students involved

- N. Bender (Wesleyan University)
- J. M. Lee (Wesleyan)
- Chris Bow (UCF)

Career development of junior personnel

The following list provides data as to the employment positions of some of the PhD and post-doctoral students involved in this MURI project.

1. Dr. Soroush Shabahang: Post-doctoral fellow at Harvard University
2. Dr. Felix Tan: L3 Harris Corprporation
3. Dr. Ahmed El Halawany: Nanospective Inc.
4. Dr. William Hayenga: Intel Corporation
5. Dr. Nicholas Nye (University of Thessaloniki, Greece, post-doctoral fellow)

6. Dr. Guangming Tao: Professor at Huazhong University of Science and Technology
7. Dr. Absar Ulhassan: Facebook
8. Dr. Fan Wu: (University of Central Florida, post-doctoral fellow)
9. Dr. Parinaz Aleahmad: Infinera Corporation, USA)
10. Dr. Joshua Kaufman: Research Assistant Professor, University of Central Florida)
11. Dr. Ali Kazemi Jahromi: Caltech, post-doctoral fellow
12. Dr. Matthew Mills: AFRL, Dayton OH, Research Physicist
13. Dr. Lane Martin: Luminar Technologies
14. Dr. Helena Lopez Aviles: Coherent/Nufern Corporation
15. Dr. Midya Parto: Caltech, post-doctoral fellow
16. Dr. E. Makri: R&D Industry, UK
17. Dr. S. Malak: Intel Corporation
18. Dr. C. Lin: Intel Corporation
19. Dr. M. Smith: AFRL)
20. Dr. Y. Yoon: DuPont Corporation
21. Dr. Mohammad Hokmabadi: Intel Corporation
22. Dr. R. Kononchuk: Wesleyan University, post-doctoral fellow
23. Dr. A. Kurnosov: Wesleyan University, post-doctoral fellow
24. Dr. H. Li: Assistant professor at Nankai University
25. Dr. V. Dominguez-Rocha: visiting faculty position at UAM -Mexico
26. Dr. R. Thomas: Senior Researcher in R&D, Electro-Optical Technologies, USA
27. Dr. Lucas Fernandez-Alcazar: Professor at IMIT-CONICET-Argentina
28. Dr. M. Nafari: Senior Researcher in R&D, Global Foundries, USA
29. Dr. Ramathasan Thevamaran: Assistant Professor, University of Wisconsin

PUBLICATIONS AND PRESENTATIONS

Throughout the run of this MURI 135 papers have been published in archival journals.

FULL LIST OF PUBLICATIONS:

2021

1. Y. Liu, P. S. Jung, M. Parto, D. N. Christodoulides, and M. Khajavikhan, "Gain-induced topological response via tailored long-range interactions," Nature Physics 17, 704-+ (2021).
2. J. H. Choi, W. E. Hayenga, Y. Liu, M. Parto, B. Bahari, D. N. Christodoulides, and M. Khajavikhan, "Room temperature electrically pumped topological insulator lasers," Nature Communications 12 (2021).
3. M. Parto, Y. G. N. Liu, B. Bahari, M. Khajavikhan, and D. N. Christodoulides, "Non-Hermitian and topological photonics: optics at an exceptional point," Nanophotonics 10, 403-423 (2021).
4. M. L. Villinger, A. Shiri, S. Shabahang, A. K. Jahromi, M. B. Nasr, C. H. Villinger, and A. F. Abouraddy, "Doubling the Near-Infrared Photocurrent in a Solar Cell via Omni-Resonant Coherent Perfect Absorption," Advanced Optical Materials 9, 2001107 (2021).

5. S. Shabahang, A. K. Jahromi, L. N. Pye, J. D. Perlstein, M. L. Villinger, and A. F. Abouraddy, "Coherent perfect absorption in resonant materials," Journal of Optics 23, 035401 (2021).
6. Y. G. N. Liu, O. Hemmatyar, A. U. Hassan, P. S. Jung, J.-H. Choi, D. N. Christodoulides, and M. Khajavikhan, "Engineering interaction dynamics in active resonant photonic structures," APL Photonics 6, 050804 (2021).

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7. M. Parto, W. Hayenga, A. Marandi, D. N. Christodoulides, and M. Khajavikhan, "Realizing spin Hamiltonians in nanoscale active photonic lattices," Nature Materials 19, 725-731 (2020).
8. D. H. Jeon, M. Reisner, F. Mortessagne, T. Kottos, and U. Kuhl, "Non-Hermitian PT-Symmetric Spectral Protection of Nonlinear Defect Modes," Physical Review Letters 125, 113901 (2020).
9. M. Parto, W. E. Hayenga, A. Marandi, D. N. Christodoulides, and M. Khajavikhan, "Nanolaser-based emulators of spin Hamiltonians," Nanophotonics 9, 4193-4198 (2020).
10. H. Liu, H. Malissa, R. M. Stolley, J. Singh, M. Groesbeck, H. Popli, M. Kavand, S. K. Chong, V. V. Deshpande, J. S. Miller, C. Boehme, and Z. V. Vardeny, "Spin Wave Excitation, Detection, and Utilization in the Organic-Based Magnet, V(TCNE)x (TCNE = Tetracyanoethylene)," Advanced Materials 32, 2002663 (2020).
11. F. O. Wu, P. S. Jung, M. Parto, M. Khajavikhan, and D. N. Christodoulides, "Entropic thermodynamics of nonlinear photonic chain networks," Communications Physics 3, 216 (2020).
12. S. Suwunnarat, R. Kononchuk, A. Chabanov, I. Vitebskiy, N. I. Limberopoulos, and T. Kottos, "Enhanced nonlinear instabilities in photonic circuits with exceptional point degeneracies," Photonics Research 8, 737-744 (2020).
13. A. Shiri, K. L. Schepler, and A. F. Abouraddy, "Programmable omni-resonance using space–time fields," APL Photonics 5, 106107 (2020).
14. N. S. Nye, A. E. Halawany, C. Markos, M. Khajavikhan, and D. N. Christodoulides, "Flexible PT-Symmetric Optical Metasurfaces," Physical Review Applied 13, 064005 (2020).
15. V. Domínguez-Rocha, R. Thevamaran, F. M. Ellis, and T. Kottos, "Environmentally Induced Exceptional Points in Elastodynamics," Physical Review Applied 13, 014060 (2020).
16. C. Xu, W. E. Hayenga, H. Hodaei, D. N. Christodoulides, M. Khajavikhan, and P. LiKamWa, "Enhanced modulation characteristics in broken symmetric coupled microring lasers," Opt. Express 28, 19608-19616 (2020).
17. W. E. Hayenga, H. Garcia-Gracia, E. S. Cristobal, M. Parto, H. Hodaei, P. LiKamWa, D. N. Christodoulides, and M. Khajavikhan, "Electrically Pumped Microring Parity-Time-Symmetric Lasers," Proceedings of the IEEE 108, 827-836 (2020).

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18. M. P. Hokmabadi, N. S. Nye, R. El-Ganainy, D. N. Christodoulides, and M. Khajavikhan, "Supersymmetric laser arrays," Science 363, 623-626 (2019).
19. M. P. Hokmabadi, A. Schumer, D. N. Christodoulides, and M. Khajavikhan, "Non-Hermitian ring laser gyroscopes with enhanced Sagnac sensitivity," Nature 576, 70-74 (2019).
20. M. Parto, H. Lopez-Aviles, J. E. Antonio-Lopez, M. Khajavikhan, R. Amezcua-Correa, and D. N. Christodoulides, "Observation of twist-induced geometric phases and inhibition of optical tunneling via Aharonov-Bohm effects," Science advances 5, eaau8135-eaau8135 (2019).
21. H. Liu, D. Sun, C. Zhang, M. Groesbeck, R. McLaughlin, and Z. V. Vardeny, "Observation of exceptional points in magnonic parity-time symmetry devices," Science Advances 5, eaax9144 (2019).
22. Y. J. Yoon, Y. Chang, S. Zhang, M. Zhang, S. Pan, Y. He, C. H. Lin, S. Yu, Y. Chen, Z. Wang, Y. Ding, J. Jung, N. Thadhani, V. V. Tsukruk, Z. Kang, and Z. Lin, "Enabling Tailorable Optical Properties and Markedly Enhanced Stability of Perovskite Quantum Dots by Permanently Ligating with Polymer Hairs," Advanced Materials 31, 1901602 (2019).
23. M. J. Smith, Q. Zeng, E. Lafalce, S. Yu, S. Zhang, Z. V. Vardeny, and V. V. Tsukruk, "Coupled Whispering Gallery Mode Resonators via Template-Assisted Assembly of Photoluminescent Microspheres," Advanced Functional Materials 29, 1902520 (2019).
24. Q. Zhong, J. Ren, M. Khajavikhan, D. N. Christodoulides, Ş. K. Özdemir, and R. El-Ganainy, "Sensing with Exceptional Surfaces in Order to Combine Sensitivity with Robustness," Physical Review Letters 122, 153902 (2019).
25. Q. Zhong, S. Nelson, M. Khajavikhan, D. N. Christodoulides, and R. El-Ganainy, "Bosonic discrete supersymmetry for quasi-two-dimensional optical arrays," Photonics Research 7, 1240-1243 (2019).
26. A. L. M. Muniz, M. Wimmer, A. Bisianov, U. Peschel, R. Morandotti, P. S. Jung, and D. N. Christodoulides, "2D Solitons in PT-Symmetric Photonic Lattices," Physical Review Letters 123, 253903 (2019).
27. Y. Li, D. Cohen, and T. Kottos, "Coherent Wave Propagation in Multimode Systems with Correlated Noise," Physical Review Letters 122, 153903 (2019).
28. R. El-Ganainy, M. Khajavikhan, D. N. Christodoulides, and S. K. Ozdemir, "The dawn of non-Hermitian optics," Communications Physics 2, 37 (2019).
29. S. Zhang, S. Yu, J. Zhou, J. F. Ponder, M. J. Smith, J. R. Reynolds, and V. V. Tsukruk, "Heterogeneous forward and backward scattering modulation by polymer-infused plasmonic nanohole arrays," Journal of Materials Chemistry C 7, 3090-3099 (2019).
30. M. J. Smith, C. H. Lin, S. Yu, and V. V. Tsukruk, "Composite Structures with Emissive Quantum Dots for Light Enhancement," Advanced Optical Materials 7, 1801072 (2019).
31. W. E. Hayenga, M. Parto, J. Ren, F. O. Wu, M. P. Hokmabadi, C. Wolff, R. El-Ganainy, N. A. Mortensen, D. N. Christodoulides, and M. Khajavikhan, "Direct generation of tunable orbital angular momentum beams in microring lasers with broadband exceptional points," Acs Photonics 6, 1895-1901 (2019).
32. R. McLaughlin, D. Sun, C. Zhang, M. Groesbeck, and Z. V. Vardeny, "Reply to ``Comment on `Optical detection of transverse spin-Seebeck effect in permalloy film

using Sagnac interferometer microscopy' "," Physical Review B 99, 106402 (2019).
33. Z. M. Gan, H. Li, and T. Kottos, "Effects of disorder in frozen-mode light," Opt. Lett. 44, 2891-2894 (2019).
34. S. Shabahang, A. K. Jahromi, A. Shiri, K. L. Schepler, and A. F. Abouraddy, "Toggling between active and passive imaging with an omni-resonant micro-cavity," Opt. Lett. 44, 1532-1535 (2019).
35. C. Xu, W. E. Hayenga, M. Khajavikhan, and P. Likamwa, "Measuring the frequency response of optically pumped metal-clad nanolasers," Opt. Express 27, 21834-21842 (2019).
36. R. Thevamaran, R. M. Branscomb, E. Makri, P. Anzel, D. Christodoulides, T. Kottos, and E. L. Thomas, "Asymmetric acoustic energy transport in non-Hermitian metamaterials," The Journal of the Acoustical Society of America 146, 863-872 (2019).

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37. G. Harari, M. A. Bandres, Y. Lumer, M. C. Rechtsman, Y. D. Chong, M. Khajavikhan, D. N. Christodoulides, and M. Segev, "Topological insulator laser: Theory," Science 359, eaar4003 (2018).
38. M. A. Bandres, S. Wittek, G. Harari, M. Parto, J. Ren, M. Segev, D. N. Christodoulides, and M. Khajavikhan, "Topological insulator laser: Experiments," Science 359, eaar4005 (2018).
39. R. El-Ganainy, K. G. Makris, M. Khajavikhan, Z. H. Musslimani, S. Rotter, and D. N. Christodoulides, "Non-Hermitian physics and PT symmetry," Nature Physics 14, 11-19 (2018).
40. M. Parto, S. Wittek, H. Hodaei, G. Harari, M. A. Bandres, J. Ren, M. C. Rechtsman, M. Segev, D. N. Christodoulides, and M. Khajavikhan, "Edge-Mode Lasing in 1D Topological Active Arrays," Physical Review Letters 120, 113901 (2018).
41. N. A. Mortensen, P. A. D. Gonçalves, M. Khajavikhan, D. N. Christodoulides, C. Tserkezis, and C. Wolff, "Fluctuations and noise-limited sensing near the exceptional point of parity-time-symmetric resonator systems," Optica 5, 1342-1346 (2018).
42. E. Makri, R. Thomas, and T. Kottos, "Reflective limiters based on self-induced violation of PT-symmetry," Physical Review A 97, 043864 (2018).
43. H. Liu, C. Zhang, H. Malissa, M. Groesbeck, M. Kavand, R. McLaughlin, S. Jamali, J. Hao, D. Sun, R. A. Davidson, L. Wojcik, J. S. Miller, C. Boehme, and Z. V. Vardeny, "Organic-based magnon spintronics," Nature Materials 17, 308-312 (2018).
44. C. H. Lin, Q. Zeng, E. Lafalce, S. Yu, M. J. Smith, Y. J. Yoon, Y. Chang, Y. Jiang, Z. Lin, and Z. V. Vardeny, "Large - Area Lasing and Multicolor Perovskite Quantum Dot Patterns," Advanced Optical Materials 6, 1800474 (2018).
45. Q. Zhong, M. Khajavikhan, D. N. Christodoulides, and R. El-Ganainy, "Winding around non-Hermitian singularities," Nature Communications 9, 4808 (2018).
46. J. Ren, Y. G. N. Liu, M. Parto, W. E. Hayenga, M. P. Hokmabadi, D. N. Christodoulides, and M. Khajavikhan, "Unidirectional light emission in PT-symmetric microring lasers," Opt. Express 26, 27153-27160 (2018).
47. Y. Chang, Y. J. Yoon, G. Li, E. Xu, S. Yu, C.-H. Lu, Z. Wang, Y. He, C. H. Lin, and

B. K. Wagner, "All-inorganic perovskite nanocrystals with a stellar set of stabilities and their use in white light-emitting diodes," ACS applied materials & interfaces 10, 37267-37276 (2018).
48. M. Taghinejad, H. Taghinejad, S. T. Malak, H. Moradinejad, E. V. Woods, Z. Xu, Y. Liu, A. A. Eftekhar, T. Lian, and V. V. Tsukruk, "Sharp and Tunable Crystal/Fano‐Type Resonances Enabled by Out‐of‐Plane Dipolar Coupling in Plasmonic Nanopatch Arrays," Annalen der Physik 530, 1700395 (2018).
49. H. Liu, R. McLaughlin, D. Sun, and Z. V. Vardeny, "Long-range transverse spin Seebeck effect in permalloy stripes using Sagnac interferometer microscopy," Journal of Physics D: Applied Physics 51, 134003 (2018).
50. A. K. Jahromi, A. V. Newkirk, and A. F. Abouraddy, "Coherent Perfect Absorption in a Weakly Absorbing Fiber," IEEE Photonics Journal 10, 1-10 (2018).
51. Q. Zeng, E. Lafalce, C. H. Lin, M. J. Smith, S. T. Malak, J. Jung, Y. J. Yoon, Z. Lin, V. V. Tsukruk, and Z. V. Vardeny, "Spectral and directional properties of elliptical quantum-dot microlasers," Journal of Photonics for Energy 8, 032218 (2018).
52. P. Chiarawongse, H. Li, W. Xiong, C. W. Hsu, H. Cao, and T. Kottos, "Statistical description of transport in multimode fibers with mode-dependent loss," New Journal of Physics 20, 113028 (2018).

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53. H. Hodaei, A. U. Hassan, S. Wittek, H. Garcia-Gracia, R. El-Ganainy, D. N. Christodoulides, and M. Khajavikhan, "Enhanced sensitivity at higher-order exceptional points," Nature 548, 187-191 (2017).
54. A. U. Hassan, B. Zhen, M. Soljačić, M. Khajavikhan, and D. N. Christodoulides, "Dynamically Encircling Exceptional Points: Exact Evolution and Polarization State Conversion," Physical Review Letters 118, 093002 (2017).
55. A. U. Hassan, G. L. Galmiche, G. Harari, P. LiKamWa, M. Khajavikhan, M. Segev, and D. N. Christodoulides, "Chiral state conversion without encircling an exceptional point," Physical Review A 96, 052129 (2017).
56. M. Chitsazi, H. Li, F. M. Ellis, and T. Kottos, "Experimental Realization of Floquet PT-Symmetric Systems," Physical Review Letters 119, 093901 (2017).
57. H. Li, S. Suwunnarat, R. Fleischmann, H. Schanz, and T. Kottos, "Random Matrix Theory Approach to Chaotic Coherent Perfect Absorbers," Physical Review Letters 118, 044101 (2017).
58. A. K. Jahromi, A. U. Hassan, D. N. Christodoulides, and A. F. Abouraddy, "Statistical parity-time-symmetric lasing in an optical fibre network," Nature communications 8, 1-9 (2017).
59. U. Kuhl, F. Mortessagne, E. Makri, I. Vitebskiy, and T. Kottos, "Waveguide photonic limiters based on topologically protected resonant modes," Physical Review B 95, 121409 (2017).
60. M. He, B. Li, X. Cui, B. Jiang, Y. He, Y. Chen, D. O'Neil, P. Szymanski, M. A. Ei-Sayed, J. Huang, and Z. Lin, "Meniscus-assisted solution printing of large-grained perovskite films for high-efficiency solar cells," Nature Communications 8, 16045

(2017).
61. A. K. Jahromi, S. Shabahang, H. E. Kondakci, S. Orsila, P. Melanen, and A. F. Abouraddy, "Transparent perfect mirror," ACS Photonics 4, 1026-1032 (2017).
62. H. E. Kondakci, A. F. Abouraddy, and B. E. A. Saleh, "Lattice topology dictates photon statistics," Scientific Reports 7, 8948 (2017).
63. L. N. Pye, M. L. Villinger, S. Shabahang, W. D. Larson, L. Martin, and A. F. Abouraddy, "Octave-spanning coherent perfect absorption in a thin silicon film," Opt. Lett. 42, 151-154 (2017).
64. J. Geldmeier, L. Rile, Y. J. Yoon, J. Jung, Z. Lin, and V. V. Tsukruk, "Dewetting-Induced Photoluminescent Enhancement of Poly(lauryl methacrylate)/Quantum Dot Thin Films," Langmuir 33, 14325-14331 (2017).
65. Y. V. Fyodorov, S. Suwunnarat, and T. Kottos, "Distribution of zeros of theS-matrix of chaotic cavities with localized losses and coherent perfect absorption: non-perturbative results," Journal of Physics A: Mathematical and Theoretical 50, 30LT01 (2017).
66. S. T. Malak, M. J. Smith, Y. J. Yoon, C. H. Lin, J. Jung, Z. Lin, and V. V. Tsukruk, "Programmed Emission Transformations: Negative - to - Positive Patterning Using the Decay - to - Recovery Behavior of Quantum Dots," Advanced Optical Materials 5, 1600509 (2017).
67. M. Ye, C. He, J. Iocozzia, X. Liu, X. Cui, X. Meng, M. Rager, X. Hong, X. Liu, and Z. Lin, "Recent advances in interfacial engineering of perovskite solar cells," Journal of Physics D: Applied Physics 50, 373002 (2017).
68. M. J. Smith, S. T. Malak, J. Jung, Y. J. Yoon, C. H. Lin, S. Kim, K. M. Lee, R. Ma, T. J. White, T. J. Bunning, Z. Lin, and V. V. Tsukruk, "Robust, Uniform, and Highly Emissive Quantum Dot–Polymer Films and Patterns Using Thiol–Ene Chemistry," ACS Applied Materials & Interfaces 9, 17435-17448 (2017).
69. S. Shabahang, H. E. Kondakci, M. L. Villinger, J. D. Perlstein, A. El Halawany, and A. F. Abouraddy, "Omni-resonant optical micro-cavity," Scientific Reports 7, 10336 (2017).
70. S. T. Malak, Y. J. Yoon, M. J. Smith, C. H. Lin, J. Jung, Z. Lin, and V. V. Tsukruk, "Decay-to-Recovery Behavior and on–off Recovery of Photoluminescence Intensity from Core/Shell Quantum Dots," ACS Photonics 4, 1691-1704 (2017).
71. S. T. Malak, G. Liang, R. Thevamaran, Y. J. Yoon, M. J. Smith, J. Jung, C. H. Lin, Z. Lin, E. L. Thomas, and V. V. Tsukruk, "High-Resolution Quantum Dot Photopatterning via Interference Lithography Assisted Microstamping," The Journal of Physical Chemistry C 121, 13370-13380 (2017).
72. H. E. Kondakci, A. Szameit, A. F. Abouraddy, D. N. Christodoulides, and B. E. A. Saleh, "Interferometric control of the photon-number distribution," APL Photonics 2, 071301 (2017).
73. J. Ren, H. Hodaei, G. Harari, A. U. Hassan, W. Chow, M. Soltani, D. Christodoulides, and M. Khajavikhan, "Ultrasensitive micro-scale parity-time-symmetric ring laser gyroscope," Opt. Lett. 42, 1556-1559 (2017).
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75. C. H. Lin, Q. Zeng, E. Lafalce, M. J. Smith, S. T. Malak, J. Jung, Y. J. Yoon, Z. Lin, Z. V. Vardeny, and V. V. Tsukruk, "Large-Scale Robust Quantum Dot Microdisk Lasers with Controlled High Quality Cavity Modes," Advanced Optical Materials 5, 1700011 (2017).
76. S. Zhang, R. Geryak, J. Geldmeier, S. Kim, and V. V. Tsukruk, "Synthesis, Assembly, and Applications of Hybrid Nanostructures for Biosensing," Chemical Reviews 117, 12942-13038 (2017).

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77. S. Shabahang, G. M. Tao, J. J. Kaufman, Y. Y. Qiao, L. Wei, T. Bouchenot, A. P. Gordon, Y. Fink, Y. L. Bai, R. S. Hoy, and A. F. Abouraddy, "Controlled fragmentation of multimaterial fibres and films via polymer cold-drawing," Nature 534, 529-+ (2016).
78. J. Jung, C. H. Lin, Y. J. Yoon, S. T. Malak, Y. X. Zhai, E. L. Thomas, V. Vardeny, V. V. Tsukruk, and Z. Q. Lin, "Crafting Core/Graded Shell-Shell Quantum Dots with Suppressed Re-absorption and Tunable Stokes Shift as High Optical Gain Materials," Angewandte Chemie-International Edition 55, 5071-5075 (2016).
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G. Lopez-Galmiche, H. E. Lopez Aviles, A. U. Hassan, A. Schumer, T. Kottos, P. L. LiKamWa, M. Khajavikhan, and D. N. Christodoulides, "Omnipolarizer Action via Encirclement of Exceptional Points," in *Conference on Lasers and Electro-Optics*(Optical Society of America, Washington, DC, 2020), p. FM1A.3.

L. Ding, A. Schumer, J. Leshin, Y. Alahmadi, A. Ul-Hassan, G. L. Galmiche, P. Likamwa, S. Rotter, D. N. Christodoulides, and M. Khajavikhan, "Bimodal Directional Laser," in *Conference on Lasers and Electro-Optics*(Optical Society of America, Washington, DC, 2020), p. FM1A.1.

M. Parto, W. Hayenga, A. Marandi, D. N. Christodoulides, and M. Khajavikhan, "Realizing Spin-Hamiltonians in Nanolaser Lattices," in *Conference on Lasers and Electro-Optics*(Optical Society of America, Washington, DC, 2020), p. FTu3A.2.
Y. G. N. Liu, P. Jung, M. Parto, W. E. Hayenga, D. N. Christodoulides, and M. Khajavikhan, "Topological Haldane Lattice," in *Conference on Lasers and Electro-Optics*(Optical Society of America, Washington, DC, 2020), p. FW3A.1.

T. Kottos, Robust Scattered Ffields from Adiabatically Driven Targets around Exceptional Points, Invited Talk, Metamaterials 2020, New York, September 29 (2020)

T. Kottos, Light propagation in disordered multimode fibers, Control of Quantum and Classical Waves in Complex Media, Invited Talk, Ein-Gedi Israel, February 19 (2020).

M. P. Hokmabadi, N. S. Nye, R. El-Ganainy, D. N. Christodoulides, and M. Khajavikhan, "Supersymmetric Laser Arrays," in Conference on Lasers and Electro-Optics(Optical Society of America, San Jose, California, 2019), p. SW4N.1.

J. Leshin, Y. Alahmadi, A. Ul-Hassan, G. L. Galmiche, P. Likamwa, D. N. Christodoulides, and M. Khajavikhan, "Bimodal Directional Laser via Dynamically Encircling an Exceptional Point," in Conference on Lasers and Electro-Optics(Optical Society of America, San Jose, California, 2019), p. FTu3B.2.

T. Kottos, Light Propagation in Disordered Multimode Fibers, Invited talk to US-Middle-East Conference on Photonics, New York, November 4-6 (2019)

T. Kottos, Chaotic Waveforms with Enhanced Targeting Capabilities, Invited talk to International Symposium on Electromagnetic Theory (EMTS 2019), San Diego, CA, May 27-31 (2019)

T. Kottos, Photonic Structures with Spatio-Temporal Symmetries and their Application to Photonic Limiters, Invited Talk, Physics of Quantum Electronics (PQE), Snowbird, Utah, January 6-11 (2019)

W. E. Hayenga, J. Ren, M. Parto, F. Wu, M. P. Hokmabadi, C. Wolff, R. El-Ganainy, N. A. Mortensen, D. N. Christodoulides, and M. Khajavikhan, "Tunable Orbital Angular Momentum Microring Lasers Using Chiral Exceptional Points," in Conference on Lasers and Electro-Optics(Optical Society of America, San Jose, California, 2019), p. FW4D.2.

Y. G. N. Liu, P. Jung, M. Parto, J. Leshin, D. N. Christodoulides, and M. Khjavikhan, "Towards a Non-magnetic Topological Haldane Laser," in Conference on Lasers and Electro-Optics(Optical Society of America, San Jose, California, 2019), p. FW3D.1.

M. Parto, W. Hayenga, D. N. Christodoulides, and M. Khajavikhan, "Mode-Dependent Coupling and Vectorial Optical Vortices in Metallic Nanolaser Arrays," in Conference on Lasers and Electro-Optics(Optical Society of America, San Jose, California, 2019), p. FM1D.2.

P. I. Galich and E. L. Thomas, Soft modes in nonlinear composites on the edge of elastic instability. Proceedings of the 26th International Congress on Sound and Vibration (ICSV26), Montreal, Canada, July 7-11, 2019.
Y. H. J. Yau, P. I. Galich, and E. L. Thomas, Designer band gaps in phononic crystals via nonsymmorphic symmetry. Proceedings of the 26th International Congress on Sound and Vibration (ICSV26), Montreal, Canada, July 7-11, 2019.

M. Parto, S. Wittek, H. Hodaei, G. Harari, M. A. Bandres, J. Ren, M. C. Rechtsman, M. Segev, D. N. Christodoulides, and M. Khajavikhan, "Complex Edge-State Phase Transitions in 1D Topological Laser Arrays," in Conference on Lasers and Electro-Optics(Optical Society of America, San Jose, California, 2018), p. FM2E.5.

T. Kottos, Non-Hermitian Photonic Structures, Invited Speaker in the conference "META'16:The 7th International Conference on Metamaterials, Photonic Crystals and Plasmonics", Malaga-Spain, 25-28 July (2016)

Kottos T., Non-Hermitian Photonic Structures, Invited Speaker in the conference IWDS10, Brescia-Italy, 27 June-1 July (2016).

Kottos T., Power Optical Limiters, Invited Speaker in the conference "Non-Hermitian Photonics in Complex Media: PT-symmetry and beyond", Heraklion-Greece, 15-18 June (2016)

M. J. Smith, S. T. Malak, J. Jung, C. H. Lin, T. J. White, T. J. Bunning, Z. Lin, & V. V. Tsukruk, "Utilizing thiol-ene click chemistry to fabricate highly emissive QD patterns for polymer based optical systems" in Symposium NT6 (Colloidal nanoparticles from synthesis to application) (Materials Research Society meeting, Phoenix, AZ) (March 29, 2016).

S. T. Malak, J. Jung, Y. Yoon, C. H. Lin, M. J. Smith, Z. Lin, & V. V. Tsukruk, "Large-area multicolor emissive patterns of quantum dot-polymer films via targeted recovery of emission signature" in Symposium NT6 (Colloidal nanoparticles from synthesis to application) (Materials Research Society meeting, Phoenix, AZ) (March 29, 2016).

C. H. Lin, E. Lafalce, J. Jung, M. J. Smith, S. T. Malak, Z. Lin, V. Vardeny, & V. V. Tsukruk, "Stable Cd-based colloidal quantum dot films with high optical gain in the quasi-continuous wave region" in Symposium NT1—Functional Nanostructures and Metamaterials for Solar Energy and

Novel Optical Phenomena (Materials Research Society meeting, Phoenix, AZ) (March 30, 2016).

S. T. Malak, J. Jung, Y. Yoon, M. J. Smith, C. H. Lin, Z. Lin, & V. V. Tsukruk, "Fabricating positive and negative photopatterns using the decay-to-recovery behavior of quantum dot emission" in Symposium NT1—Functional Nanostructures and Metamaterials for Solar Energy and Novel Optical Phenomena (Materials Research Society meeting, Phoenix, AZ) (March 30, 2016).

A. Basiri, I. Vitebskiy, T. Kottos, Light scattering in pseudo-passive media with uniformly balanced gain and loss, edt. G. S. Subramania, S. Foteinopoulou, Conference on Active Photonic Materials VII, ACTIVE PHOTONIC MATERIALS VII Book Series: Proceedings of SPIE Vol. 9546, 95461H (2015)

M. Koirala, A. Yamilov, A. Basiri, Y. Bromberg, H. Cao, T. Kottos, Critical States Embedded in the Continuum, CONFERENCE ON LASERS AND ELECTRO-OPTICS (CLEO), Book Series: Conference on Lasers and Electro-Optics (2015)

D. Christodoulides, "PT symmetry in Optics", invited, paper S6.00004, APS March Meeting, San Antonio-Texas, March 2–6, (2015).

M. A. Miri, M. Heinrich, and D. Christodoulides, "Supersymmetry and transformation optics", paper T9.00008, APS March Meeting, San Antonio-Texas, March 2–6, (2015).

D. Christodoulides and M. A. Miri, "PT symmetry in Optics", Session 12, The Ninth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, Georgia-Athens, April 1-4 (2015).

M. A. Miri, N. Nye, D. Christodoulides, H. Hodaei, "PT-symmetric diffraction gratings", Session 31, The Ninth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, Georgia-Athens, April 1-4 (2015).

M. Khajavikhan, D. Christodoulides, and H. Hodaei, "PT-symmetric microring lasers", Session 31, The Ninth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, Georgia-Athens, April 1-4 (2015).

R. El-Ganainy, D. Christodoulides, and L. Ge, "Singlet lasing in supersymmetric laser arrays", Session 31, The Ninth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, Georgia-Athens, April 1-4 (2015).

H. Hodaei,M. A. Miri, D. Christodoulides, and M. Khajavikhan, "On-chip PT-symmetric microring lasers", Session 31, The Ninth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, Georgia-Athens, April 1-4 (2015).

Hassan: N. Nye and D. Christodoulides, "Ultra sensitivity using higher order exceptional points", Session 31, The Ninth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, Georgia-Athens, April 1-4 (2015).

H. Hodaei, W. Hayenga, M. Miri, A. Ulhassan, D. Christodoulides, and M. Khajavikhan, "Dark state microring lasers: Using non-Hermitian exceptional points for mode management," in Postdeadline Paper JTh5B.6, CLEO: 2015, San Jose, California, May 10-15, 2015.

W. Hayenga, M. Miri, H. Hodaei, A. Ulhassan, M. Heinrich, D. Christodoulides, and M. Khajavikhan, "Single Mode Broad Area PT-Symmetric Microring Lasers," paper FW1D.6, CLEO: 2015, San Jose, California, May 10-15, 2015.

H. Hodaei, W. Hayenga, M. Miri, A. Ulhassan, D. Christodoulides, and M. Khajavikhan, "Tunable Parity-Time-Symmetric Microring Lasers," paper SF1I.1, CLEO 2015, San Jose, California, May 10-15, 2015.

M. Miri, M. Heinrich, and D. Christodoulides, "Supersymmetry and transformation optics on the line," paper FTh3D.8, CLEO 2015, San Jose, California, May 10-15, 2015.

N. Nye, M. Miri, and D. Christodoulides, "Single-Sided Diffraction by PT-Symmetric Metasurfaces," paper FTu2C.5, CLEO 2015, San Jose, California, May 10-15, 2015.

K. Makris, Z. Musslimani, D. Christodoulides, and S. Rotter, "Waves of constant intensity and their instabilities in non-Hermitian photonic structures," paper JTu5A.18, CLEO 2015, San Jose, California, May 10-15, 2015.

R. El-Ganainy, M. Khajavikhan, D. Christodoulides, and L. Ge, "Supersymmetric Laser Arrays," paper FTh3D.5, CLEO 2015, San Jose, California, May 10-15, 2015.

M. Heinrich, M. A. Miri, S. Stützer, S. Nolte, A. Szameit1, and D. N. Christodoulides, "Supersymmetric photonics: Mode conversion, scattering and transformation optics" invited paper, NTu2A.6, Nonlinear Optics NLO (OSA), Kauai, Hawaii, USA, July 26-31 (2015).

M. Wimmer, A. Regensburger, M.A. Miri, C. Bersch, D. Christodoulides, and U. Peschel, "Photonic Mesh Lattices: From PT Solitons to Optical Superfluidity", invited paper, paper EF-2.3, CLEO Europe 2015, Munich, Germany, June 21-25 (2015).

M. Heinrich, M. A. Miri, S. Stützer, S. Nolte, D. Christodoulides, and A. Szameit, "Supersymmetric scattering and transformation optics", invited talk, CE-3.1, CLEO Europe 2015, Munich, Germany, June 21-25 (2015).

M. Heinrich, M. A. Miri, M. Khajavikhan, and D. Christodoulides, "PT symmetry in optics and nonlinear optics", invited talk, CD-3.4, CLEO Europe 2015, Munich, Germany, June 21-25 (2015).

M. Heinrich, H. Hodaei, M.A. Miri, D.N. Christodoulides, M. Khajavikhan, "PT-symmetric microring lasers", paper CB-4-4, 2015 European Conference on Lasers and Electro-Optics - European Quantum Electronics Conference (OSA), Munich, Germany, June 21-25, 2015.

M. Wimmer, A. Regensburger, M.A. Miri, C. Bersch, D.N. Christodoulides, U. Peschel, "Observation of PT-symmetric optical solitons in time-domain photonic lattices", paper FM2D.4, FiO 2015, San Jose, California, USA, October 18-22, 2015.

K. Makris, Z. Musslimani, D.N. Christodoulides, S. Rotter, "Diffractionless Waves of Constant Intensity", paper LM2I.3, FiO 2015, San Jose, California, USA, October 18-22, 2015.

M. Heinrich, M.A. Miri, S. Stutzer, S. Nolte, A. Szameit, D.N. Christodoulides, "Supersymmetric photonics: From mode converters to a new class of transformation optics", 9th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics (METAMATERIALS 2015), pp. 103-105, Oxford, United Kingdom, September 7-12, 2015.

M.A. Miri, N. Nye, M. Khajavikhan, D.N. Christodoulides, "PT-symmetric scatterers (Presentation Recording)", Proc. SPIE 9546, Active Photonic Materials VII, San Diego, California, September 1, 2015.

M. Khajavikhan, H. Hodaei, M.A. Miri, and D. Christodoulides, "Single-mode parity-time-symmetric micro-ring lasers", invited paper 28D2-1, Conference on Lasers and Electro-Optics

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A. Hassan, H. Hodaei, W. Hayenga, M. Khajavikhan, and D. Christodoulides, “Enhanced Sensitivity in Parity-Time-Symmetric Microcavity Sensors”, paper SeT4C.3, Advanced Photonics 2015 (OSA), Boston, Massachusetts, USA, June 27-July 1, 2015.

H. Ramezani, T. Kottos, I. Vitebskiy, “Unidirectional lasing emerging from frozen light in nonreciprocal cavities”, edt.G. S. Subramania, S Foteinopoulou, Conference on Active Photonic Materials VI, ACTIVE PHOTONIC MATERIALS VI Book Series: Proceedings of SPIE Vol. 9162, 91621R (2014)

H. Hodaei, M. Miri, M. Heinrich, D. N. Christodoulides, and M. Khajavikhan, "PT symmetry breaking and transverse mode filtering in microring lasers," in Frontiers in Optics 2014, OSA Technical Digest (online) (Optical Society of America, 2014), paper LTh4I.2.

M. Heinrich, S. Stützer, M. Miri, R. El-Ganainy, S. Nolte, D. N. Christodoulides, and A. Szameit, "Supersymmetric mode converters," in CLEO: 2014, OSA Technical Digest (online) (Optical Society of America, 2014), paper SF2O.2.

M. Miri, S. Stuetzer, M. Heinrich, R. El-Ganainy, S. Nolte, D. N. Christodoulides, and A. Szameit, "Observation of supersymmetric dynamics in photonic lattices," in Frontiers in Optics 2014, OSA Technical Digest (online) (Optical Society of America, 2014), paper FTu2E.3.

D. N. Christodoulides, M. Miri, H. Hodaei, M. Heinrich, and M. Khajavikhan, "PT symmetry in optics," in Frontiers in Optics 2014, OSA Technical Digest (online) (Optical Society of America, 2014), paper FTu2E.1.

M. Miri, M. Heinrich, and D. N. Christodoulides, "Beyond PT-symmetry: SUSY-mediated real spectra in complex refractive index landscapes," in CLEO: 2014, OSA Technical Digest (online) (Optical Society of America, 2014), paper FM1D.1.

M. Miri, M. A. Eftekhar, M. Facao, and D. N. Christodoulides, "Scattering off PT-symmetric particles," in CLEO: 2014, OSA Technical Digest (online) (Optical Society of America, 2014), paper FM1D.5.

H. Hodaei, M. Miri, M. Heinrich, D. N. Christodoulides, and M. Khajavikhan, "PT symmetric large area single mode DFB lasers," in CLEO: 2014, OSA Technical Digest (online) (Optical Society of America, 2014), paper FM1D.3.

M. Miri, H. Hodaei, M. Heinrich, M. Khajavikhan, and D. N. Christodoulides, "PT-symmetric microring lasers," in Frontiers in Optics 2014, OSA Technical Digest (online) (Optical Society of America, 2014), paper FTu5D.2.

R. El-Ganainy, M. Teimourpour, A. Eisfeld, and D. N. Christodoulides, "Light Transport in PT Photonic Structures with Hidden Symmetries," in CLEO: 2014, OSA Technical Digest (online) (Optical Society of America, 2014), paper FM1D.4.

H. Hodaei, M.-A. Miri, M. Heinrich, D. N. Christodoulides, M. Khajavikhan, “Single mode PT symmetric large area lasers”, Proc. SPIE 9162, Active Photonic Materials VI, 91621Q (September 12, 2014).

D. N. Christodoulides, M.-A. Miri, “PT symmetry in optics and photonics”, Proc. SPIE 9162, Active Photonic Materials VI, 91621P (September 29, 2014).

M.-A. Miri, M. Heinrich, D. N. Christodoulides, “Supersymmetric optical waveguides”, Proc. SPIE 8980, Physics and Simulation of Optoelectronic Devices XXII, 89801F (March 7, 2014).

CONFERENCES/COLLOQUIA/SEMINARS:

T. Kottos, Time-Reversal Symmetry and its Applications: from Waveform Shaping to System Protection, VII Leopoldo Garcia-Colin Mexican meeting on Mathematical and Experimental Physics, Plenary lecture, Mexico City February 17 (2020)

T. Kottos, Time-reversal Symmetry and its Applications to waveform Shaping and System Protection, Colloquium at the Physics Depts. of UMBC, February 6 (2019)

T. Kottos, Time-reversal Symmetry and its Applications to waveform Shaping and System Protection, Colloquium at the Physics Depts. of Dickinson College, January 31 (2019)

T. Kottos, A quest for Extreme Wave-Matter Interactions and the Emergence of New Technologies, Key Note Lecture, Summer Research Program, Wesleyan Univ., July 25 (2019)

E. L. Thomas, “Designer Band Gaps in Phononic Crystals via Nonsymmorphic Symmetry,” YHJ Yau, PI Galich, EL Thomas, 26th International Congress on Sound and Vibration (ICSV26), Montreal, Canada, July, 2019

E. L. Thomas, “Soft Modes in Nonlinear Composites on the Edge of Elastic Instability”. P. I. Galich and E. L. Thomas, 26th International Congress on Sound and Vibration (ICSV26), Montreal, Canada, July 7-11, 2019.
E. L. Thomas, “Representative Volume Element and Irreducible Brillouin Zone Path Choice for Complete Band Gap Search in 3D Acoustic and Phononic Crystals”. P. I. Galich and E. L. Thomas, 15th U.S. National Congress on Computational Mechanics (USNCCM15), Austin, TX, July 28 - August 1, 2019.

V. Vardeny, “Observation of PT symmetry in magnetism”. Condensed Matter Seminar, Department of Physics & Astronomy, University of Utah, October 2019, Salt Lake City, UT.

V. Vardeny, Non-Hermitian Laser Mode Dynamics in Coupled Quantum Dot Microdisks”. Condensed Matter Seminar, Department of Physics & Astronomy, University of Utah, January 2019, Salt Lake City, UT.

T. Kottos, Time-Reversal Symmetry and its Applications to Waveform Shaping and System Protection, Colloquium, Phys. Dept., University of Crete, May 17 (2018)

T. Kottos, Time-Reversal Symmetry and its Applications to Waveform Shaping and Photonic Limiters, invited Lecture at summer school on “Waves in Complex Photonics Media: Fundamentals and Device Applications”, Anacapri-Italy, June 4-7 (2018)

T. Kottos, Statistical Theory of Waveform Shaping for Enhanced Targeting Efficiency, Invited

Speaker, RCM Workshop, University of Maryland, November 3 (2017).

T. Kottos, Statistical Theory of Coherent Perfect Absorption in Chaotic Cavities and Complex Networks, Invited talk at the AFOSR/AFRL Center of Excellence: The Science of Electronics in Extreme Electromagnetic Environments, March 23 2017.

T. Kottos, Non-Hermitian wave transport: new possibilities and challenges, Colloquium, Department of Physics, UTRGV, March 10 (2017)

E. L. Thomas, Asymmetric Transport Using Coupled Acoustic Resonators," Materials Engineering Department, Brown University, October 13, 2017

S. Aryal, V. Vardeny; "Photoluminescence and lasing properties of MAPbBr3 single crystals grown from solution", APS March meeting, Baltimore, March 14-18, 2016.

Y. Zhai, V. Vardeny; "Transient Spectroscopy of Photoexcitations and Morphology Control of Organometal Trihalide Perovskites", APS March meeting, Baltimore, March 14-18, 2016.

V. Vardeny; "Organic inorganic trihalide perovskites; photovoltaic and beyond", Colloquium at University of California Riverside, March 30, 2016.

Edwin L. Thomas; "Indistinguishable from Magic," Institute of Materials Science, Los Alamos National Lab, Los Alamos, New Mexico, March 22, 2016.

Edwin L. Thomas; "Polymers for Future Applications," Department of Materials Science, University of Nebraska, Lincoln, Nebraska, April 25, 2016

Edwin L. Thomas; "Advances in Polymeric Materials," Department of Chemical Engineering, Technion, Haifa, Israel, June 5, 2016

Chun Hao Lin, Evan Lafalce, Jaehan Jung, Marcus Smith, Sidney T. Malak, Zhiqun Lin, Valy Vardeny, & Vladimir V. Tsukruk, Stable and highly loaded CdSe/Cd1-xZnxSe1-ySy crosslinked quantum dot films with high gain in the quasi-continuous wave region (Symp. NT1)

Sidney T. Malak, Jaehan Jung, Young Jun Yoon, Chun Hao Lin, Marcus Smith, Zhiqun Lin, & Vladimir V. Tsukruk, Fabricating large-area multicolored photopatterns via targeted recovery of selected QD emission peaks in mixed QD films (Symp. NT1)

Marcus J. Smith, Sidney T. Malak, Jaehan Jung, Young Jun Yoon, Chun Hao Lin, Timothy White, Zhiqun Lin, & Vladimir V. Tsukruk, Utilizing thiol-ene click chemistry to fabricate highly photoluminescent QD patterns for advanced photonic devices (Symp. NT1)

Sidney T. Malak, Jaehan Jung, Young Jun Yoon, Marcus Smith, Chun Hao Lin, Zhiqun Lin, & Vladimir V. Tsukruk, Positive/negative photopatterning: Utilizing the decay-to-recovery of quantum dot emission to control the development process (Symp. NT6)

V. Vardeny; "Organic inorganic trihalide perovskites; photovoltaic and beyond", Science and Breakfast series, Salt Lake City, September 30, 2015.

C. Zhang, V. Vardeny; "Magneto-photocurrent in hybrid perovskite devices", APS March meeting, San Antonio, March 6-9, 2015.

Edwin L. Thomas; "Advances in Microstructured Polymers," International Symposium on

Polymer Analysis and Characterization, Houston, Texas, June 10, 2015

Edwin L. Thomas; “Advances in Polymeric Materials,” Kyoto Institute of Technology, Kyoto, Japan, November 24, 2015

V. Vardeny; “Organic inorganic trihalide perovskites; photovoltaic and beyond”, ‘Optical Probes 2015’, Hong Kong, June 14-19, 2015.

M. Chitsazi, N. Bender, L. Fowler-Gerace, H. Li, F. Ellis, T. Kottos, Experimental Studies of a Driven PT Dimer, APS March meeting, March 2-6 2015

A. Basiri, T. Kottos, I. Vitebskiy, Light propagation in synthetic pseudo-passive media with balanced gain and loss, APS March meeting, March 2-6 2015

N. Bender, M. Chitsazi, H. Li, F. Ellis, T. Kottos, PT-symmetric Floquet Lattices, APS March meeting, March 2-6 2015

M. Chitsazi, S. Factor, J. Schindler, H. Ramezani, F. Ellis, T. Kottos, Experimental observation of amplification death via asymmetric gain, APS March meeting, March 2-6 2015

E. Makri, T. Kottos, I. Vitebskiy, Reflective Optical Limiter Based on Resonant Transmission, APS March meeting, March 2-6 2015

T. Kottos, H. Li, B. Shapiro, Thermal Transport in Cayley-Tree Networks, APS March meeting, March 2-6 2015

N. Bender, H. Ramezani, T. Kottos, Caustics Formation and Sharp Focusing in PT-symmetric Waveguide Arrays, APS March meeting, March 2-6 2015

A. Kleeman, R. Deora, H. Li, F. Ellis, T. Kottos, I. Vitebskiy, Non-reciprocal acoustic transport in media with spectral asymmetry and losses, APS March meeting, March 2-6 2015

H. Li, T. Kottos; Concept of Linear Thermal Circulator Based on Coriolis forces, APS March meeting, March 2-6 2015

T. Kottos; Non Hermitian Optics and the useful phases of loss, University of Nice and CNRS, Colloquium, 10 December (2015)

T. Kottos; Photonic structures with PT-symmetry, Colloquium, Department of Physics, University of Utah, November 12 (2015)

T. Kottos; Non-Hermitian Optical Structures with Losses, Invited Speaker in the conference Quantum Chaos, Billiards, RMT and more, Cuarnavaca, Mexico, August 31-September 4 (2015)

T. Kottos; Non-Hermitian Optical Structures with Losses, Invited Speaker, Conference “Quantum (and Classical) Physics with Non-Hermitian Operators (PHHQP13), Jerusalem Israel, 12-16 July (2015).

T. Kottos; Wave Propagation in the Presence of Parity-Time Symmetry: Examples from Integrated Optics and Electronics, Invited Speaker in SPIE conference, Prague Republic, 6-9 July (2015).

T. Kottos; Designing novel materials with Parity-Time symmetries: Examples from integrated photonics and electronics, Invited Lecture at Quantum Lunch Seminar, Los Alamos, June 11 (2015).

T. Kottos; Macroscopic magnetic structures with balanced gain and loss, Invited speaker at the conference “Emerging Paradigms in Nonlinear Complexity: From PT symmetry to nonlinear Dirac sysems, From Polaritons to Skyrmions”, Santa Fe, New Mexico, June 8-10 (2015).

N. Bender, F. Nazari, H. Ramezani, M. Moravvej-Farshi, D. N. Christodoulides, T. Kottos; Optical Asymmetry Induced by PT-symmetric Nonlinear Fano Resonances, APS March meeting, 3-7 March 2014

E. Makri, H. Ramezani, T. Kottos, I. Vitebskiy; Reflective Optical and Microwave Limiters based on Non-Linear Localized Modes, APS March meeting, 3-7 March 2014

T. Kottos; Non Hermitian Optics: Applications in Optics and Electronics, International, Conference on "Quantum and classical chaos: What comes next?", Invited speaker, Ljubljana, Slovenia, 9-11 October (2014)

T. Kottos; PT-symmetric Magnetic Structures, Invited Speaker in 9th International Conference on Disordered, Systems, San Antonio-Texas, 18-22 August (2014)

T. Kottos; PT-symmetric Magnetic Structures, Invited Speaker in SIAM International conference on "Nonlinear Waves in Systems with PT Symmetry", Cambridge U.K, 13 August (2014)

T. Kottos; Taming Wave Propagation Via Parity-Time Symmetry: Examples From Integrated Optics and Electronic, Quantum/Nanophysics Seminar, Dartmouth College (Phys. Dept), 10 July.

T. Kottos; Asymmetric Wave Transport Using PT -symmetry, International Conference on PT -symmetry, University of Connecticut, Invited Speaker, 11 June (2014)

T. Kottos; Asymmetric wave transport in structures with parity-time symmetry, Colloquium, Michigan, Technological University (Phys. Dept), 17 March (2014)

T. Kottos; Random matrix theory approach to thermal transport in complex lattices, Invited Speaker in International Conference on Weak Chaos and Weak turbulence, Dresden/Germany 03 – 07 February (2014)

V. Vardeny; “Studies of photoexcitations in π-conjugated copolymers”, SPIE, San Diego, August 2014.

V. Vardeny; “Laser action in π-conjugated polymers”, colloquium, university of Bath, UK, November (2014)