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Numerical methods for generation and characterization of disordered aperiodic photonic lattices

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Abstract: We introduce numerical modeling of two different methods for the deterministic randomization of two-dimensional aperiodic photonic lattices based on Mathieu beams, optically induced in a photorefractive media. For both methods we compare light transport and localization in such lattices along the propagation, for various disorder strengths. A disorder-enhanced light transport is observed for all disorder strengths. With increasing disorder strength light transport becomes diffusive-like and with further increase of disorder strength the Anderson localization is observed. This trend is more noticeable for longer propagation distances. The influence of input lattice intensity on the localization effects is studied. The difference in light transport between two randomization methods is attributed to various levels of input lattice intensity. We observe more pronounced localization for one of the methods. Localization lengths differ along different directions, due to the crystal and lattice anisotropy. We analyze localization effects comparing uniform and on-site probe beam excitation positions and different probe beam widths.

1. Introduction

The phenomenon of Anderson localization (AL) originally discovered a few decades ago is one of the basic prominent phenomena in solid-state physics [1,2]. Originally introduced to explain the localization of electronic wave functions in disordered crystals, it has found growing applications in a variety of classical and quantum systems [3–5], including light waves in different materials [6–8]. AL of light has achieved renewed interest due to the potential for the realization of localization of optical waves in random media, especially in discrete systems [9], laser-written waveguide arrays [10–13], and/or optically induced randomized potential [14]. It is in the focus of investigations, especially in nonlinear optics and photonics, due to the development of new optical technologies and media, such as disordered photonic crystals and photonic lattices, in which the presence of AL appreciably changes the propagation of light [15–17]. Owing to the analogy of paraxial photonic systems to solid-state systems, where the wave function evolution corresponds to propagation of light and thanks to the fact that longitudinally invariant disorder can be effectively realized in lattices, experimental activities in AL of light started to attract the attention of optical community [8].

Up to now, periodic photonic structures have led to light control by photonic band gaps in space and time, whereas random photonic structures give rise to localization [6,8,18]. Dynamical control and manipulation of light by deterministic aperiodic or complex photonic structures [19–21] at the intersection between periodic and random crystal structures, especially the randomization of aperiodic structures, have not yet been fully understood nor exploited for applications. Two-dimensional aperiodic photonic lattices were experimentally realized by the optical induction technique in photorefractive crystal by different combinations of nondiffracting

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Optics Letters

Light transport and localization in disordered aperiodic Mathieu lattices

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Complex optical systems such as deterministic aperiodic Mathieu lattices are known to hinder light diffraction in a manner comparable to randomized optical systems. We systematically incorporate randomness in our complex optical system, measuring its relative contribution of randomness, to understand the relationship between randomness and complexity. We introduce an experimental method for the realization of disordered aperiodic Mathieu lattices with numerically controlled disorder degree. Added disorder always enhances light transport. For lower disorder degrees, we observe diffusive-like transport, and in the range of highest light transport, we detect Anderson localization. With further increase of disorder degree, light transport is slowly decreasing and localization length decreases indicating more pronounced Anderson localization. Numerical investigation at longer propagation distances indicates that the threshold of Anderson localization detection is shifted to lower disorder degrees.

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Localization of light has drawn considerable attention in many areas of light–matter interaction owing to the evident potential for the realization in disordered media [1–4]. In contrast, Anderson localization (AL) is a well-known effect in condensed-matter physics, which predicts that electrons may become immobile in a disordered crystal. This concept of waves in disordered media has been subsequently transferred to many other areas, such as matter waves, ultracold atoms, and light or sound waves [2]. Realizing that AL is a wave phenomenon relying on interference, these concepts were extended to optics and photonics. The AL of light has been successfully demonstrated in various customized configurations, when the disorder degree (DD) is increased [5–10]. In optically induced disordered photonic quasicrystals with weak disorder, it is observed that weak disorder enhances light transport. When increasing disorder finite-time, diffusive-like transport appears, while a further increase of disorder leads first to coherent backscattering [11] and for the strong disorder to AL. Thereby, the spatial extent of the probe beam decreases and its central part of the log-plot intensity profile displays an exponential decay [9,12,13].

In nature, perfect periodicity, in contrast to disorder or aperiodicity, is not very often encountered. Deviation from periodicity results in higher complexity. In optics, the properties of various photonic quasicrystals and aperiodic systems have been studied [13–18]. Considering localization characteristics, such structures lie between periodic and random structures. Numerous aperiodic and quasiperiodic photonic structures have been realized artificially [19–21]. Non-diffracting beams, with propagation invariant transverse intensity distributions, are applicable in modern photonic research e.g. numerous two-dimensional aperiodic photonic lattices have been optically induced in photosensitive media using them [21–23]. Aperiodic lattices contain non-uniform distances between the lattice sites with non-homogeneous intensity depth distributions, and hence light propagation crucially depends on the nature of the local environment of the probe beam positions. In contrast that occurring in periodic systems, light diffraction is hampered owing to the aperiodicity [12,21,22,24]. Still, light localization in aperiodic lattices is an unexplored area of research, especially in randomized aperiodic lattices. In our previous studies, we introduced a method for the creation of various two-dimensional aperiodic photonic structures by the interference of Mathieu beams, experimentally realized in a single optical induction process in parallel [23]. We showed that such obtained aperiodic Mathieu photonic lattice (AML) hinders linear light expansion in comparison to periodic lattice and supports nonlinear light localization[24].

In this Letter, we introduce a numerical method for controllable randomization of AMLs to investigate if they support AL. We construct an experimental system for the realization of disordered lattices by a single optical induction process in parallel using a spatial light modulator (SLM) and numerically precalculated disordered patterns with adjustable DDs. This numerical method and experimental configuration, in comparison to the previous one [5,12], enable us direct control of the lattice DD and parallel optical induction of the corresponding light intensity in the whole volume of the photorefractive crystal.

Here, we investigate the light propagation in disordered AMLs numerically and experimentally. We study the conditions for light localization in such lattices as well as the effects of disorder during the propagation. For all DDs, we experimentally obtain and numerically confirm disorder-enhanced transport in

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Optics EXPRESS

Interdimensional radial discrete diffraction in Mathieu photonic lattices

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Abstract: We demonstrate transitional dimensionality of discrete diffraction in radial-elliptical photonic lattices. Varying the order, characteristic structure size, and ellipticity of the Mathieu beams used for the photonic lattices generation, we control the shape of discrete diffraction distribution over the combination of the radial direction with the circular, elliptic, or hyperbolic. We also investigate the transition from one-dimensional to two-dimensional discrete diffraction by varying the input probe beam position. The most pronounced discrete diffraction is observed along the crystal anisotropy direction.

1. Introduction

The ability to tailor and manipulate light in photonic lattices is an important topic of scientific investigations and practical applications in optics [1]. Photonic lattices or arrays of evanescently coupled waveguides are typical examples of structures where discrete effects and dynamics can be investigated. Light focused into one waveguide that linearly propagates along the waveguide array will tunnel to neighboring sites, exhibiting a characteristic diffraction pattern with the intensity mainly focused in the outer lobes. This phenomenon, called the discrete diffraction of light [2] was theoretically and experimentally observed in one-dimensional (1D) waveguide arrays [3] and two-dimensional (2D) photonic lattices [4]. It is also investigated in aperiodic photonic lattices [5–8] as well as in other systems, such as atomic photonic lattices [9–11].

The truncation of periodic photonic lattice causes an additional distortion in the periodicity and results in the formation of optical surface states that are analogous to the surface states in the electronic theory of periodic systems [12,13]. Optical self-trapped discrete surface waves - surface solitons - have been demonstrated in 1D waveguide arrays [14,15] and in 2D photonic lattices [16]. Physical systems with dimensionality crossover have attracted huge attention, for example, the continuous transformation of photonic lattice from one dimension to two dimensions [17]. In such systems, intermediate states can occur that do not exist in either 1D or 2D geometries. For these structures, there are still open questions: How, when and why does a system cross over from one to two dimensions?

Nondiffracting beams are convenient for the generation of 2D photonic lattices, since they can retain propagation-invariant structure even under weak nonlinearity [18]. There are four major nondiffracting beam families that are exact solutions of the Helmholtz equation in different coordinate systems [19,20]: plane waves in Cartesian, Bessel beams in circular cylindrical [21], Mathieu beams in elliptic cylindrical [22], and parabolic beams in parabolic cylindrical coordinates [23]. We opt for Mathieu beams, since they are used for optical lattice-writing that allows solitons or even elliptically shaped vortex solitons [24]. They are also used for the creation

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2022 TECHNICAL PROGRAMME

AND

EXHIBITION GUIDE

SPIE. PHOTONICS EUROPE

3–7 APRIL 2022 | PALAIS DE LA MUSIQUE ET DES CONGRÈS | STRASBOURG, FRANCE

SESSION 5

LOCATION: SALON 9, NIVEAU/LEVEL 0 . . . . TUE 10:50 TO 12:30

Multimode Dynamics I

Session Chair: **Peter Horak,** Optoelectronics Research Ctr. (United Kingdom)

10:50: **Spatiotemporal complexity: multimode fiber light sources and their applications** *(Invited Paper)*, Katarzyna Krupa, Institute of Physical Chemistry PAS (Poland). . . . . [12143-19]

11:20: **Towards a new understanding of optical poling efficiency in multimode fibers**, Maxime Jonard, XLIM Institut de Recherche (France); Maggy Colas, Institut de Recherche sur les Céramiques, Univ. de Limoges (France); Yann Leventoux, Tigran Mansuryan, XLIM Institut de Recherche (France); Julie Cornette, Institut de Recherche sur les Céramiques (France); Alessandro Tonello, XLIM Institut de Recherche (France); Stefan Wabnitz, Mario Zitelli, Sapienza Univ. di Roma (Italy); Fabio Mangini, Univ. degli Studi di Brescia (Italy); Mario Ferraaro, Yifan Sun, Sapienza Univ. di Roma (Italy); Vincent Couderc, Claire Lefort, XLIM Institut de Recherche (France) . [12143-21]

11:40: **Dissipative solitons and frequency combs in a ring quantum cascade laser** *(Invited Paper)*, Lorenzo Luigi L. Columbo, Dipartimento di Elettronica e Telecomunicazioni, Politecnico di Torino (Italy); Marco Piccardo, Harvard John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge (USA) and Center for Nano Science, Fondazione Istituto Italiano di Tecnologia and Technology, Milano (Italy); Franco Prati, Luigi Lugiato, Dipartimento di Scienza e Alta Tecnologia, Università dell'Insubria, Como (Italy); Massimo Brambilla, Dipartimento di Fisica Interateneo and CNR-IFN, Università e Politecnico di Bari (Italy); Alessandra Gatti, Dipartimento di Scienza e Alta Tecnologia, Università dell'Insubria, Como (Italy) and Istituto di Fotonica e Nanotecnologie IFN-CNR (Italy); Carlo Silvestri, Mariangela Gioannini, Dipartimento di Elettronica e Telecomunicazioni,Politecnico di Torino (Italy); Nikola Opacak, Institute of Solid State Electronics, TU Wien (Austria); Benedikt Schwarz, Institute of Solid State Electronics (Austria); Federico Capasso, Harvard John A. Paulson School of Engineering and Applied Sciences, Cambridge (USA). . . . . [12143-8]

12:10: **Discretized X-wave in a multimode optical fiber**, Karolina Stefanska, Lab. Interdisciplinaire Carnot de Bourgogne (France) and Wroclaw Univ. of Science and Technology (Poland); Pierre Béjot, Lab. Interdisciplinaire Carnot de Bourgogne (France); Karol Tarnowski, Wroclaw Univ. of Science and Technology (Poland); Bertrand Kibler, Lab. Interdisciplinaire Carnot de Bourgogne (France) . . . . [12143-23]

Lunch/Exhibition Break . . . . .Tue 12:30 to 13:50

SESSION 6

LOCATION: SALON 9, NIVEAU/LEVEL 0 . . . . .TUE 13:50 TO 17:10

Nonlinear Material Systems I

Session Chair: **Thibaut Sylvestre,** FEMTO-ST (France)

13:50: **Nonlinear topological photonics** *(Invited Paper)*, Hrvoje Buljan, Univ. of Zagreb (Croatia) . . . . [12143-24]

14:20: **Time-varying optical nonlinearities near an epsilon-near-zero condition**, Anton Bykov, King's College London (United Kingdom); Guixin Li, Institute for Quantum Science and Engineering, Southern Univ. of Science and Technology (China); Anatoly V. Zayats, King's College London (United Kingdom). . . . . [12143-25]

14:40: **Turbulence control by time-symmetry breaking**, Salim Benadouda Ivars, Muriel Botey, Ramon Herrero, Univ. Politècnica de Catalunya (Spain); Kestutis Staliunas, Univ. Politècnica de Catalunya (Spain) and Institució Catalana de Recerca i Estudis Avançats (Spain) . . . . [12143-28]

15:00: **All-optical Fredkin gate using silicon nitride microring resonator**, Menglong He, Kambiz Jamshidi, TU Dresden (Germany) . . . . [12143-29]

15:20: **Second harmonic generation in silicon oxynitride thin films**, Jakub Lukeš, Karel Zidek, Institute of Plasma Physics of the CAS, v.v.i. (Czech Republic). . . . . [12143-70]

Coffee Break. . . . . Tue 16:00 to 16:30

LOCATION: SCHWEITZER AUDITORIUM, NIVEAU/LEVEL 0 . . . . . . 16:30 TO 18:05

Hot Topics II

Francis Berghmans, Vrije Univ. Brussel (Belgium)
2022 Symposium Chair

16:30: **Welcome and opening remarks**

16:35: **Enhancing optical contrast for cancer detection and therapy guidance** *(Plenary)*, Brian W. Pogue, Thayer School of Engineering at Dartmouth (USA) . . . .[12146-500]

17:20: **Cell by lens: arguments and divagations for next visionary challenges in biophotonics and beyond** *(Plenary)*, Pietro Ferraro, Istituto di Scienze Applicate e Sistemi Intelligenti "Eduardo Caianiello" (Italy) . [12144-500]

WEDNESDAY 6 APRIL

SESSION 7

LOCATION: SALON 9, NIVEAU/LEVEL 0 . . . . .WED 8:30 TO 10:20

Nonlinear Material Systems II

Session Chair: **Hrvoje Buljan,** Univ. of Zagreb (Croatia)

8:30: **Parametric phase-sensitive amplification in silicon nitride waveguides** *(Invited Paper)*, Victor Torres-Company, Peter Andrekson, Magnus Karlsson, ping Zhao, Zhichao Ye, Chalmers Univ. of Technology (Sweden) . . . . . [12143-30]

9:00: **Polyvinylcarbazole: a new material for passive optical limiting**, Olivier Muller, Morgane Guerchoux, Silke Braun, Théo Jean, Manon Dandois, Lionel Merlat, Institut Franco-Allemand de Recherches de Saint-Louis (France). [12143-31]

9:20: **Experimental and theoretical study of second and third harmonic generation in amorphous silicon**, Laura Rodríguez-Suné, Univ. Politècnica de Catalunya (Spain); Michael Scalora, U.S. Army Combat Capabilities Development Command (USA); Crina M. Cojocaru, Univ. Politècnica de Catalunya (Spain); Neset Akozbek, US Army (USA); Ramon Vilaseca, Jose F. Trull, Univ. Politècnica de Catalunya (Spain) . . . . [12143-32]

9:40: **Electric-field poling of silicon nitride waveguides for the linear phase modulation**, Boris Zabelich, Edgars Nitiss, Ecole Polytechnique Fédérale de Lausanne (Switzerland); Anton Stroganov, LIGENTEC SA (Switzerland); Camille-Sophie Brès, Ecole Polytechnique Fédérale de Lausanne (Switzerland) . . . . [12143-33]

10:00: **Investigation of LBO and BBO subnanosecond optical parametric amplifiers operating in the visible spectrum range**, Julius Vengelis, Gabrielė Stanionytė, Eglė Vėjalytė, Viktorija Tamulienė, Vygandas Jarutis, Vilnius Univ. (Lithuania) . . . . [12143-34]

Coffee Break. . . . . .Wed 10:20 to 10:50

SESSION 8

LOCATION: SALON 9, NIVEAU/LEVEL 0 . . . . .WED 10:50 TO 12:20

Nonlinear Sources and Dynamics

Session Chair: **Victor Torres Company,** Chalmers Univ. of Technology (Sweden)

10:50: **Pulse dynamics in microlasers** *(Invited Paper)*, Soizic Terrien, The Univ. of Auckland (New Zealand). . . . . [12143-35]

11:20: **Polarization symmetry breaking of regenerative pulses in excitable microlasers with delayed optical feedback**, Stefan Ruschel, The Univ. of Auckland (New Zealand); Venkata Anirudh Pammi, Ctr. de Nanosciences et de Nanotechnologies (France); Bernd Krauskopf, Neil G. R. Broderick, The Univ. of Auckland (New Zealand); Sylvain Barbay, Ctr. de Nanosciences et de Nanotechnologies (France) . . . . [12143-36]

11:40: **Investigation of optical parametric generator pumped by subnanosecond passively Q-switched micro-laser pulses**, Jonas Banys, Justina Savickytė, Ona Balachninaitė, Simona Armalytė, Viktorija Tamulienė, Vygandas Jarutis, Julius Vengelis, Vilnius Univ. (Lithuania) . . . . [12143-37]

12:00: **Computation of Kerr lensing effect in laser amplifiers**, Christoph Pflaum, Friedrich-Alexander-Univ. Erlangen-Nürnberg (Germany) . . . [12143-38]

Lunch/Exhibition Break . . . . .Wed 12:20 to 13:50

SESSION 9

LOCATION: SALON 9, NIVEAU/LEVEL 0 . . . . .WED 13:50 TO 15:20

Multimode Dynamics II

Session Chair: **Katarzyna Krupa,** Institute of Physical Chemistry PAS (Poland)

13:50: **Multimode effects in nonlinear fibre optics: from telecommunications to high-harmonic generation** *(Invited Paper)*, Peter Horak, Optoelectronics Research Ctr. (United Kingdom) . . . . [12143-39]

14:20: **Fast nonlinear integration of the nonlinear Schrödinger equation using a neural network**, Lauri Salmela, Tampere Univ. (Finland); Mathilde Hary, Tampere Univ. (Finland) and Institut FEMTO-ST, Univ. Bourgogne Franche-Comté (France); Mehdi Mabed, John M. Dudley, Institut FEMTO-ST, Univ. Bourgogne Franche-Comté (France); Goëry Genty, Tampere Univ. (Finland) . . . . [12143-40]

14:40: **Light propagation in disordered aperiodic Mathieu lattices generated with two different randomization methods**, Jadranka Vasiljević, Institute of Physics Belgrade (Serbia); Dejan V. Timotijević, Institute for Multidisciplinary Research, Univ. of Belgrade (Serbia); Dragana M. Jović Savić, Institute of Physics Belgrade (Serbia) . . . . [12143-41]

Light transport and localization in disordered aperiodic Mathieu lattices

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Complex systems may be governed by just a few simple rules, not unlike highly ordered systems such as periodic, still, they produce patterns that can be compared to random systems. Complex photonic lattices are suitable for the investigation of many physical phenomena from solid-state to atomic physics with easier experimental realization. Light transport in complex optical systems is a rich and fascinating topic of research. From the investigation of light propagation in aperiodic and disordered media plentiful interesting optical phenomena are obtained, such as Anderson localization.

Nondiffracting beams are highly relevant in optics and atom physics, particularly because their transverse intensity distributions propagate unchanged for hundreds of diffraction lengths [1]. They have potential applications in free-space wireless communications, optical interconnections, long-distance laser machining, and surgery. Four different fundamental families of propagation invariant light fields, distinguish in the underlying real space coordinate system, exist: Discrete, Bessel, Mathieu, and Weber nondiffracting beams [2-4], also, suitable for generation of photonic lattices [5-8].

We realized deterministic aperiodic photonic lattices with controllable complexity, using Mathieu beams combined in metastructures and spliced in both transverse dimensions with different offsets [7], and shown that such lattices hinder light diffraction in comparison to periodic lattices [9]. A further step of randomization of these structures allows for an additional level of diffraction control. Also, the propagation of light in such structures is an unexplored topic, hence will be one of the topics of investigation in this paper. The aim is to involve the fundamental concepts of structured dielectric materials, photonic crystals, as promising candidates for advanced information processing with the unique property of light localization as a nonlinear light-mater interaction phenomenon. We focus our research on the generation of randomized aperiodic lattices with gradually controlled disorder degree in various systems with the investigation of the relationship between complexity and randomness.

We present a comprehensive numerical study of the transverse localization of light in disordered aperiodic Mathieu photonic lattices comparing disorder degree differentiation. A disorder-enhanced light transport is observed for all disorder degrees. With increasing disorder strength light transport becomes diffusive-like and with further increase of disorder degree the Anderson localization is observed. Furthermore, the influence of lattice intensity on the localization effects is studied. The difference in light transport is attributed to various levels of lattice intensity managed by disorder degree. Additionally, we show that localization length differs along different directions, due to the crystal and lattice anisotropy.

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Summary for the program

Light transport and localization in disordered aperiodic Mathieu lattices

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Complex photonic lattices are suitable for the investigation of many physical phenomena from solid-state to atomic physics with easier experimental realization. Light transport in complex optical systems is a rich and fascinating topic of research. Nondiffracting beams are highly relevant in optics and atom physics, particularly because their transverse intensity distributions propagate unchanged for hundreds of diffraction lengths, moreover, suitable for the generation of photonic lattices. Four different fundamental families of propagation invariant light fields, distinguish in the underlying real space coordinate system, exist: Discrete, Bessel, Mathieu, and Weber nondiffracting beams. We realized deterministic aperiodic photonic lattices with controllable complexity, using Mathieu beams combined in metastructures and spliced in both transverse dimensions with different offsets, and shown that such lattices suppress light diffraction comparing with periodic lattices. A further step of randomization of these structures permits an additional level of diffraction control. The propagation of light in such structures is an unexplored topic, hence it is one topic of investigation in this paper. The aim is to involve the fundamental concepts of structured dielectric materials, photonic crystals, as promising candidates for advanced information processing with the unique property of light localization as a nonlinear light-mater interaction phenomenon. We generate randomized aperiodic lattices with gradually controlled disorder degree in various systems to investigate the relationship between complexity and randomness. We present a comprehensive numerical study of the transverse localization of light in disordered aperiodic Mathieu lattices comparing disorder degree differentiation. A disorder-enhanced light transport is observed for all disorder degrees. With increasing disorder strength light transport becomes diffusive-like and with further increase of disorder degree, the Anderson localization is observed. Furthermore, the influence of lattice intensity on the localization effects is studied. The difference in light transport is attributed to various levels of lattice intensity managed by disorder degree.

Light propagation in disordered aperiodic Mathieu lattices generated with two different randomization methods

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ABSTRACT

We present the numerical modeling of two different randomization methods of two-dimensional aperiodic photonic lattices based on Mathieu beams, optically induced in a photorefractive media. We numerically study light propagation in such lattices. For both methods, we compare light transport and localization in such lattices along the propagation and for various disorder strengths. For all disorder strengths, a disorder-enhanced light transport is observed. With increasing disorder strength light transport becomes diffusive-like while with further increase of disorder strength, the Anderson localization is observed. For longer propagation distances this transition is more pronounced. The influence of input lattice intensity on the localization effects is studied. We observe more pronounced localization for one of the methods, and different diffraction and localization along different directions, due to the crystal and lattice anisotropy. The difference in light transport and localization between two randomization methods is attributed to various levels of input lattice intensity.

Keywords: light propagation, disordered lattices, Mathieu beams, Anderson localization, disorder-enhanced light transport, diffusive-like transport

1. INTRODUCTION

Some of the fascinating effects observed when light propagation through different types of periodic photonic structures was studied are light discrete diffraction or discrete spatial solitons.[1–3] It was demonstrated that periodic lattices have essential characteristics of photonic crystal structures (Brillouin zones, band structure, etc.) leading to light control by photonic band gaps in space and time. Also, light localization in disordered media was investiagted.[4,5] Anderson localization (AL), a basic phenomenon from solid-state physics has found applications for light waves in different materials,[6–8] Bose-Einstein condensates,[9] and sound waves.[10] It was demonstrated an appreciable change of light propagation in the presence of disorder, the transition from the diffraction of light to spatial AL is observed by increasing disorder strength in different customized configurations.[8,11–14]

Deterministic aperiodic structures are at the intersection between periodic and disorder crystal structures. Various aperiodic and quasiperiodic photonic structures were realized artificially,[15,16] their properties have been studied for light control and manipulation.[17,18] Aperiodic lattices contain non-uniform distances between the lattice waveguides with unequal waveguides intensity depths. Therefore in such lattices in contrast to periodic, light propagation strongly depends on local environments of the probe beam excitation position,[15,19] and linear light diffraction is hampered owing to the aperiodicity.[15,19] Also, aperiodic lattices support nonlinear light localization.[19,20] Still, numerous aperiodic structures exist and have not yet been fully explained or exploited for applications. For instance, Penrose or Fibonacci structures have limited variation in probing local environments, however aperiodic Mathieu lattices[21] with the adjustable spatial and intensity distribution allow the tunable optical response which is provided with numerous different probing local environments, as well as introducing structure anisotropy variability. For the experimental realization of photonic lattices by optical induction technique in general, nondiffracting beams are convenient since they are propagation invariant for weak nonlinearity.[22] Two-dimensional aperiodic photonic lattices based on multiplexing of nondiffracting beams were experimentally realized by the optical induction technique in photorefractive crystal.[21,23]

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ID: 120

TOM 5 Resonant Nanophotonics

Controlling chromaticity by lamellar gratings

Hiroyuki Ichikawa, Naoki Arita, Keigo Shikimi, Ryunosuke Tani

Ehime University, Japan

Fundamental numerical study on controlling chromaticity with the simplest diffractive structure is carried out. Observed various characteristics on transmission/reflection and dielectric/metal will be useful guidelines for practical optimisation of device structures.

ID: 150

TOM 8 Non-linear and Quantum Optics

Light propagation in disordered aperiodic Mathieu photonic lattices

Jadranka M Vasiljević[1], Dejan V Timotijević[2], Dragana M Jović Savić[1]

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We present the numerical modeling of two different randomization methods of photonic lattices. We compare the results of light propagation in disordered aperiodic and disordered periodic lattices. In disordered aperiodic lattice disorder always enhances light transport for both methods, contrary to the disordered periodic lattice. For the highest disorder levels, we detect Anderson localization for both methods and both disordered lattices. More pronounced localization is observed for disordered aperiodic lattice.

ID: 251

TOM 13 Advances and Applications of Optics and Photonics

Chip integrated photonics for ion based quantum computing

Steffen Sauer[1,2], Anastasiia Sorokina[1,2], Carl-Frederik Grimpe[3], Guochun Du[3], Pascal Gehrmann[1,2], Elena Jordan[3,5], Tanja Mehlstäubler[3,4], Stefanie Kroker[1,2,3]

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Ion traps are a promising platform for the realisation of high-performance quantum computers. To enable the future scalability of these systems, integrated photonic solutions for guiding and manipulating the laser light at chip level are a major step. Such passive optical components offer the great advantage of providing beam radii in the µm range at the location of the ions without increasing the number of bulk optics. Different wavelengths, from UV to NIR, as well as laser beam properties, such as angle or polarisation, are required for different cooling and readout processes of ions. We present

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Light propagation in disordered aperiodic Mathieu photonic lattices

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Abstract. We present the numerical modeling of two different randomization methods of photonic lattices. We compare the results of light propagation in disordered aperiodic and disordered periodic lattices. In disordered aperiodic lattice disorder always enhances light transport for both methods, contrary to the disordered periodic lattice. For the highest disorder levels, we detect Anderson localization for both methods and both disordered lattices. More pronounced localization is observed for disordered aperiodic lattice.

1 Introduction

Anderson localization (AL), a well-known phenomenon in solid-state physics [1] is transferred to other fields like ultracold atoms, matter, light or sound waves [2], and demonstrated in various customized configurations [3–6]. The physics of periodic photonic systems has fundamental importance. Still, deviations from periodicity are significant as they may result in higher complexity, like the realization of photonic quasicrystals, the structures that are between periodic and disordered ones. Heretofore, light propagation properties have been studied in periodic photonic lattices [7, 8], as well as in disordered ones [3, 9, 10]. However, the quasiperiodic and aperiodic photonic lattices are merged as a further attractive research field for light propagation.

In our previous studies, we introduced aperiodic Mathieu structures with controllable complexity [11] and we studied light localization in them [12]. In such lattice, light expansion is hindered in comparison to periodic lattice and nonlinear light localization is demonstrated [12]. Randomization of periodic lattices can lead to AL [3, 9] or its suppression [13], while disordered quasiperiodic Penrose lattice can support AL and disorder-enhanced transport (DET) [14].

In this paper, we present two numerical methods for controllable randomization of photonic lattices and study disorder level (DL) influence on light propagation. For both methods, we numerically investigate the linear light propagation in disordered aperiodic Mathieu (DA) and disordered periodic (DP) lattices. For all DLs, we observe DET and AL is verified for higher DLs in DA lattices, for both methods. In contrast, in DP lattices disorder suppress diffraction and AL is observed for higher DLs. Localization length differs along different transverse directions owing to the crystal and lattice anisotropy. We confirm a more pronounced localization for DA lattices in both directions and both methods.

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2 Light propagation in DA and DP lattics

Two-dimensional disordered structures $\boldsymbol{DS}$, with an adjustable DL, are numerically realized by combining an original structure $\boldsymbol{S}$ with a disorder pattern $\boldsymbol{D}$ according to the relation $A_{DS} = (1-p)*A_S + p*A_D$, where A is the field amplitude, and parameter p is the relative contribution of the original structure and disorder pattern, i.e. DL. To ensure propagation invariant structures with the same propagation constant, we preset the Fourier spectrum of the disorder pattern, numerically calculated by interfering plane waves with constant amplitude and random phases, to be located on the same circle with radius k as the original structure [15]. As the original structure we use an aperiodic Mathieu structure created as in our paper [11], or square lattice with period d equal to the characteristic structure size $a = 25\,\mu$m of Mathieu beams used for the creation of the aperiodic structure. Disorder pattern's mean grain size $2\pi/k$ is equal to a of Mathieu beams. A case when the maximum lattice intensity I_{m} of the disordered lattice $I_{DL} = |A_{DS}|^2$ for each DL is unscaled, we will refer as M1, and M2 is the case when I_{DL} is scaled with I_{in} for each DL. For both methods, an increase of DL modifies the transverse intensity distribution of the original structure until completely substitutes it with the disorder pattern. For the same DL, the spatial intensity distributions of the disordered lattices are the same for both methods, but they differ in waveguides depths. For both methods, I_{m} dependencies of DL for DA and DP lattices are almost the same (Fig. 1 (A)). Opposite to the periodic lattice, our aperiodic lattice is not uniform in waveguide's distances, and their depths vary. We calculate averaged lattice intensity $I_{\mathrm{avg}} = \sum_{\mathbf{r}} I_{DL}(\mathbf{r})$ of DA and DP lattices for both methods (Fig. 1 (B)). For both methods, I_{avg}s are lower for DA than for DP lattices. For M1, I_{m} and I_{avg} are lower than for M2.

We study the difference in light propagation in DA and DP lattices realized with these methods. We use intensity distributions of disordered structures I_{DL} in numerical simulation of the light propagation along the z-axis in disordered lattices in a photorefractive crystal, numerically

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STRUCTURED LIGHT AND MULTIMODE EFFECTS

Dimensionality crossover of radial discrete diffraction in optically induced Mathieu photonic lattices (/conference-proceedings-of-spie/13004/130040J/Dimensionality-crossover-of-radial-discrete-diffraction-in-optically-induced-Mathieu/10.1117/12.3017229.full)

Presentation + Paper

Jadranka M. Vasiljević (/profile/Jadranka.Vasiljević-4097119), Vladimir P. Jovanović (/profile/Vladimir.Jovanovic-5044206), Aleksandar Ž. Tomović (/profile/Aleksandar.Tomovic-5044208), Dejan V. Timotijević, Radomir Žikic, Milivoj R. Belić, Dragana M. Jović Savić

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Hide Abstract -

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Spontaneous parametric down-conversion in ultrathin samples (/conference-proceedings-of-spie/13004/130040K/Spontaneous-parametric-down-conversion-in-ultrathin-samples/10.1117/12.3016302.full) Presentation + Paper

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Quantum correlated twin beams in cascaded optical parametric oscillator (/conference-proceedings-of-spie/13004/130040L/Quantum-correlated-twin-beams-in-cascaded-optical-parametric-oscillator/10.1117/12.3016656.full) Presentation + Paper

Salvatore Castrignano, Iolanda Ricciardi, Pasquale Maddaloni (/profile/Pasquale.Maddaloni-52021), Paolo De Natale (/profile/Paolo.de-Natale-25131), Stefan Wabnitz (/profile/Stefano.Wabnitz-7150), Maurizio De Rosa (/profile/Maurizio.De-Rosa-4261090)

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Read Abstract +

Dimensionality crossover of radial discrete diffraction in optically induced Mathieu photonic lattices

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ABSTRACT

We demonstrate transitional dimensionality crossover of radial discrete diffraction in optically induced radial-elliptical Mathieu photonic lattices. Varying the order, characteristic structure size, and ellipticity of the Mathieu beams used for the photonic lattices generation, we control the shape of discrete diffraction distribution over the combination of the radial direction with the circular or elliptic. We also investigate the transition from one-dimensional to two-dimensional discrete diffraction by varying the input probe beam position. Discrete diffraction is the most pronounced along the crystal anisotropy direction.

Keywords: Dimensionality crossover, radial discrete diffraction, photonic lattices, discrete diffraction, Mathieu beams, optical induction, strontium barium niobate crystal

1. INTRODUCTION

One of the main areas of research and applications in optics is the control and manipulation of light in photonic lattices.[1] Arrays of evanescently coupled waveguides or photonic lattices are common structures for discrete effects and dynamics studies. When light is focused into one single waveguide and propagates linearly along the array, it will tunnel to the neighboring waveguide and display a distinctive diffraction pattern, with the intensity mainly concentrated in the outer lobes. The discrete diffraction of light[2] was observed in one-dimensional (1D) waveguide arrays[3]and two-dimensional (2D) photonic lattices,[4] both theoretically and experimentally. It is also studied in other systems, like atomic[5,6] and aperiodic[7–10] photonic lattices.

An additional periodicity distortion is produced by the truncation of the periodic photonic lattice, leading to the development of optical surface states that are analogous to the surface states in the electrical theory of periodic systems.[11,12] Surface solitons (optical self-trapped discrete surface waves) have been found in 2D photonic lattices[13] and 1D waveguide arrays.[14,15] Physical systems that exhibit dimensionality crossover have gained significant interest; one such example is the continuous transformation of 1D into a 2D photonic lattice.[16] One can observe intermediate states that do not have 1D or 2D geometry in such systems. An unanswered question regarding these structures remains: How, when, and why does a system transition from one to two dimensions?

Nondiffracting beams are practical for 2D photonic lattice creation as they retain their propagation-invariant structure even with weak nonlinearity.[17] Four principal nondiffracting beam families are exact solutions of the Helmholtz equation in different coordinate systems:[18,19] plane waves in Cartesian, Bessel beams in circular cylindrical,[20] Mathieu beams in elliptic cylindrical,[21] and parabolic beams in parabolic cylindrical coordinates.[22] Mathieu beams are utilized for optical lattice writing, even allowing the development of elliptically formed vortex solitons.[23] They are additionally used for different aperiodic photonic lattices generation by the optical induction technique in photorefractive crystals[10,24] and for particle manipulation.[25]

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Dimensionality crossover of radial discrete diffraction in optically induced Mathieu photonic lattices

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Light manipulation in photonic lattice (PL) is a prime area of investigation and application in optics [1]. PLs provide a huge platform for investigating discrete light diffraction effects. Discrete diffraction of light was theoretically and experimentally observed in both one-dimensional (1D) and two-dimensional (2D) structures, as well as in aperiodic or other systems. Truncating periodic PLs cause additional distortion of the periodicity, resulting in the formation of optical surface states akin to electronic surface states in periodic systems [2]. The continuous transition from 1D to 2D PLs is an attractive field of study, with a still open question regarding intermediate states that can occur in such physical systems with dimensionality crossover that do not exist in either 1D or 2D geometries [3].

Nondiffracting beams, propagation-invariant fields over hundreds of diffraction lengths even in the presence of weak nonlinearity [4], are ideal for generating 2D PLs and have diverse applications in free-space wireless communications, optical interconnections, long-distance laser machining, and surgery. There are four fundamental families of such propagation-invariant light fields: Discrete, Bessel, Mathieu, and Weber nondiffracting beams [5-7]. Among these, Mathieu beams are preferred for optical lattice writing, enabling solitons, elliptical vortex solitons, and the creation of various aperiodic and disordered PLs through optical induction in photorefractive crystals, as well as for particle manipulation [8-12].

In this paper, experimentally and theoretically we examine conditions for discrete diffraction occurrence in aperiodic Mathieu PLs. The unique shape of Mathieu beams enables the creation of ***naturally truncated aperiodic PLs*** with our advanced one-pass experimental realization by optically induction in the photorefractive crystal using a single Mathieu beam [13]. Such photonic structures in elliptical-radial geometries offer diverse shapes, with circular, elliptical, and hyperbolic waveguide paths and radial spikes, raising questions about discrete diffraction dimensionality. Mathieu lattice period and the refractive index modulation are connected via Mathieu beam parameters (the beam order, characteristic structural size, and the ellipticity of the beam). Different local environments within these lattices during propagation create additional variations in discrete diffraction effects.

We study weak nonlinear light propagation in various aperiodic Mathieu PLs and experimentally and numerically demonstrate radial and angular discrete diffraction in them. We are able to control discrete diffraction in the radial direction and shape their distributions in perpendicular directions: circular, elliptic, or hyperbolic, by modifying the Mathieu beam's order, size, and ellipticity. Additionally, we investigate the transition from 1D to 2D discrete diffraction, highlighting the significant role of crystal anisotropy in our medium, with the most prominent 2D discrete diffraction observed along the crystal anisotropy direction. Our findings lay the groundwork for exploiting light propagation in a novel class of optical lattices, extending beyond these specific lattice configurations, and generalized to diverse types of optically induced lattices. Such adaptivity and reconfigurability of light-guiding structures are vital for advancement in modern photonics with a significant step towards innovative wave-guiding applications and light-routing approaches.

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Summary for the program :

Dimensionality crossover of radial discrete diffraction in optically induced Mathieu photonic lattices

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We focus our experimentally and numerical investigation of weak nonlinear light propagation in various aperiodic Mathieu lattices optically induced in the photorefractive medium using our advanced one-pass experimental setup. We demonstrate the transitional dimensionality of discrete diffraction within such radial-elliptical Mathieu photonic lattices. We control the shape of discrete diffraction distribution over the combination of the radial direction with the circular, elliptic, or hyperbolic through adjustments of beam order, characteristic structure size, and ellipticity of the Mathieu beams used for the photonic lattices generation. By varying the input beam position, we investigated the transition from one-dimensional to two-dimensional diffraction, and we observed the most prominent discrete diffraction along the crystal's anisotropic direction.

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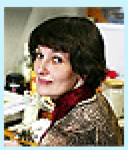

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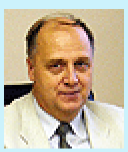

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Monday, 19 July, 2021

***S5.1* (16:00 – 17:30)** **Chair**: Sergey Stremoukhov (Russia)

16:00 – 16:20 J M Vasiljević (Institute of Physics, Belgrade, Serbia), A Zannotti (Institute of Applied Physics and Center for Nonlinear Science (CeNoS), Munster, Germany), D V Timotijević (Institute for Multidisciplinary Research, Belgrade, Serbia), C Denz (Institute of Applied Physics and Center for Nonlinear Science (CeNoS), Munster, Germany), D .M Jović Savić (Institute of Physics, Belgrade, Serbia)
Twisted Photonic Lattices Created by Elliptical Mathieu Beams Abstract

16:20 – 16:35 D H G Espinosa (School of Electrical Engineerig and Computer Science, University of Ottawa, Ottawa, Canada), S R Harrigan (Department of Physics, University of Ottawa, Ottawa, Canada), K M Awan (Stewart Blusson Quantum Matter Institute, University of British Columbia, Vancouver, Canada), P Rasekh (School of Electrical Engineerig and Computer

Twisted Photonic Lattices Created by Elliptical Mathieu Beams

J M Vasiljević[1], A Zannotti[2], D V Timotijević[3], C Denz[2], and D .M Jović Savić[1]

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Nondiffracting beams are highly applicable in optics, photonics, and atom physics, peculiar because their transverse intensity distributions propagate unchanged for hundreds of diffraction lengths and allow the creation 1D and 2D photonic lattices in photosensitive media[1]. Four different fundamental families of propagation invariant light fields exist, distinguish in the underlying real space coordinate system: Discrete, Bessel, Weber, and Mathieu nondiffracting beams [2-5]. *Mathieu beams* are the solution of the Helmholtz equation in elliptic cylindrical coordinates [5-7], therefore they are the best suited to address physical effects in elliptical coordinates. Mathieu beams are classified according to their symmetry properties as even and odd. Their transverse discrete intensity distributions can be shaped by their order and an ellipticity parameter. These real-valued beams are characterized by only discrete spatial phase distributions. By complex superposition of appropriate even and odd Mathieu beams, *elliptical Mathieu beams* are obtained, with remarkable continuously modulated spatial phase distributions that act as orbital angular momenta, related with transverse energy flow [8].

Experimentally and numerically, we investigated linear and nonlinear self-action of elliptical Mathieu beams in a photorefractive SBN crystal [8]. Linear propagation of elliptic Mathieu beams enables a nondiffracting transverse intensity distribution with transverse energy redistribution along elliptic paths compensated in each point. In contrast, their nonlinear self-action in SBN breaks this sensitive equilibrium and leads to the formation of high-intensity filaments, which rotate in the direction determined by the energy flow. We show that such filamentation depends on the strength of the nonlinearity and the structure size of used Mathieu beams. We investigate the nonlinear propagation of such refractive index formations in SBN crystal and show they are convenient as lattice-writing light to optical induction of two-dimensional chiral twisted photonic refractive index structures with tunable ellipticity. This study provides considerably advancing the field of chiral light and photonic structures since we demonstrated that elliptical Mathieu beams are suitable for the fabrication of two-dimensional photonic lattices with elliptic trajectories by optical induction technique.

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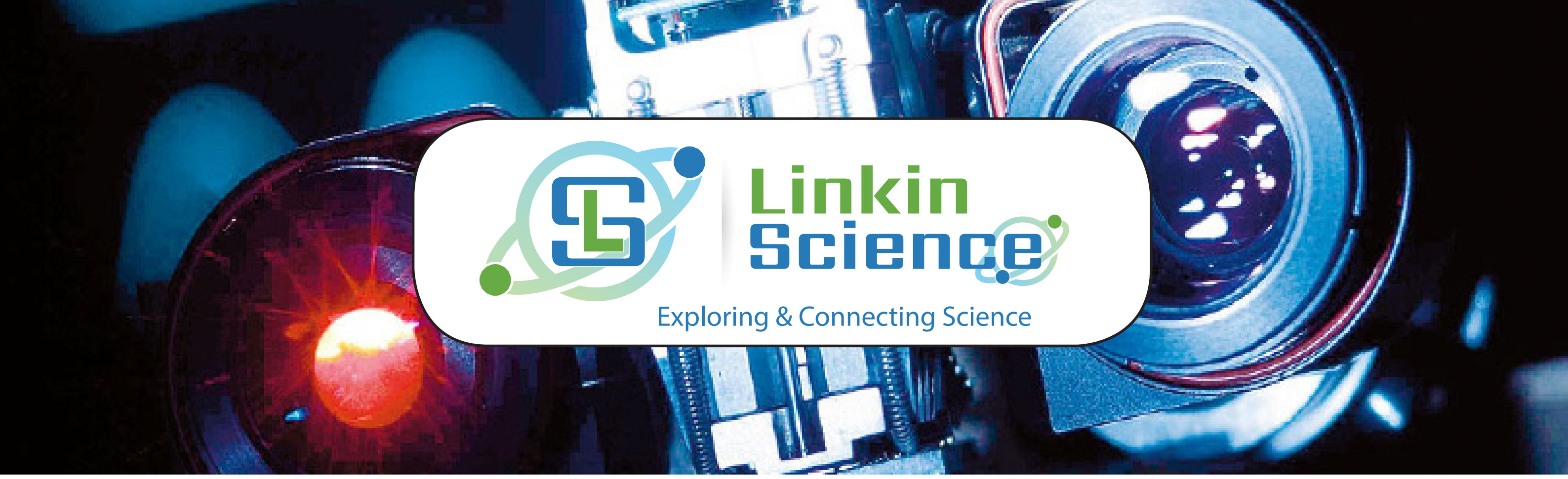

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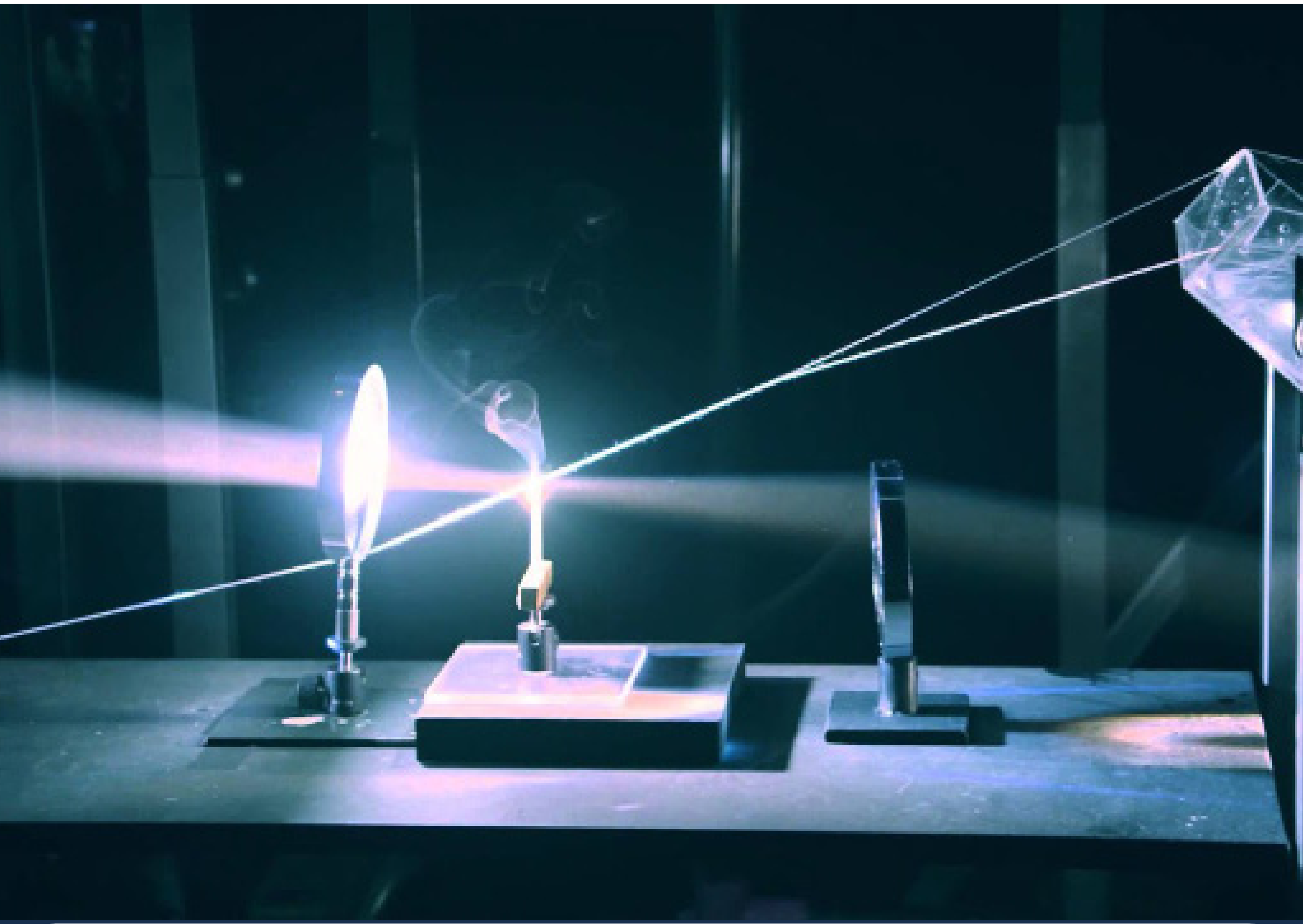

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Experimental realization of chiral photonic lattices

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Nondiffracting beams find their applications in optics, photonics, and atom physics. Particularly, their transverse intensity distribution propagates unchanged for hundreds of diffraction lengths, consequently allowing the creation of 1D and 2D photonic lattices with nondiffracting beams in photosensitive media. Low diffraction and robustness of nondiffracting beams make them appropriate for deployment in free-space wireless communications, optical interconnections, long-distance laser machining, optical tweezers, biology, surgery, etc. There are four different propagation invariant light fields: Plane waves, Bessel, Weber, and Mathieu nondiffracting beams. Mathieu beams are the solution of the Helmholtz equation in elliptic cylindrical coordinates, therefore being the best suited to address physical effects described in elliptical coordinates. They are classified according to their symmetry properties as even and odd Mathieu beams. Elliptical Mathieu beams are obtained as a complex superposition of appropriate even and odd Mathieu beams, with remarkable continuously-modulated spatial phase distributions that create orbital angular momenta, related with a transverse energy flow. Their transverse intensity distribution can be shaped by their order and the parameter of ellipticity.

We study linear characteristics and nonlinear self-action of elliptical Mathieu beams in a photorefractive crystal experimentally and numerically. Linear propagation of such beams validates a nondiffracting transverse intensity distribution with transverse energy redistribution along elliptic paths compensated in each point. In contrast, their nonlinear self-action breaks this sensitive equilibrium and leads to the formation of high-intensity filaments, which rotate in the direction determined by the energy flow. Our study advances the field of chiral light and photonic structures by pointing to the suitability of Elliptical Mathieu beams as light patterns for optical induction of chirally twisted photonic lattices with elliptic envelopes in the transverse plane. The order of used Elliptical Mathieu beam determines the number of created chiral waveguides, where the waveguides slopes can be manipulated by changing the nonlinearity strength or the structure size of the used beam.

Biography

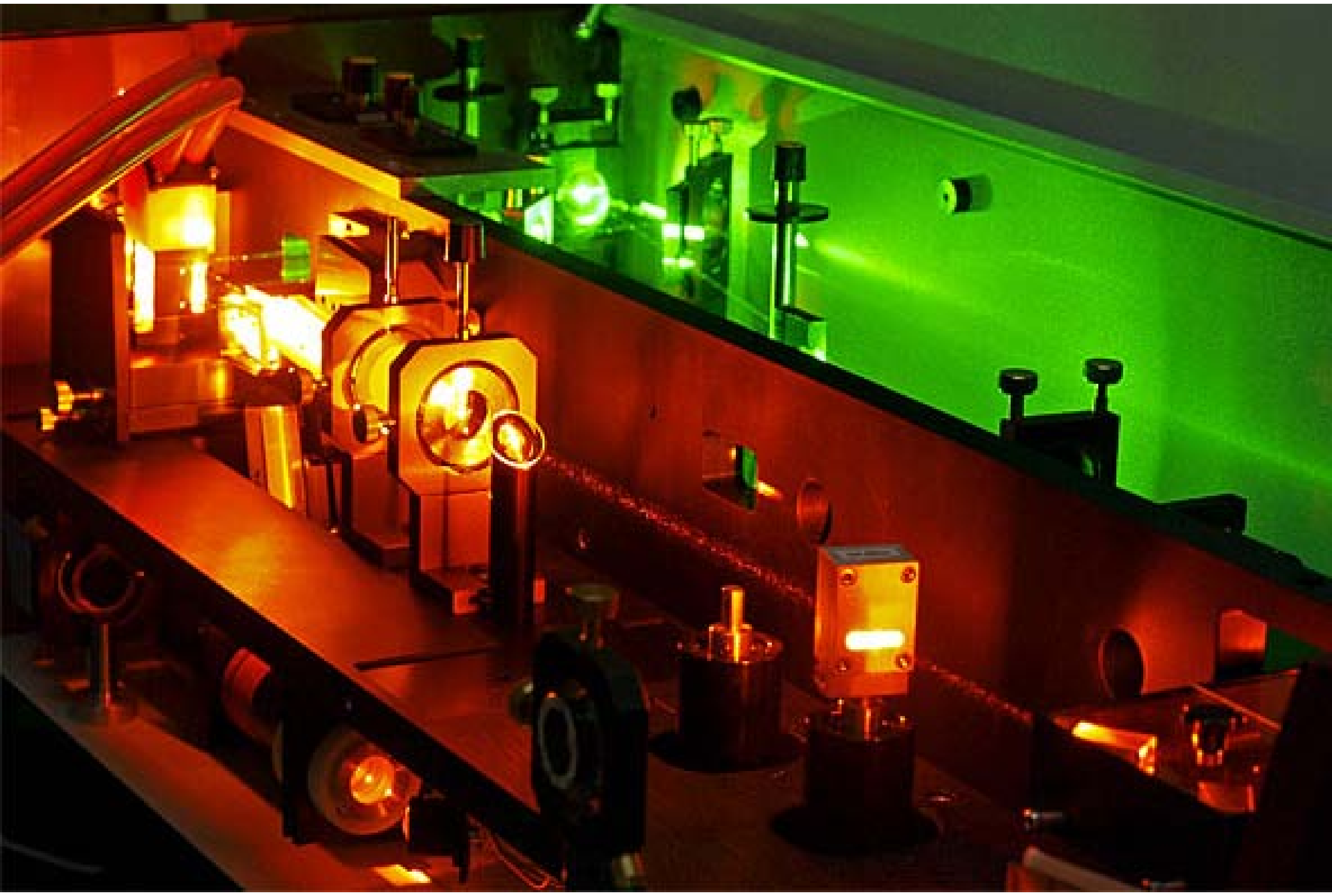
Dr. Jadranka M. Vasiljević received her Ph.D. degree in 2020 at the Faculty of Physics at Belgrade University, Serbia. Since 2015 she joined the research group of Dr. DraganaJovićSavić at the Institute of Physics, University of Belgrade, Serbia. She is part of the Laboratory for Nonlinear Photonics at the Institute of Physics, University of Belgrade, Serbia. Her research area is Nonlinear Optics and Photonics. Currently, research interests are nondiffracting beams, in particular, based on the family of Mathieu beams. She is studying the realization of two-dimensional dynamical structures in the photorefractive medium by Mathieu beams, aperiodic and complex structures with Mathieu beams, and investigating phenomena correlated with light propagation in Mathieu photonic lattices.

Notes:

Conference Program

3rd Edition of Virtual Online Conference on Advancements of Lasers, Optics and Photonics

September 01-02, 2021



HOSTING ORGANISATION

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Conference Program

DAY 1: Wednesday 1st September 2021 EDT Time Zone

09:00-09:30	Opening Session Welcome Address
09:30-10:05 **Keynote**	**Photonics in Radar and LiDAR Systems** Paulo Pereira Monteiro, *University of Aveiro, Portugal* (Local Time: 14:30)
10:05-10:40 **Keynote**	**Creating Materials with a desired Refraction Coefficient** Alexander G. Ramm, *Kansas State University, USA* (Local Time: 09:05)
10:40-11:15 **Keynote**	**Cryogenic Laser Technology** David C Brown, *Fellow of The Optical Society of America, Advanced Pho tonic Sciences, USA* (Local Time: 10:40)
11:15-11:35	**Break Out Session/ Networking Lounge 20 mins**
11:35-12:00 **Oral Session**	**Multi-Electron Trojan Wave Packets in the Circularly Polarized and the Magnetic Fields on the Multi-layer Langmuir Type (1) Trajectories in Helium Atoms and Quantum Dots** Matt Kalinski, *Utah State University, USA* (Local Time: 09:35)
12:00-12:25 **Oral Session**	**Application of lasers in phosphor material development for solid-state lighting** Hisham Menkara, *PhosphorTech Corporation, USA* (Local Time: 12:00)
12:25-12:50 **Oral Session**	**Experimental realization of chiral photonic lattices** Jadranka Vasiljevic, *University of Belgrade, Serbia* (Local Time: 18:25)
12:50-13:15 **Oral Session**	**Application of ultra-short pulse lasers in the restauration of historical stained-glass** Luis A Angurel, *University of Zaragoza, Spain* (Local Time: 18:50)
13:15-13:35	**Break Out Session/ Networking Lounge 20 mins**
13:35-13:50 **Poster Presentation**	**LED Photobiomodulation therapy combined with biomaterial as a scaffold promotes better bone quality in the dental alveolus in an experimental extraction model** Vanessa Dalapria, *UNINOVE- Nove de Julho University, Brazil* (Local Time: 14:35)

Oral

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Certificate of Recognition

Linkin Science and Scientific Committee of Advancements Of Laser, Optics & Photonics 2021

Wish to thank

Prof/Dr/Ms. Jadranka Vasiljevic

University of Belgrade, Serbia

for phenomenal and worthy Oral presentation on

Experimental realization of chiral photonic lattices

at the 3rd Edition of Virtual Conference On Advancements Of Laser, Optics & Photonics

held during September 01-02, 2021

Laser, Optics & Photonics 2021 Scientific Committee

David C. Brown

David C Brown

Advanced Photonic Sciences, USA

Subject **Share your research on | 10-11 Feb, 2023**
From Laser, optics and photonics
Sender Laser, optics and photonics
To Jadranka
Date 17.10.2022 08:28

Dear Dr. Jadranka M Vasiljević,

Wishes from Sciwide webinars.

We extend our immense honor to invite you as a Keynote Speaker for the upcoming webinar on "4th Edition of Laser, Optics and Photonics Virtual", which is scheduled during 10-11 Feb 2023 from GMT 07:00 to 12:00.

This virtual conference holds special promise to discuss the future discoveries. The colossal and enthusiastic presence of young and brilliant researchers, scientists, academicians, opticians, laser experts, healthcare professionals, business delegates and exceptional student communities adds to the excitement of the two-days virtual congress which provides an insight

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We look forward meeting you in Virtually.

Thanks & Regards,
Rama. G |Webinar Secretary
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SCIWIDE WEBINARS

Final Program

4[Th] Edition of Laser, Optics and Photonics Virtual

February 10, 2023

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Webinar Timings	Speakers Timings	
07:00 – 07:10		Introduction

Keynote Sessions-1

07:10 – 07:45	10:10 – 10:45	Title: Shape Memory Effect and Atomic Scale Aspects of Reversibility in Shape Memory Alloys **Osman Adiguzel, Firat University, Turkey.**
07:45 – 08:20	15:45 – 16:20	Title: Recent advance of laser lipolysis **Bin Chen, Xi'an Jiaotong University, China.**
08:20 – 08:55	17:20 – 17:55	Title: Plasmonics and Plasmonic Metamaterials Using Random Metal Nanostructures for High Efficiency Light-Emitting Devices **Koichi Okamoto, Osaka Metropolitan University, Japan.**
08:55 – 09:30	19:55 – 20:30	Title: Nucleation and Dynamics of Chiral Spin Textures in Topological Materials **Oleg Tretiakov, University of New South Wales, Australia.**
09:30 – 10:05	10:30 – 11:05	Title: Composite photonic structures: generation and light propagation in them **Jadranka Vasiljević, Institute of Physics, Serbia.**
10:05 – 10:40	18:05 – 18:40	Title: Photoalignment and photopatterning based on nanosize azodye layers for new liquid crystal display and photonics devices **Vladimir Chigrinov, Hong Kong University of Science and Technology, Hong Kong.**

Invited Sessions

SCIWIDE WEBINARS

V-LASER2023 wish to thank

Prof/Dr/Mr/Ms. *Jadranka Vasiljević*

Institute of Physics, Serbia

for his/her worthy Keynote presentation at

"4th Edition of Laser, Optics and Photonics Virtual"

held on February 10, 2023

Prof. Bin Chen

Xi'an Jiaotong University, China

Composite photonic structures: generation and light propagation in them

J. M. Vasiljević[1], D. V. Timotijević[2], D. M. Jović Savić[1]

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Institute/ Organization: Institute of Physics, Belgrade
Country: Serbia
Presentation Category: Oral Presentation

Abstract: Nondiffracting beams are highly applicable in optics, photonics, and atom physics, because their transverse intensity distributions propagate unchanged for hundreds of diffraction lengths and allow the creation of 1D and 2D photonic lattices in photosensitive media [1]. Depending on coordinate system four fundamental families of propagation invariant light fields exist: Discrete, Bessel, Weber, and Mathieu nondiffracting beams [2-4]. Mathieu beams are the solution of the Helmholtz equation in elliptic cylindrical coordinates [4-6]. According to their symmetry properties they are classified as even and odd. Their order and an ellipticity parameter can shape their transverse discrete intensity distributions.

Deterministic aperiodic or complex photonic structures are at the intersection between periodic and disorder crystal structures. In optics, the properties of such structures have been studied, as appealing structures for the control and manipulation of light. Various aperiodic and quasiperiodic photonic structures are realized artificially and light propagation is investigated in them. We experimentally realized the aperiodic photonic structures with controllable complexity, created by different combinations of Mathieu beams, by splicing them in both transverse dimensions in different offsets [7] and we studied light localization in them. In such lattice, light expansion is hindered in comparison to periodic lattice and nonlinear light localization is demonstrated [8].

Furthermore, we numerically modeled two different randomization methods of photonic lattices [9]. We compare the results of light propagation in disordered aperiodic Mathieu lattices and disordered periodic lattices. In disordered aperiodic lattice disorder always enhances light transport for both methods, contrary to the disordered periodic lattice. For the highest disorder levels, we detect Anderson localization for both methods and both disordered lattices. More pronounced localization is observed for disordered aperiodic lattices.

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[9] D. V. Timotijević, J. M. Vasiljević, and D. M. Jović Savić. Opt. Express 30(5), 7210 (2022).

Biography of Presenting Author:

Dr. Jadranka M. Vasiljević received her Ph.D. degree in 2020 at the Faculty of Physics at Belgrade University, Serbia. Since 2015 she joined Laboratory for Nonlinear Photonics at the Institute of Physics, University of Belgrade, Serbia. Since 2022 Jadranka is member of project supported by the Science Fund of the Republic of Serbia, program IDEAS, 7714356 – **CompsLight**. Her research area is Nonlinear Optics and Photonics. She is studying realization of two-dimensional dynamical structures in the photorefractive medium by Mathieu beams; realization of aperiodic and complex structures with Mathieu beams; investigation of phenomena correlated with light propagation in Mathieu photonic lattices.

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