Preface

The recent decade or so has witnessed remarkable advances in understanding localized phenomena in various wave motions. Even though the term “localization” or “localized mode” is commonly used, it often happens that mechanisms behind it are quite different. Localization may occur in both linear and nonlinear systems and may be classified accordingly as the system is continuous or discrete, bounded or unbounded, and periodic or random. Localization may also be delocalized in some cases.

In linear systems, a typical example is trapped waves or trapped modes, which may be regarded as a kind of localization. As is well known, the presence of a boundary, a surface or an interface, can often support waves trapped in the vicinity of it. Also an obstacle is capable of trapping waves. Since Ursell showed existence of trapped water waves around an obstacle more than 50 years ago, extensive study has been made especially in the last two decades. Although most work is theoretical, a few experiments show the existence of trapped modes. Another example is Anderson localization, which was discovered 50 years ago to occur due to disorder in solid state physics. Both localizations are ubiquitous in acoustic, electromagnetic and optical wave systems, and in water waves, and so forth.

In nonlinear systems, the most famous localization concerns propagation of a soliton, which results from a balance between dispersion and nonlinearity in continuous systems or continuum approximations. Since the term “soliton” was coined by Zabusky and Kruskal in the sixties, an enormous amount of research has been carried out. One impetus of soliton research is given by the so-called Fermi–Pasta–Ulam (FPU) problem in lattice dynamics. Two decades ago, however, a new localized phenomenon was discovered by Sievers and Takeno in perfect and discrete lattices, and called “discrete breathers” or “intrinsic localized modes” in contrast to localization due to “extrinsic” disorder. As discrete breathers have recently been observed experimentally, they are not only restricted to lattices but may also occur in any discrete, perfectly periodic and nonlinear system.

Thanks to recent hi-technologies, spatially periodic structures are being fabricated from macroscopic scales to nanoscales, such as semiconductors, photonic or sonic crystals, optical fibers as well as huge marine and space structures. In continuous and periodic systems, a linear feature is the appearance of stopping bands in frequency, i.e. a band gap due to Floquet–Bloch theory. In the gap, nonlinearity gives birth to a slowed-down or even stationary “gap soliton,” discovered in one-dimensional optical fibers with suitable gratings due to Bragg resonance. When a discrete structure is embedded in continuous and multidimensional systems in the form of a periodic array, a new type of localization occurs due to discreteness and nonlinearity. Further, when such a discrete and periodic system has a surface or interface, there appear new surface or interfacial solitons trapped around it by nonlinearity.

This special issue is intended, by inviting experts in the respective fields, to survey the “state-of-the-art” of linear and nonlinear localization of wave motions. Topics related with propagating solitons are so diverse that they are excluded from this issue except for the gap soliton and the surface/interfacial solitons.

This issue is composed of eight articles from the viewpoint outlined above. Porter describes a new result of linear trapped waves around a cut-out in a thin elastic plate governed by the bi-harmonic wave equation, different from the Helmholtz equation so far considered. Linton and McIver use the Helmholtz equation to discuss embedded trapped modes, whose frequency lies in a continuous spectrum above the cut-off where wave energy is permitted to propagate to infinity. Photiadis reviews Anderson localization in random media by taking the self-consistent diagrammatic view to explain evolution of the wave character as the irregularity is
varied. Aceves reviews nonlinear localization in fiber optics with three cases; one-dimensional fiber grating, two-dimensional waveguides gratings and optical fiber arrays, and discusses effects of defects or randomness. Kivshar and Molina discuss discrete surface solitons near the edge of a semi-infinite waveguide array or interface of periodic photonic crystals. Feng and Kawahara first review the discrete breathers in higher-dimensional lattices and then describe a quasi-continuum approximation. Yoshimura and Doi consider moving discrete breathers in the FPU-β lattice and clarify a relation between a tail and resonance with a particular set of normal modes. Watanabe, Hamada and Sugimoto introduce discrete breathers in an articulated engineering structure, which is subjected to a non-local force, and belongs to a constrained Hamiltonian system different from the usual ones considered in lattice dynamics.

The content of this issue provides an instantaneous “cross-section” of evolving research. Although they arise in physically different contexts, specific ideas are applicable to other fields and will lead, hopefully, to much new and exciting progress in the field.

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