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Intrinsic Localized Modes in Optical Photonic Lattices and Arrays

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Discretizing light behavior requires optical elements that can confine optical energy at distinct sites. One possible scenario in implementing such arrangements is to store energy within low loss high Q-microcavities and then allow photon exchange between such components in time. This scheme requires high-contrast dielectric elements that became available with the advent of photonic crystal technologies. Another possible avenue where such light discretization can be directly observed and studied is that based on evanescently coupled waveguide arrays. As indicated in several studies, discrete systems open up whole new directions in terms of modifying light transport properties. One such example is that of discrete solitons. By nature, discrete solitons represent self-trapped wavepackets in nonlinear periodic structures and result from the interplay between lattice diffraction (or dispersion) and material nonlinearity. In optics, this class of self-localized states has been successfully observed in both one- and two-dimensional nonlinear waveguide arrays. In recent years such photonic lattices have been implemented or induced in a variety of material systems, including those with cubic (Kerr), quadratic, photorefractive, and liquid-crystal nonlinearities. In all cases the underlying periodicity or discreteness can lead to new families of optical solitons that have no counterpart whatsoever in continuous systems. Interestingly, these results paved the way for observations in other physical systems obeying similar evolution equations like Bose-Einstein condensates. New developments in laser writing ultrashort femtosecond laser pulses, now allow the realization of all-optical switching networks in fully 3D environments using nonlinear discrete optics. Using this approach all-optical routing can be achieved using blocking operations. The spatio-temporal evolution of optical pulses in both normally and anomalously dispersive arrays can lead to novel schemes for mode-locking and pulse compression. A strong signature of discrete X-wave formation was also demonstrated in such structures. In the last few years, Anderson localization was unequivocally observed in array systems where the transition from ballistic transport to diffusive, and the cross-over to Anderson localization was studied as a function of disorder and nonlinearity. In recent studies synthetic lattices exhibiting parity-time (PT) symmetry were also considered. The interplay of gain and loss in this latter family of structures leads to counterintuitive characteristics and behavior such as non-reciprocal propagation and power oscillations. The realization of discrete array systems at su-bwavelenth scales is another important direction that is nowadays intensively pursued. References 1. D. N. Christodoulides, F. Lederer, and Y. Silberberg, Nature 424, 817- 823 (2003). 2. F. Lederer, G. I. Stegeman, D. N. Christodoulides, G. Assanto, M. Segev and Y. Silberberg, Phys. Reports 463, 1-126 (2008). 3. M Wimmer, A Regensburger, MA Miri, C. Bersch, D.N Christodoulides, and U. Peschel, "Observation of optical solitons in PT-symmetric lattices" Nature Communications 6, 7782 (2015).