

Нелинейная локализация света в топологических и динамических волноводных структурах

По материалам публикаций

Архипова А.А., Компанец В.О., Карташов Я.В., Чекалин С.В., Задков В.Н.

совместно с Центром квантовых технологий МГУ и теоретическими группами из зарубежных университетов

Институт спектроскопии РАН, г. Москва, г. Троицк, 2023



- Введение
- Пространственная локализация в топологических волноводных массивах
 - Observation of Nonlinearity-Controlled Switching of Topological Edge States
 - Observation of Edge Solitons in Topological Trimer Arrays
- Пространственная локализация в двумерных волноводных массивах
 - Observation of Rotation-Induced Light Localization in Waveguide Arrays
 - Observation of Linear and Nonlinear Light Localization at the Edges of Moire Arrays

➤ Введение

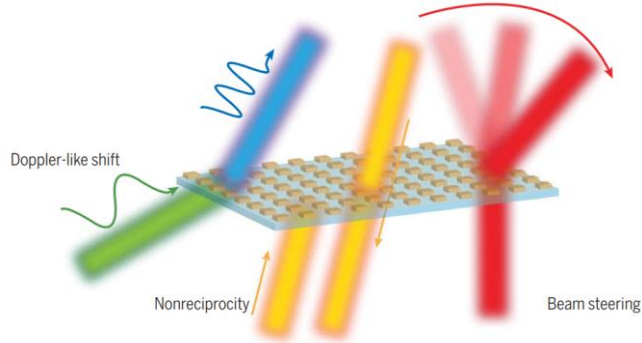
➤ Пространственная локализация в топологических волноводных массивах

- Observation of Nonlinearity-Controlled Switching of Topological Edge States
- Observation of Edge Solitons in Topological Trimer Arrays

➤ Пространственная локализация в двумерных волноводных массивах

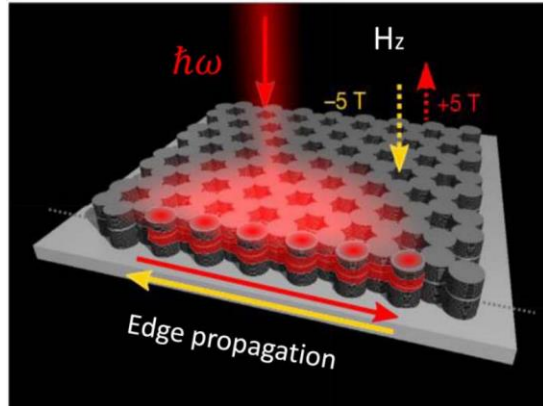
- Observation of Rotation-Induced Light Localization in Waveguide Arrays
- Observation of Linear and Nonlinear Light Localization at the Edges of Moire Arrays

Metasurfaces



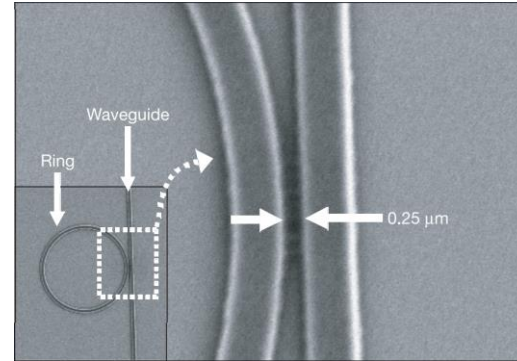
Shaltout, A. M., Shalaev, V. M. & Brongersma, M. L. *Spatiotemporal light control with active metasurfaces. Science* 364, eaat3100 (2019)

Microcavity polaritons



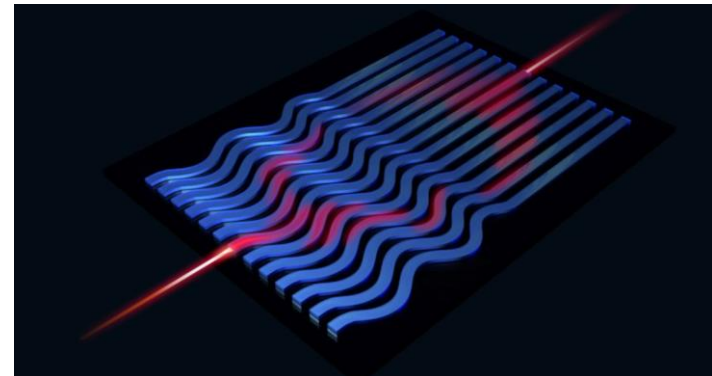
S. Klemmt et al., "Exciton-polariton topological insulator," *Nature* 562, 552 (2018)

Ring resonators



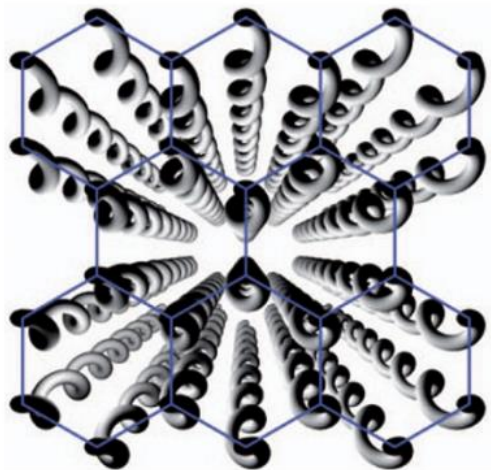
V. R. Almeida, C. A. Barrios, R. R. Panepucci, and M. Lipson, "All-optical control of light on a silicon chip," *Nature*, vol. 431, pp. 1081-1084 (2004)

Waveguide arrays

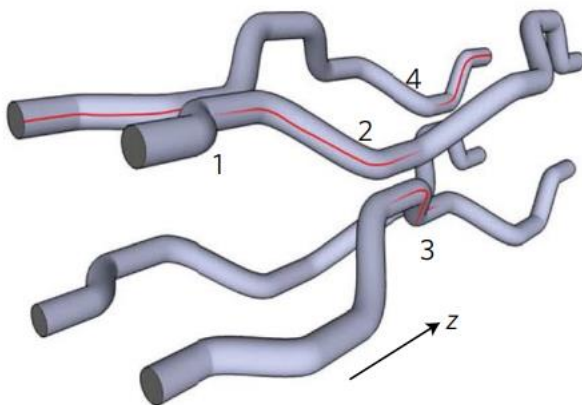


W. Song et al., "Subwavelength self-imaging in cascaded waveguide arrays," *Adv. Photonics* 2(3), 036001 (2020)

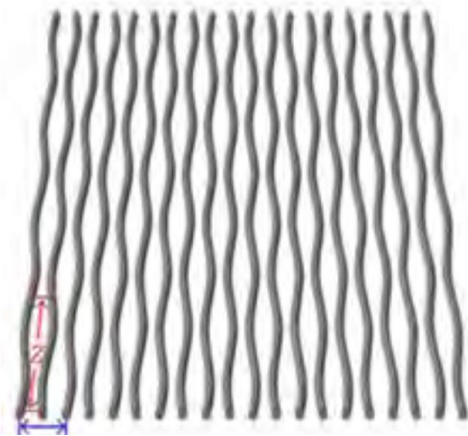
Введение



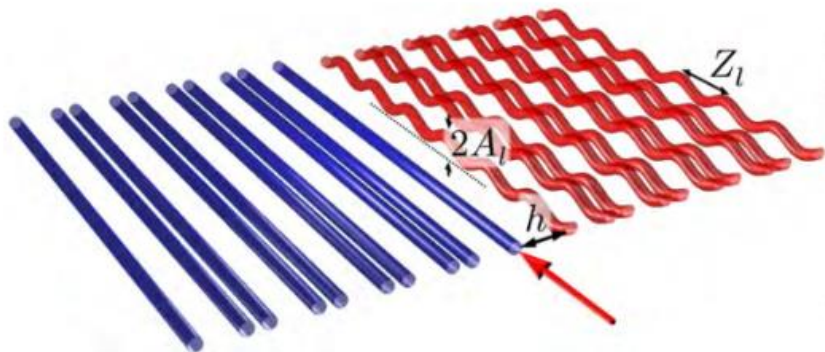
Rechtsman, M. C. et al. Photonic Floquet topological insulators. *Nature* 496, 196–200 (2013)



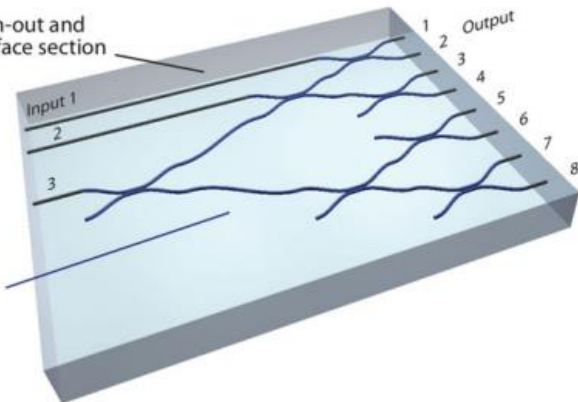
Mukherjee, S. et al. Experimental observation of anomalous topological edge modes in a slowly driven photonic lattice. *Nat. Commun.* 8, 13918 (2017).



Fan-out and interface section

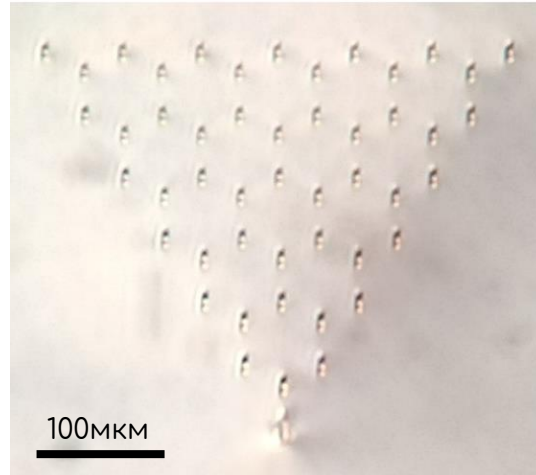
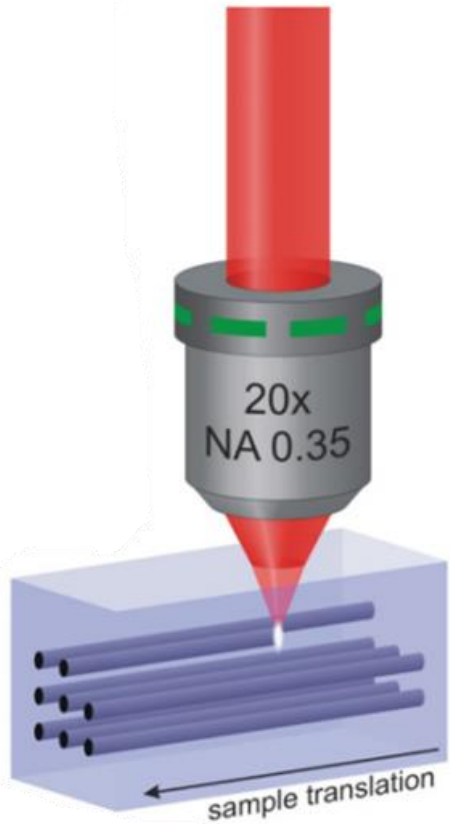


Functional section



Meany, T. et al. Laser written circuits for quantum photonics. *Laser Photon. Rev.* 9, 363–384 (2015)

Введение

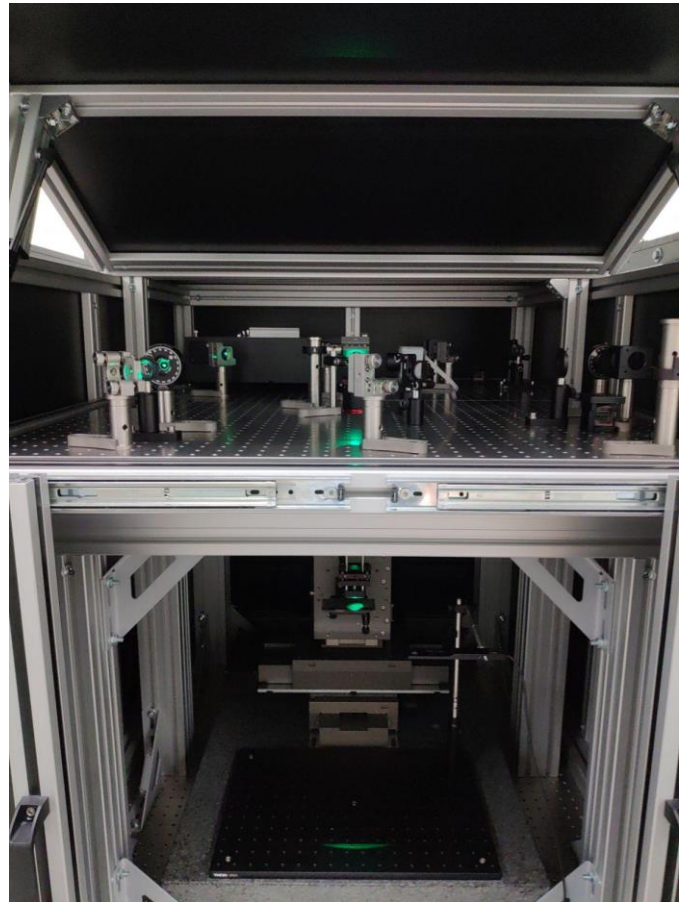


*Микрофотография торца
массива волноводов*

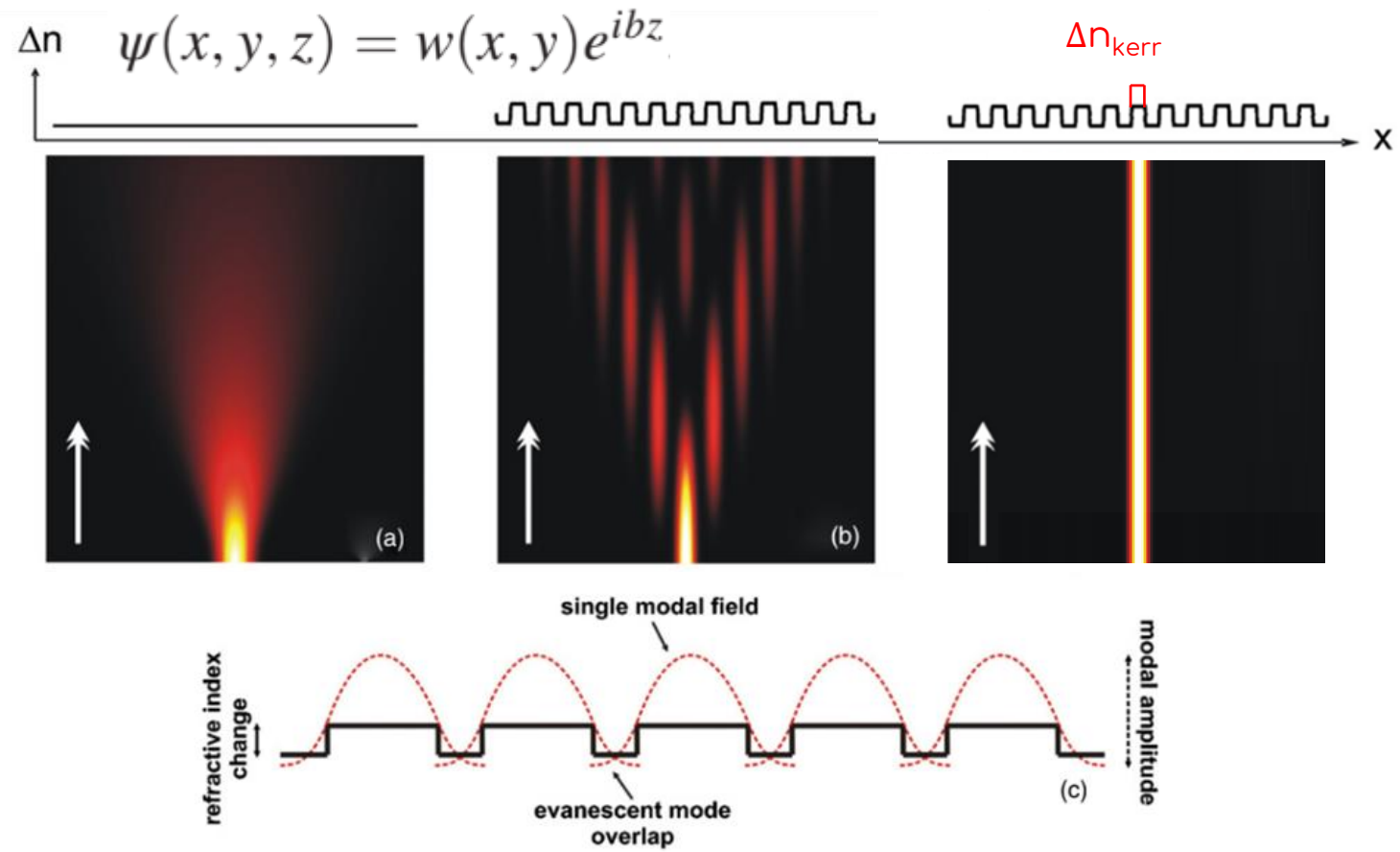


*Фотография 10см образца с тремя
волноводными массивами*

Szameit, A, and S. Nolte , "Discrete optics in femtosecond-laser written photonic structures," J. Phys. B 43 (16), 163001 (2010)



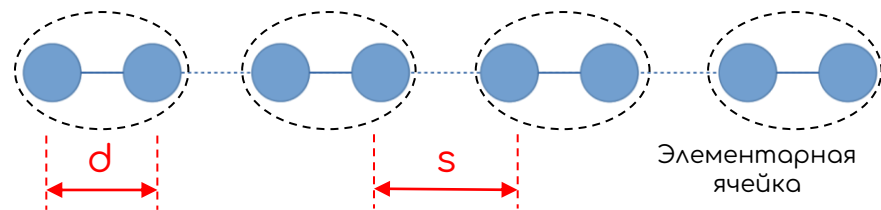
Система лазерной записи волноводов Центра квантовых технологий МГУ



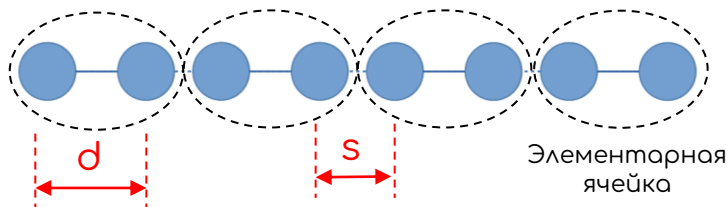
- Введение
- **Пространственная локализация в топологических волноводных массивах**
 - Observation of Nonlinearity-Controlled Switching of Topological Edge States
 - Observation of Edge Solitons in Topological Trimer Arrays
- **Пространственная локализация в двумерных волноводных массивах**
 - Observation of Rotation-Induced Light Localization in Waveguide Arrays
 - Observation of Linear and Nonlinear Light Localization at the Edges of Moire Arrays

Модель Су-Шриффера-Хигера

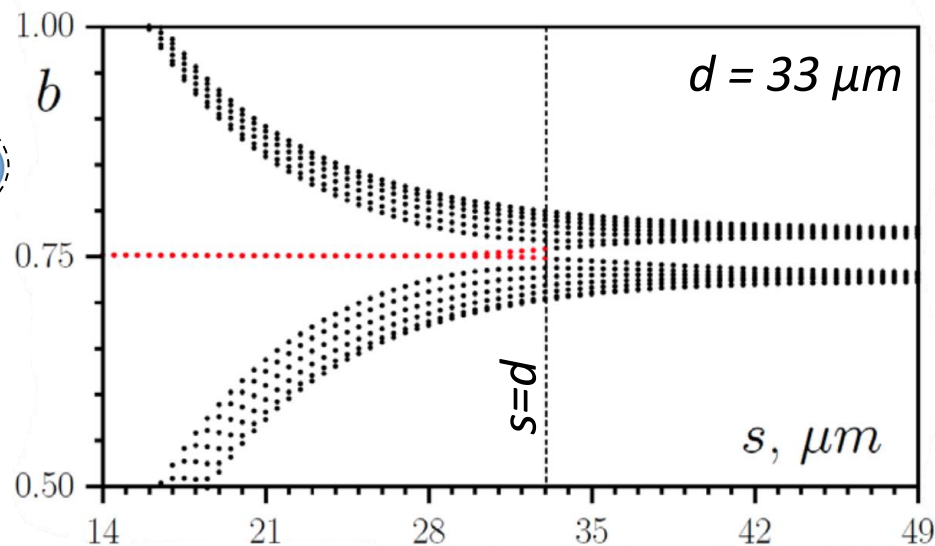
1. $s > d$ - нетопологический



2. $s < d$ - топологический

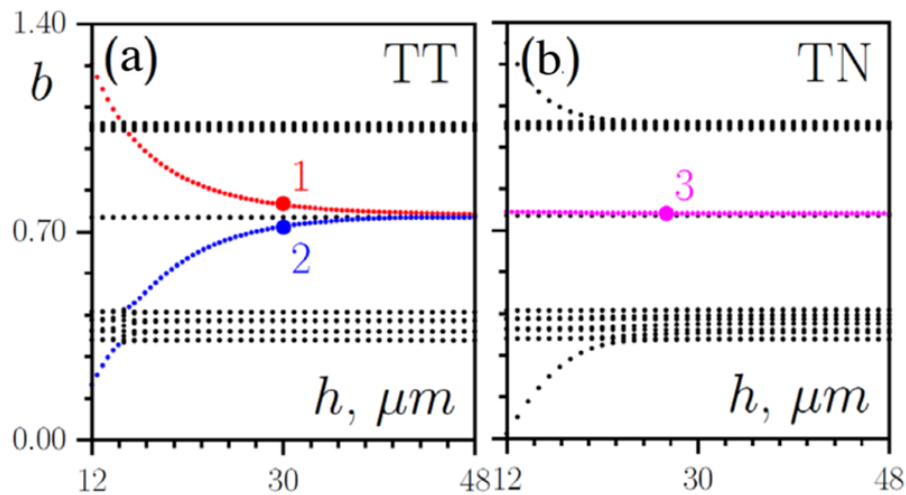
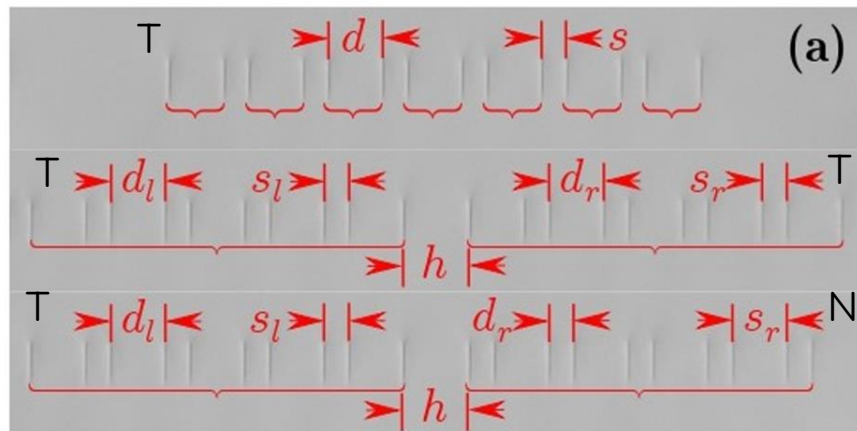


$$\psi(x, y, z) = w(x, y)e^{ibz}$$

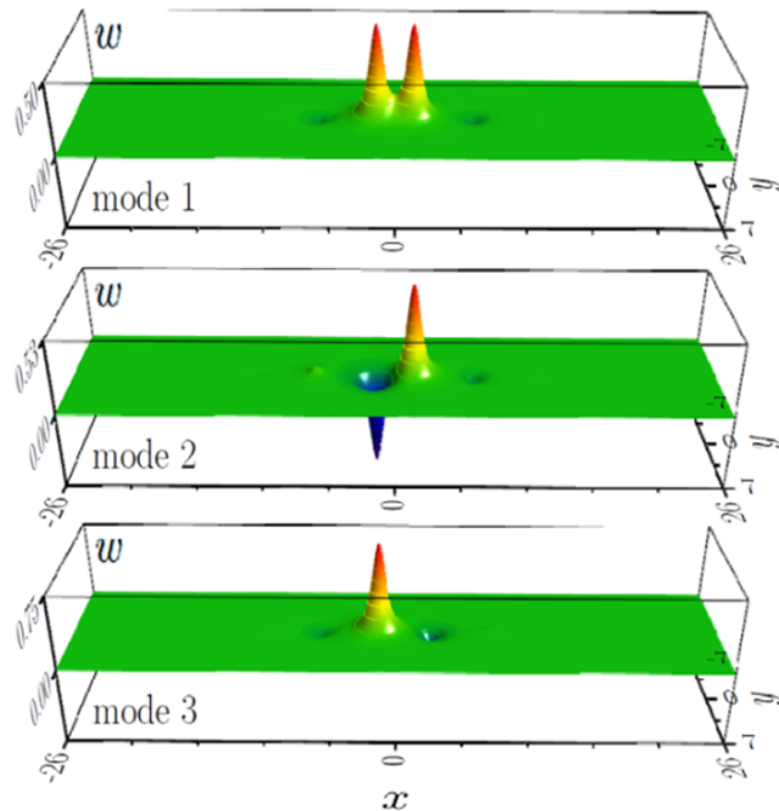


- Введение
- Пространственная локализация в топологических волноводных массивах
 - Observation of Nonlinearity-Controlled Switching of Topological Edge States
 - Observation of Edge Solitons in Topological Trimer Arrays
- Пространственная локализация в двумерных волноводных массивах
 - Observation of Rotation-Induced Light Localization in Waveguide Arrays
 - Observation of Linear and Nonlinear Light Localization at the Edges of Moire Arrays

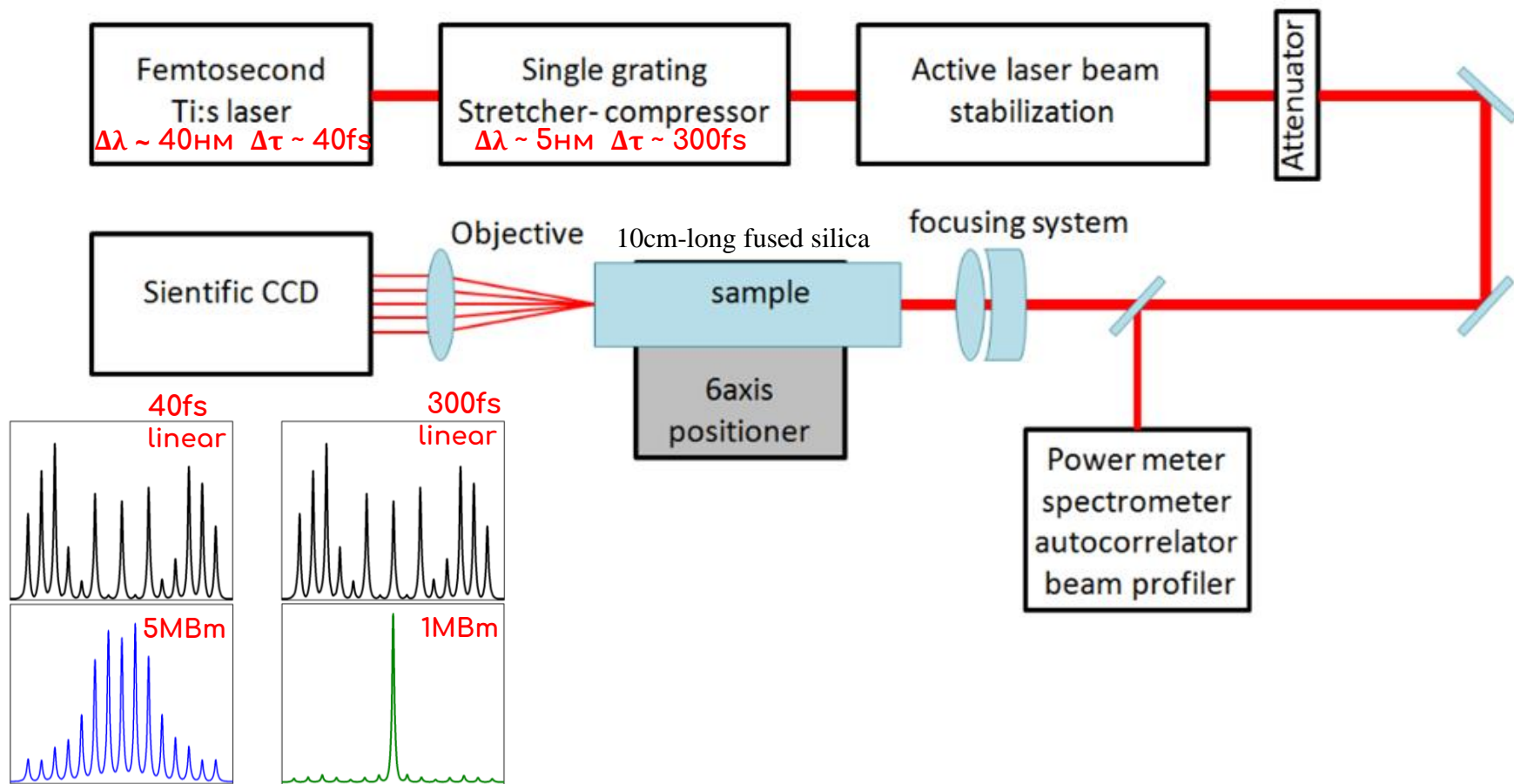
Nonlinearity-controlled switching of topological edge states



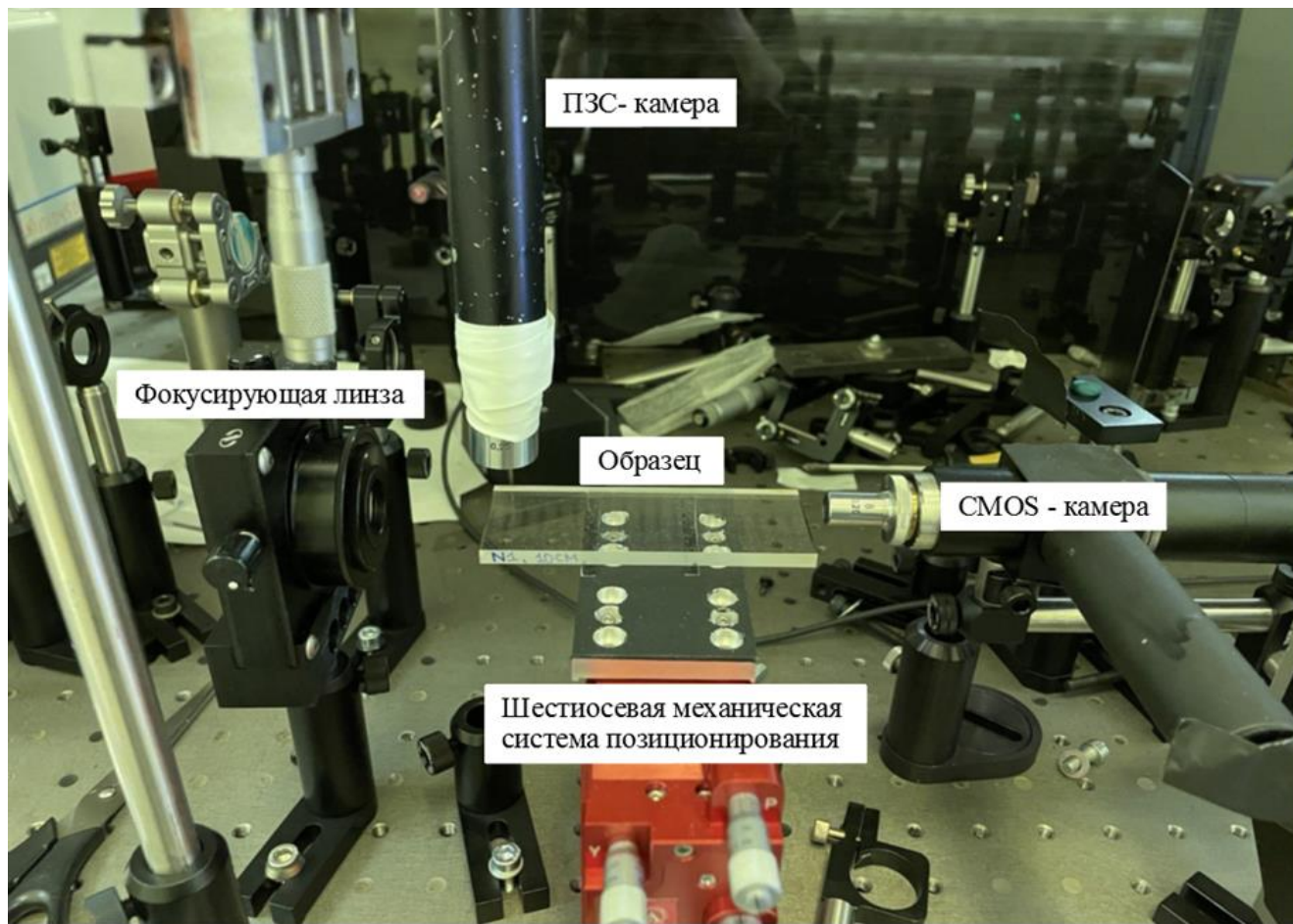
$$\psi(x, y, z) = w(x, y)e^{ibz}$$



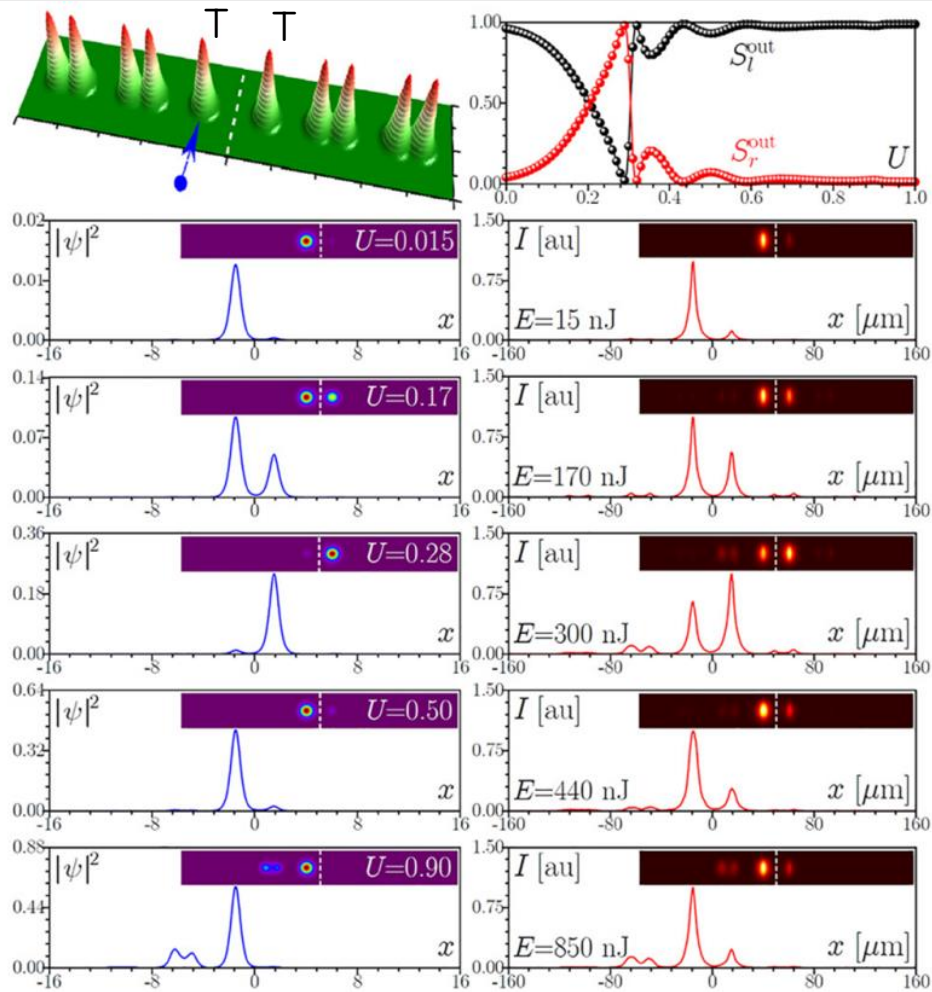
Nonlinearity-controlled switching of topological edge states



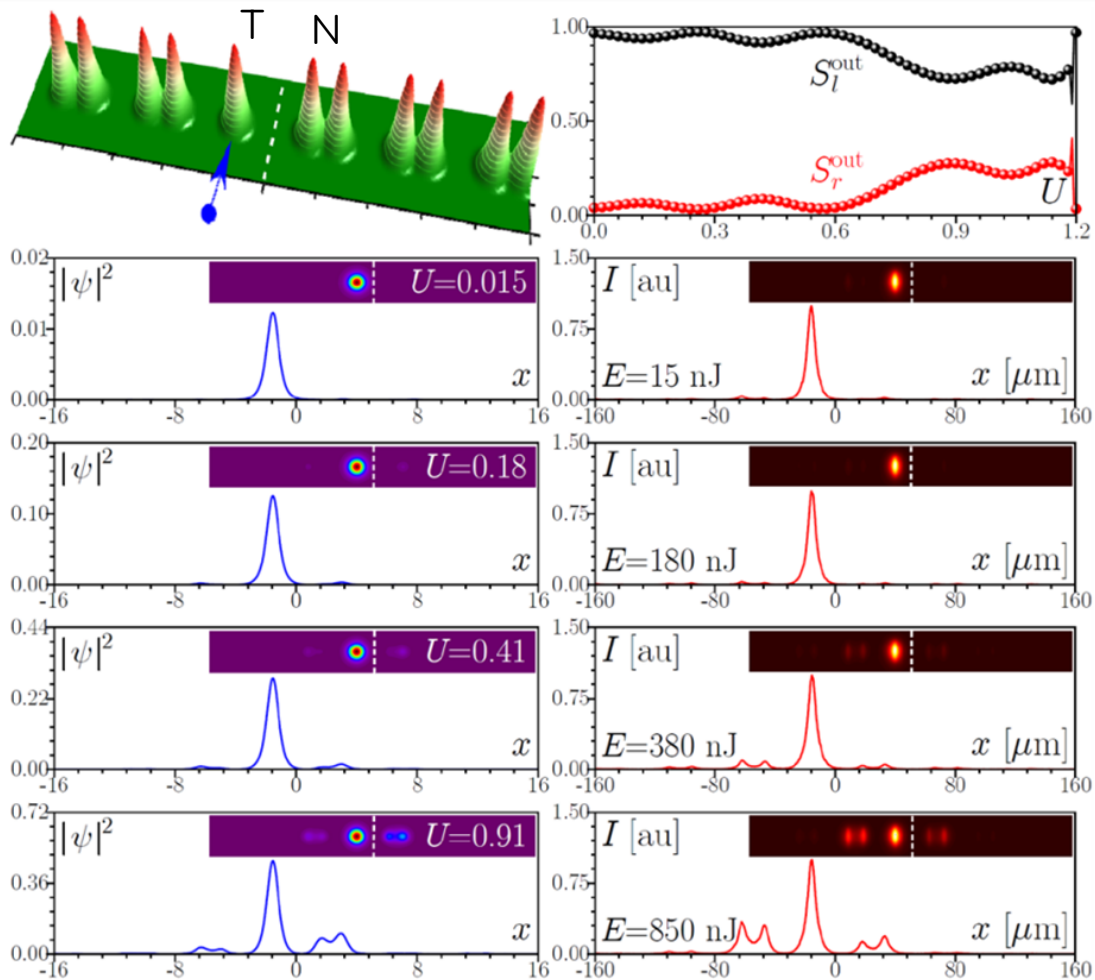
Nonlinearity-controlled switching of topological edge states



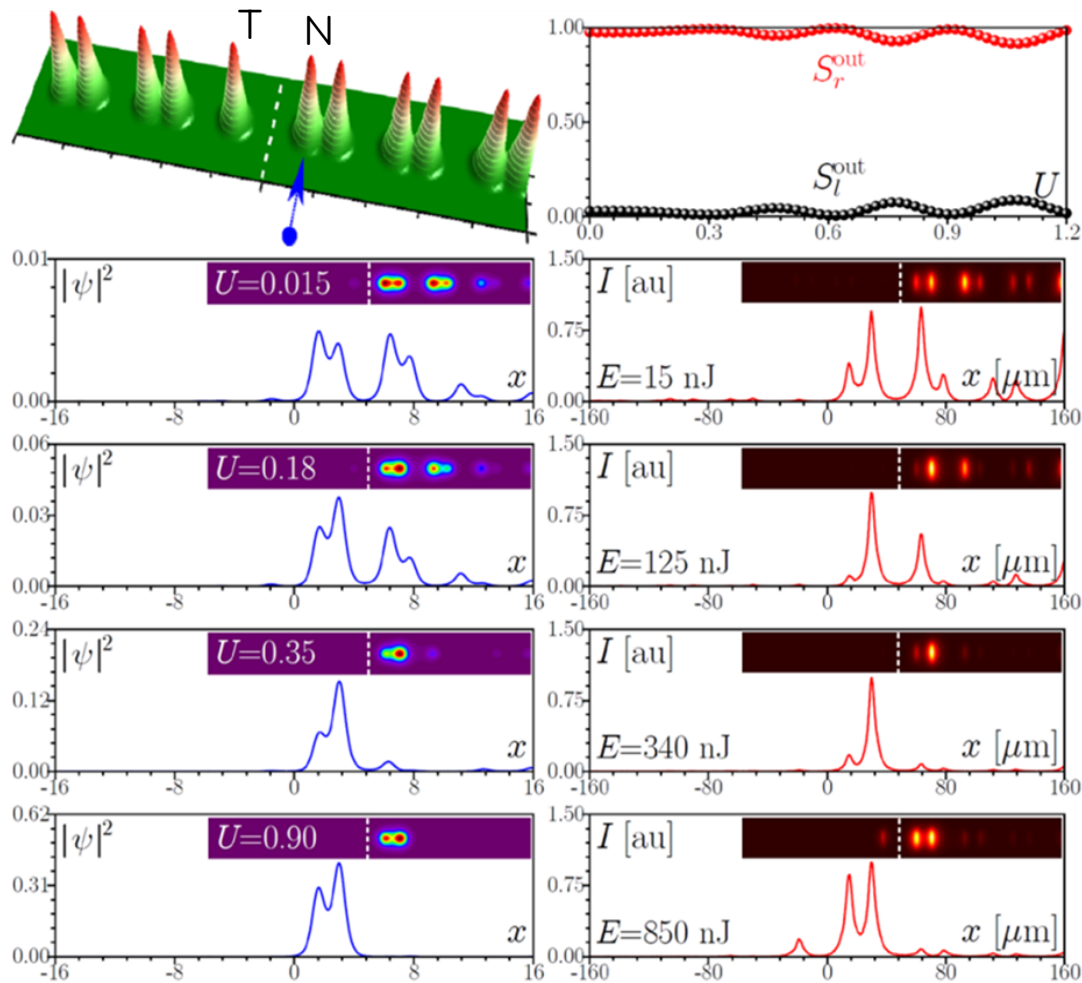
Nonlinearity-controlled switching of topological edge states



Nonlinearity-controlled switching of topological edge states



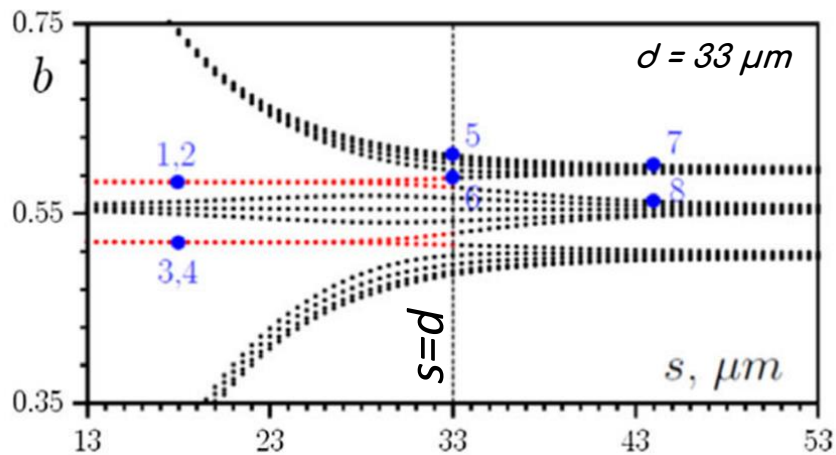
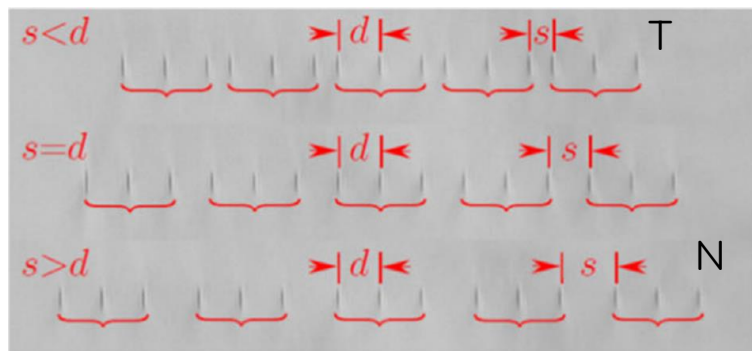
Nonlinearity-controlled switching of topological edge states



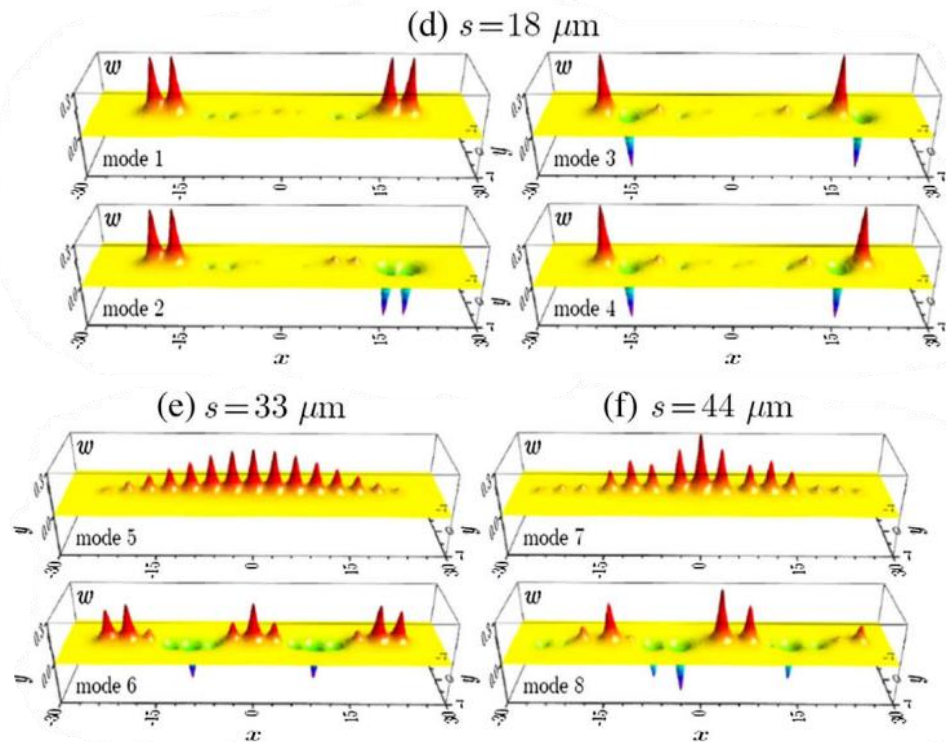
A. A. Arkhipova, S. K. Ivanov, S. A. Zhuravitskii, N. N. Skryabin, I. V. Dyakonov, A. A. Kalinkin, S. P. Kulik, V. O. Kompanets, S. V. Chekalin, Y. V. Kartashov and V. N. Zadkov, "Observation of nonlinearity-controlled switching of topological edge states", *Nanophotonics*; Vol 11, Issue 16, 3653–3662, 2022

- Введение
- Пространственная локализация в топологических волноводных массивах
 - Observation of Nonlinearity-Controlled Switching of Topological Edge States
 - Observation of Edge Solitons in Topological Trimer Arrays
- Пространственная локализация в двумерных волноводных массивах
 - Observation of Rotation-Induced Light Localization in Waveguide Arrays
 - Observation of Linear and Nonlinear Light Localization at the Edges of Moire Arrays

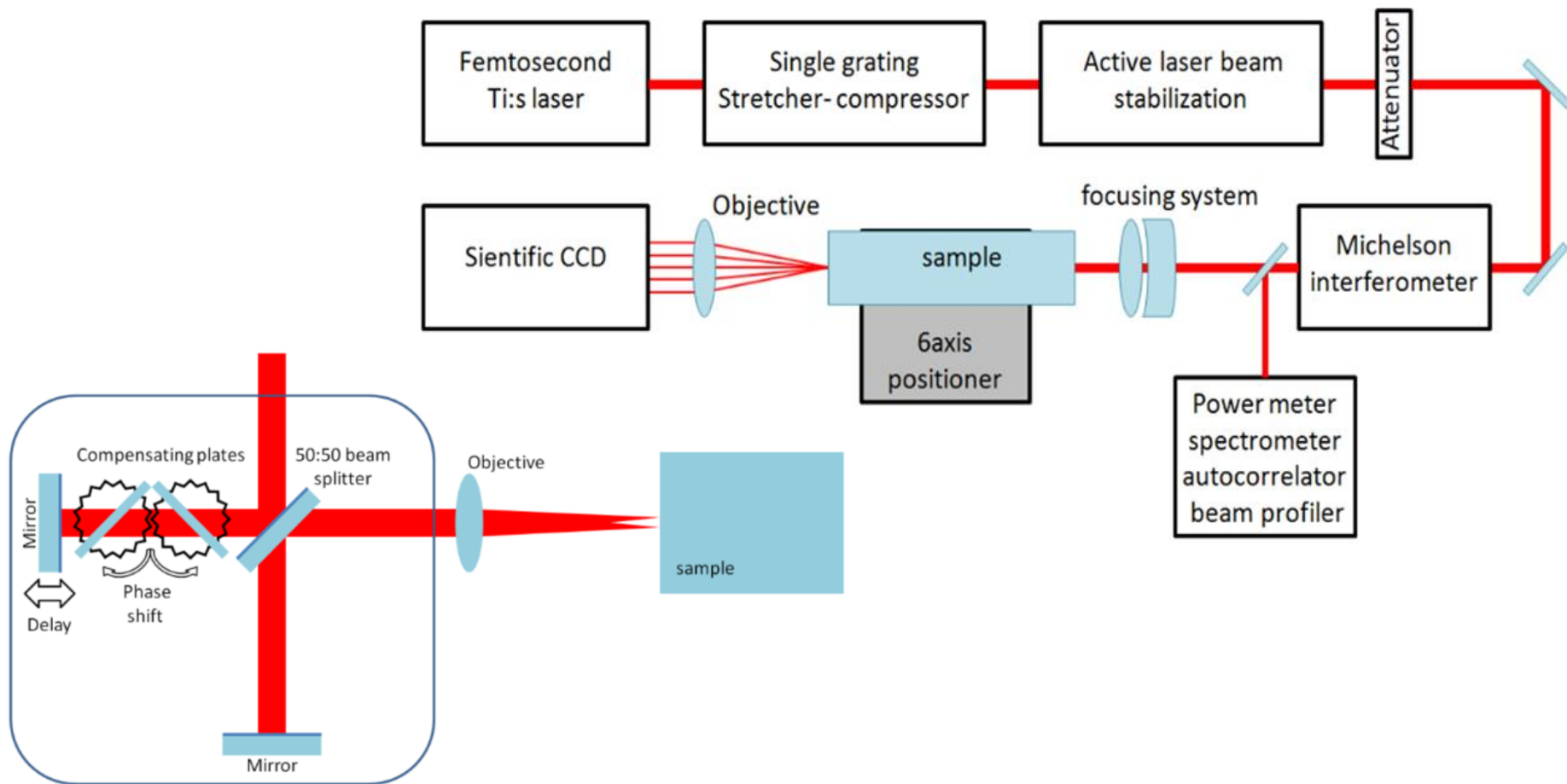
Edge Solitons in Topological Trimer Arrays



$$\psi(x, y, z) = w(x, y)e^{ibz}$$

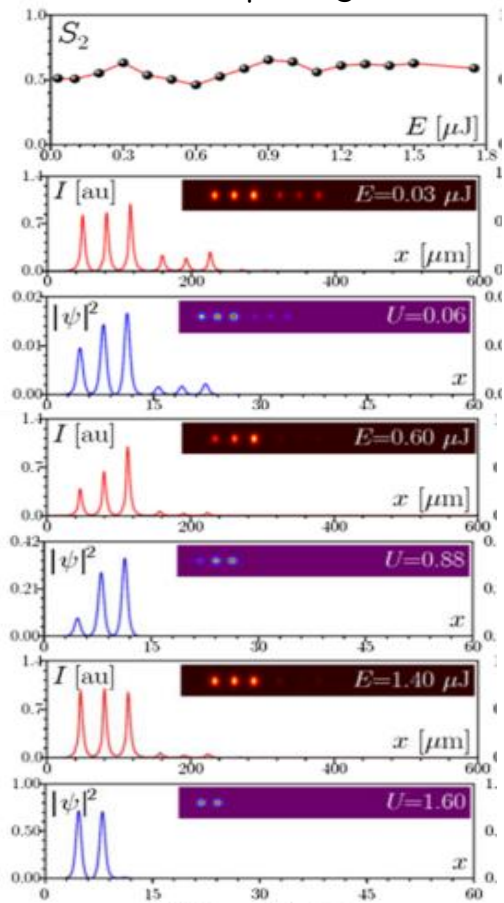


Edge Solitons in Topological Trimer Arrays



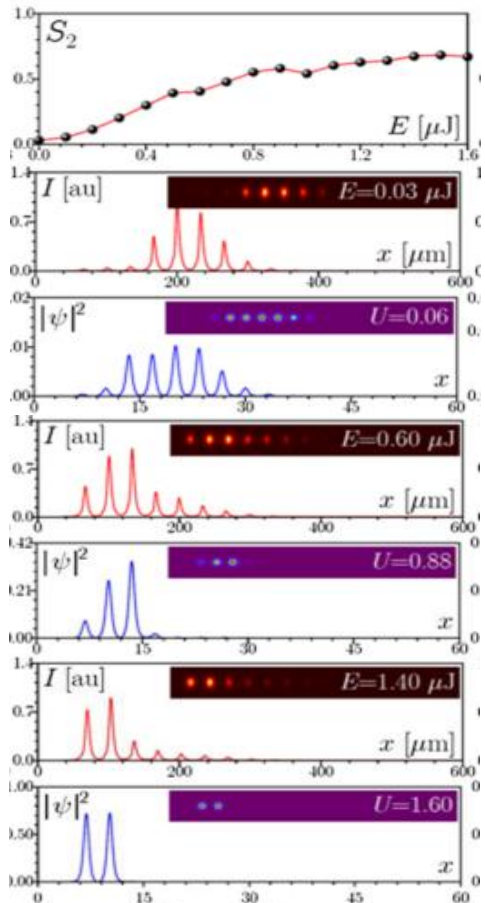
Edge Solitons in Topological Trimer Arrays

Nontopological



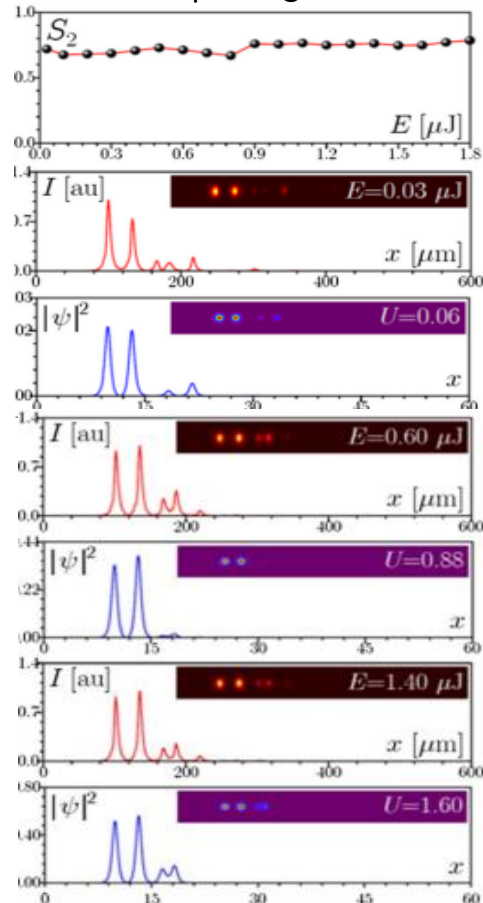
(a) $s = 44 \mu\text{m}$

Uniform



(b) $s = 33 \mu\text{m}$

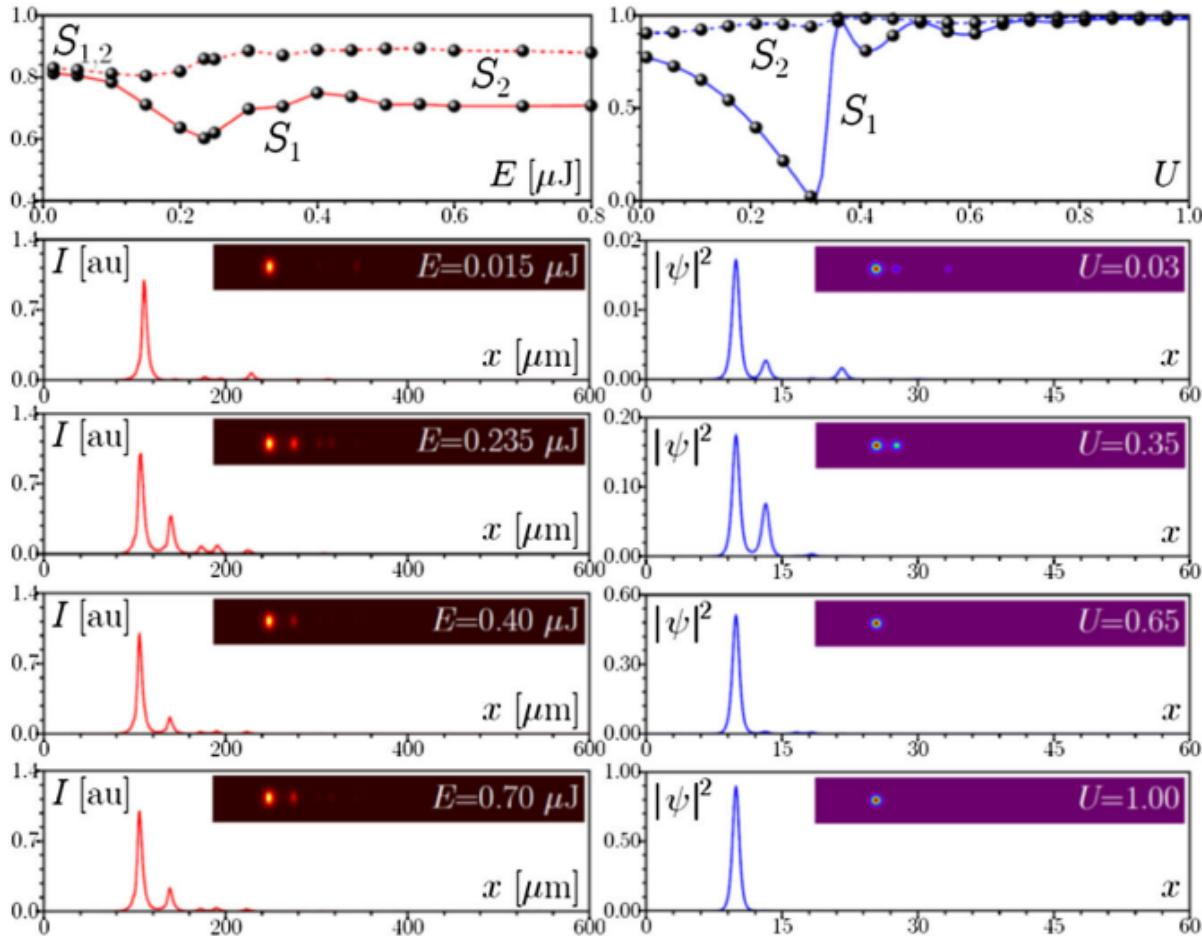
Topological



(c) $s = 18 \mu\text{m}$

Edge Solitons in Topological Trimer Arrays

Topological



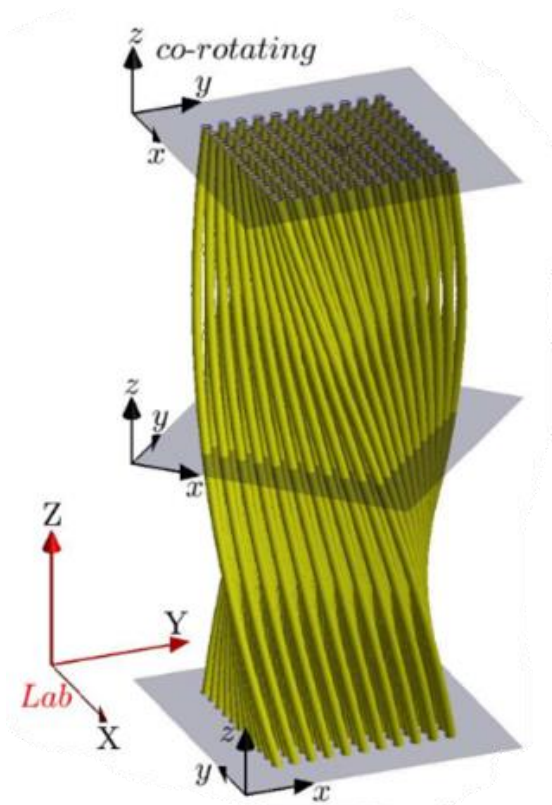
$s = 18 \mu\text{m}$

Y. V. Kartashov, A. A. Arkhipova, S. A. Zhuravitskii, N. N. Skryabin, I. V. Dyakonov, A. A. Kalinkin, S. P. Kulik, V. O. Kompanets, S. V. Chekalin, L. Torner, and V. N. Zadkov, "Observation of Edge Solitons in Topological Trimer Arrays", *Phys. Rev. Lett.* 128, 093901 (2022) «Editors' Suggestion»

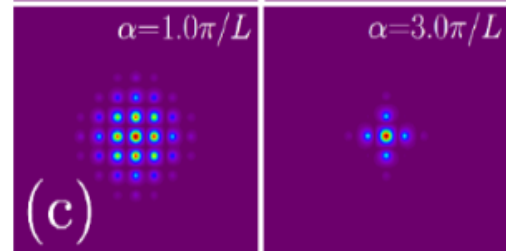
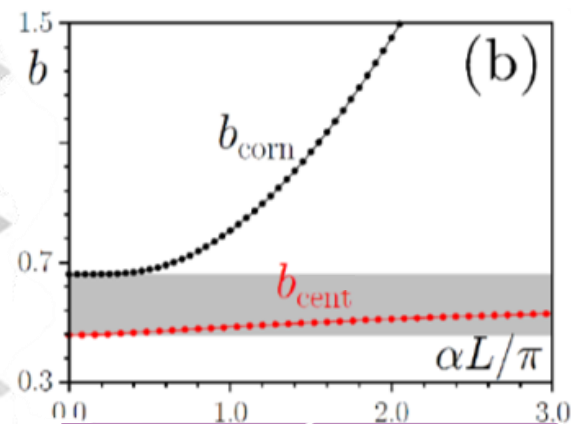
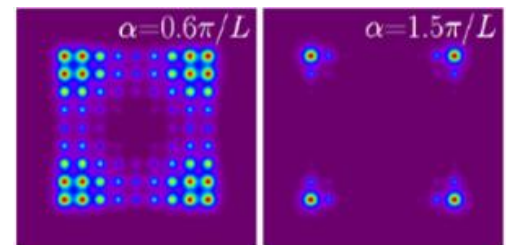
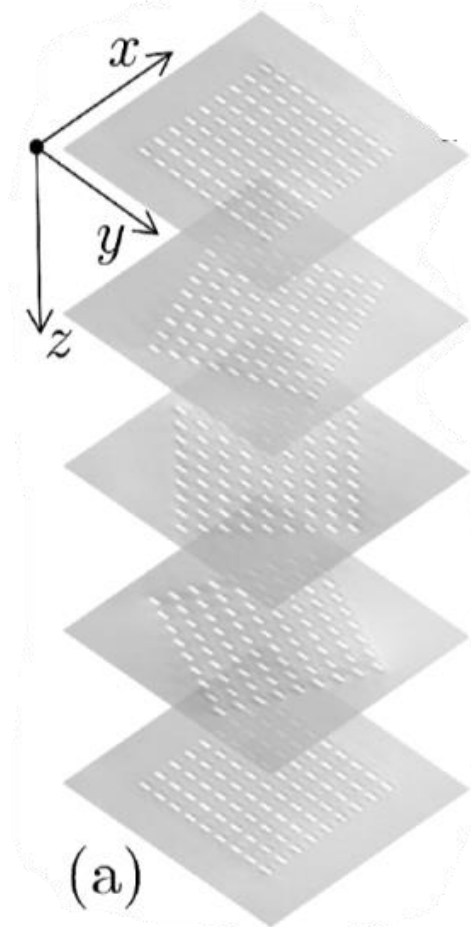
- Введение
- Пространственная локализация в топологических волноводных массивах
 - Observation of Nonlinearity-Controlled Switching of Topological Edge States
 - Observation of Edge Solitons in Topological Trimer Arrays
- Пространственная локализация в двумерных волноводных массивах
 - Observation of Rotation-Induced Light Localization in Waveguide Arrays
 - Observation of Linear and Nonlinear Light Localization at the Edges of Moire Arrays

- Введение
- Пространственная локализация в топологических волноводных массивах
 - Observation of Nonlinearity-Controlled Switching of Topological Edge States
 - Observation of Edge Solitons in Topological Trimer Arrays
- Пространственная локализация в двумерных волноводных массивах
 - Observation of Rotation-Induced Light Localization in Waveguide Arrays
 - Observation of Linear and Nonlinear Light Localization at the Edges of Moire Arrays

Rotation-Induced Light Localization in Waveguide Arrays



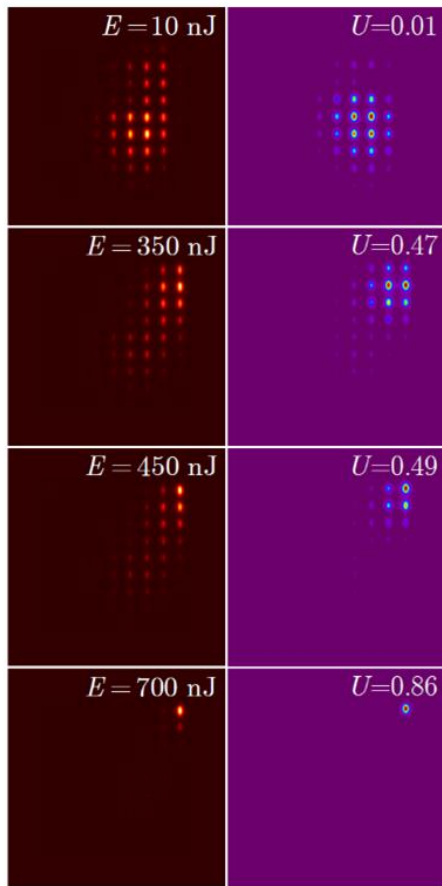
Milián, C., Kartashov, Y. V., Torner, L.: Robust ultrashort light bullets in strongly twisted waveguide arrays. *Phys. Rev. Lett.* 123, 133902 (2019).



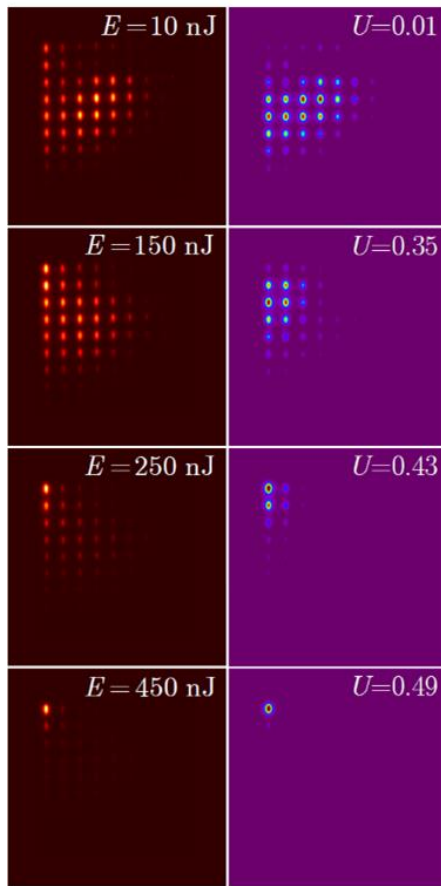
(c)

Rotation-Induced Light Localization in Waveguide Arrays

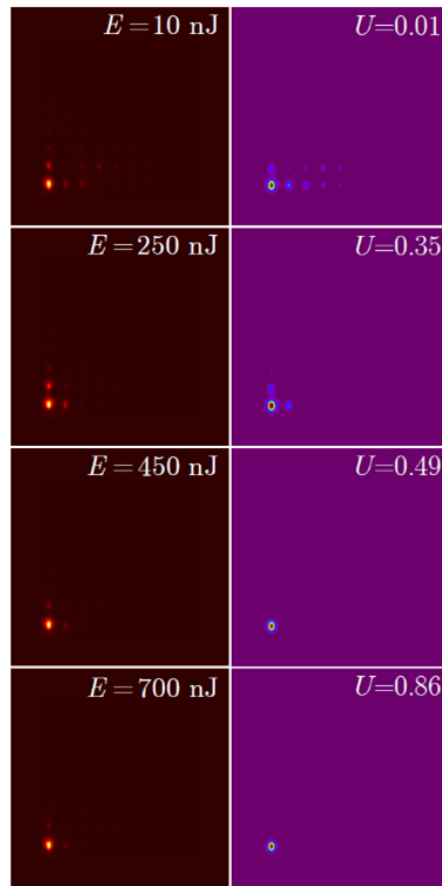
(a) $\alpha = 0.00\pi/L$



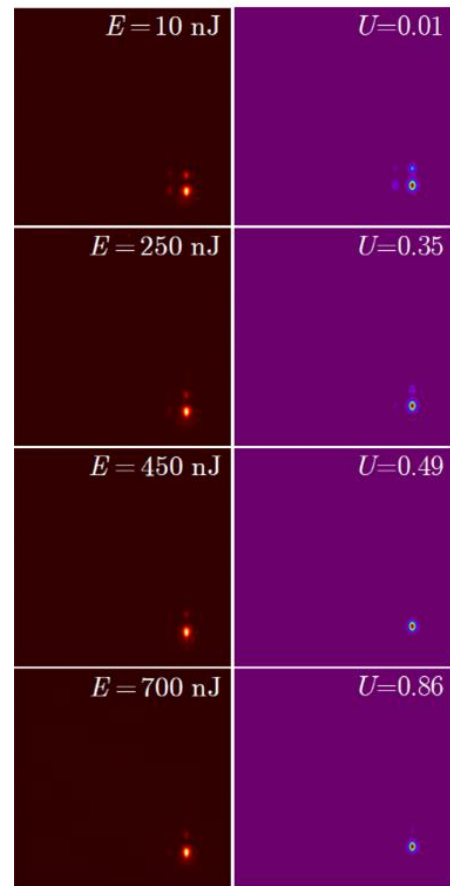
(b) $\alpha = 0.50\pi/L$



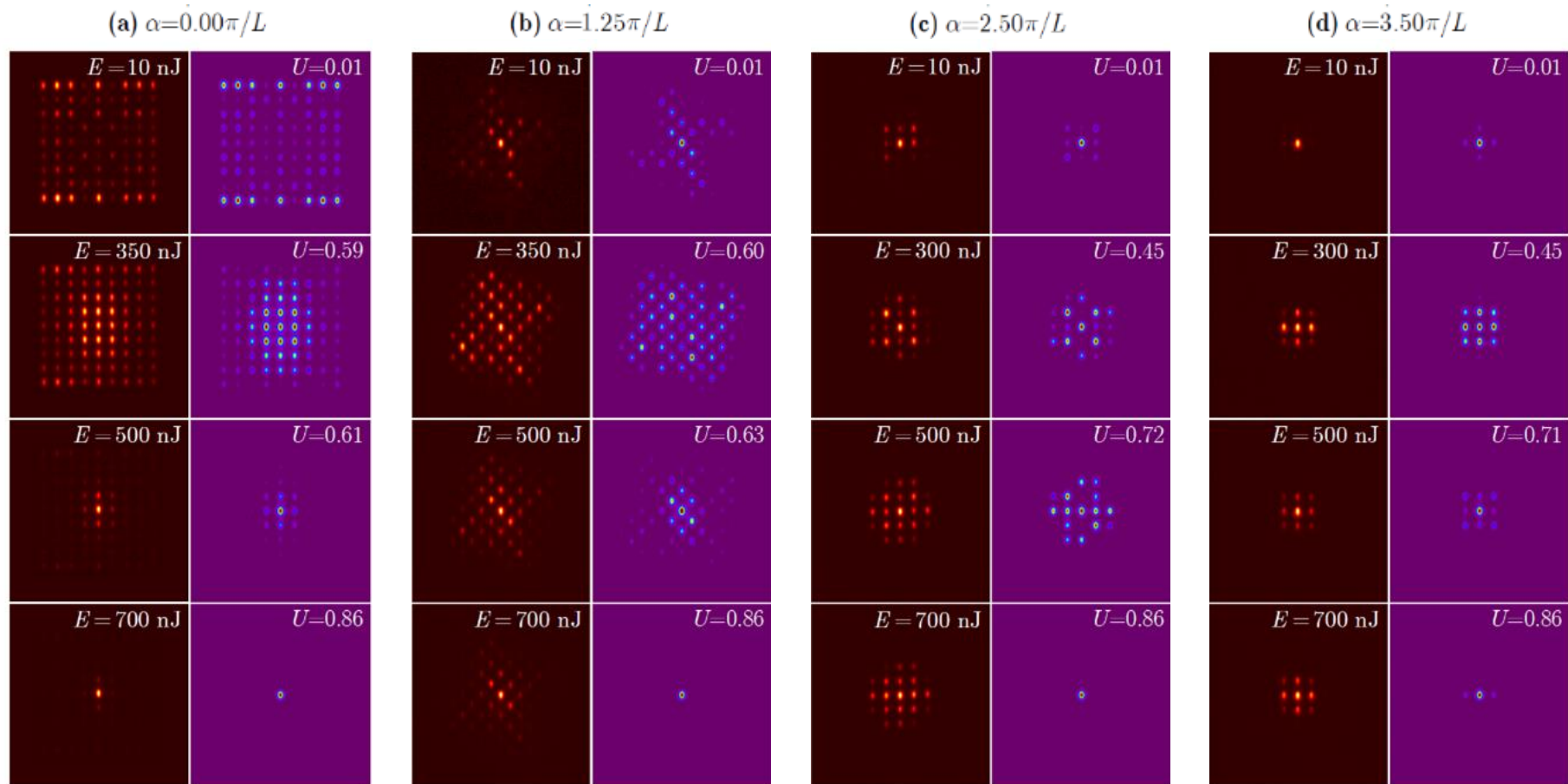
(c) $\alpha = 1.00\pi/L$



(d) $\alpha = 1.50\pi/L$



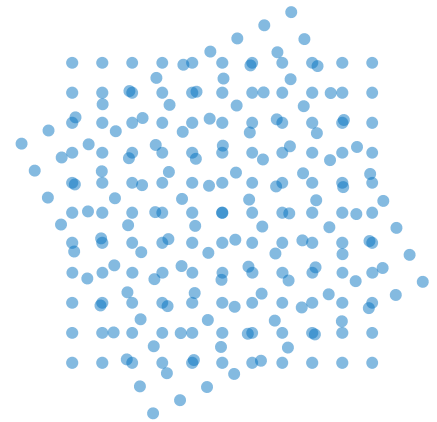
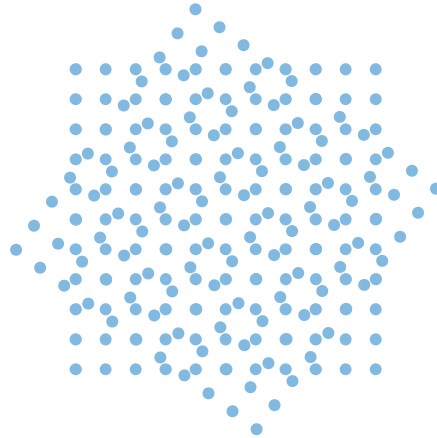
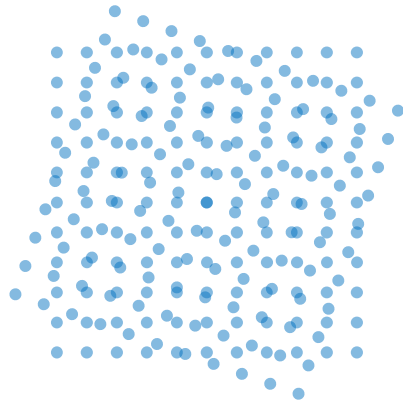
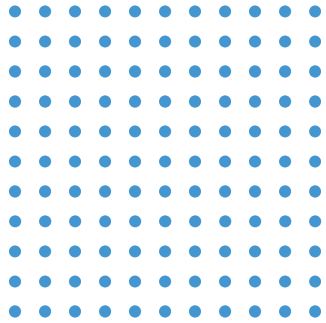
Rotation-Induced Light Localization in Waveguide Arrays



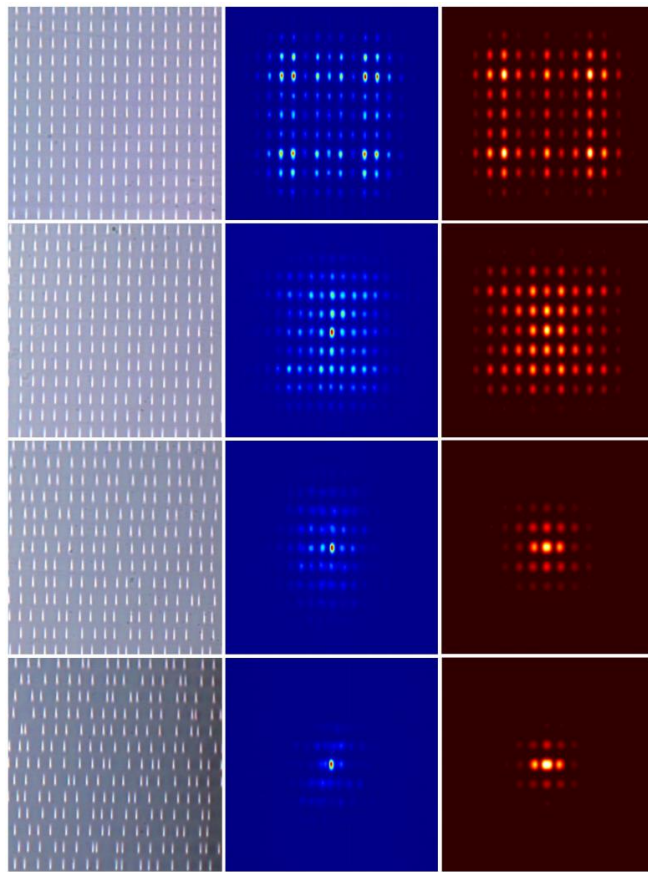
На рецензии в Optica

- Введение
- Пространственная локализация в топологических волноводных массивах
 - Observation of Nonlinearity-Controlled Switching of Topological Edge States
 - Observation of Edge Solitons in Topological Trimer Arrays
- Пространственная локализация в двумерных волноводных массивах
 - Observation of Rotation-Induced Light Localization in Waveguide Arrays
 - Observation of Linear and Nonlinear Light Localization at the Edges of Moire Arrays

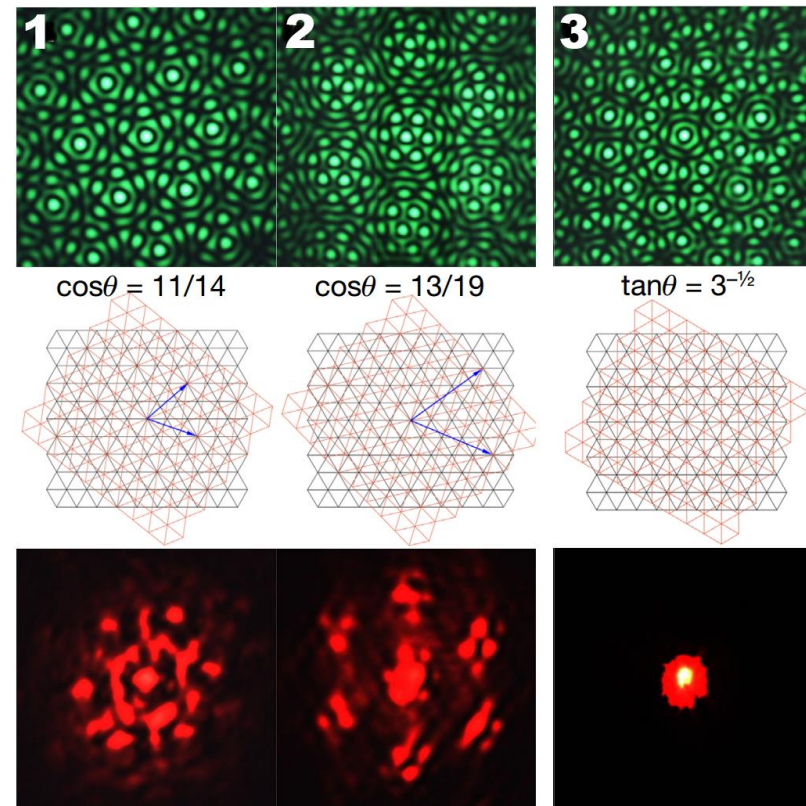
Linear and Nonlinear Light Localization at the Edges of Moire Arrays



Linear and Nonlinear Light Localization at the Edges of Moire Arrays

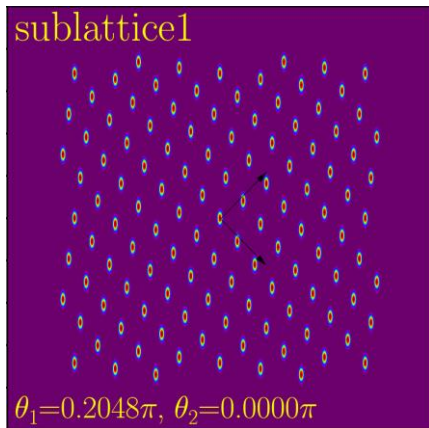
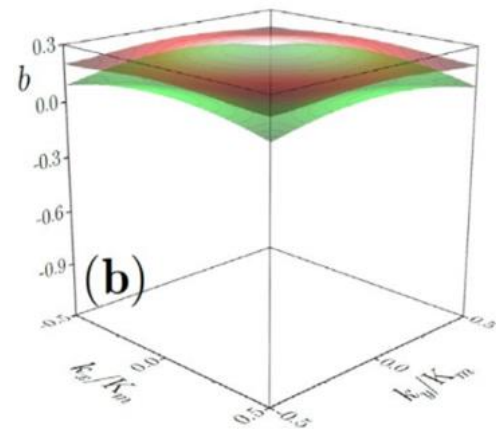
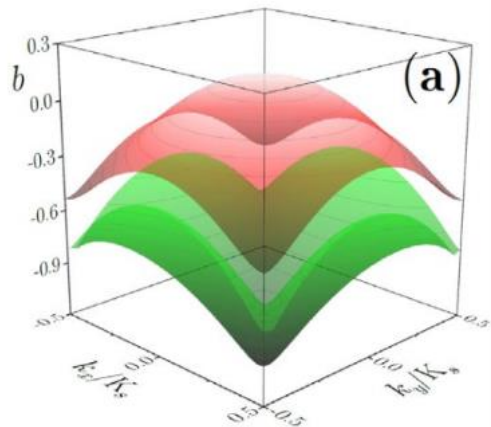


S. Stützer, Y. V. Kartashov, V. A. Vysloukh, A. Tünnermann, S. Nolte, M. Lewenstein, L. Torner, and A. Szameit *Optics Letters* 37, 1715-1717 (2012).

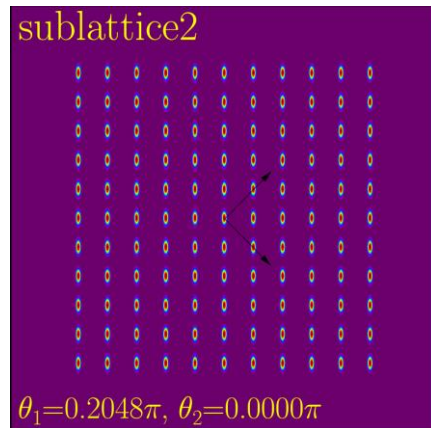


P.Wang, Y.Zheng, X.Chen, C.Huang, Y.Kartashov, L.Torner, .Konotop, F.Ye. Localization and delocalization of light in photonic moiré lattices. *Nature* 577, 42-46 (2020).

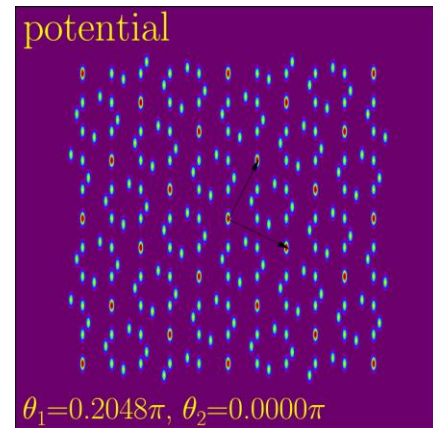
Linear and Nonlinear Light Localization at the Edges of Moire Arrays



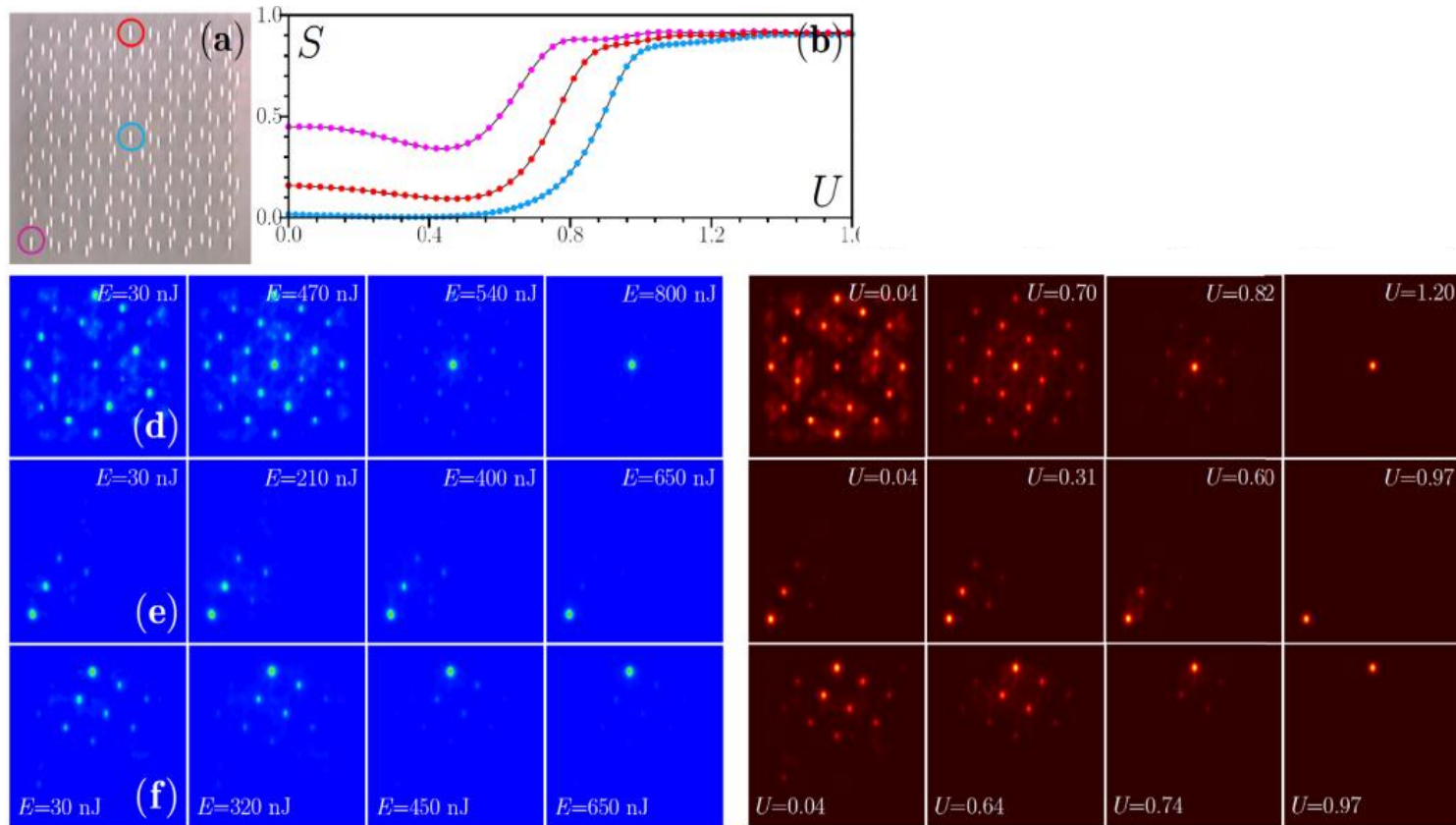
+



=



Linear and Nonlinear Light Localization at the Edges of Moiré Arrays



A. A. Arkhipova, Y. V. Kartashov, S. K. Ivanov, S. A. Zhuravitskii, N. N. Skryabin, I. V. Dyakonov, A. A. Kalinkin, S. P. Kulik, V. O. Kompanets, S. V. Chekalin, F. Ye, V. V. Konotop, L. Torner, V. N. Zadkov,
"Observation of linear and nonlinear light localization at the edges of moiré lattices", *Phys. Rev. Lett.* 130, 083801 (2023)

Выводы

1. Впервые экспериментально продемонстрировано переключение между топологическими краевыми состояниями в одномерных массивах волноводов. Скорость переключения управлялась нелинейностью.
2. Экспериментально наблюдались беспороговые топологические солитоны, ответвляющиеся от линейных локализованных мод, в структуре с двумя запрещенными зонами.
3. Экспериментально подтверждено наличие механизма локализации в двумерных вращающихся массивах волноводов. Показана зависимость степени локализации солитонов не только от мощности света, но и от угла вращения.
4. Исследованы эффекты локализации, возникающие в усеченной муаровой решетке при пифагоровых углах поворота. Наблюдались локализованные состояния, формирующиеся на глубоких волноводах, попадающих в угол или на границу решетки, а также ответвляющиеся от них практически беспороговые солитоны.