Šviesos darinių valdymas lokalinių Hilberto transformacijų pagrindu

Management of light patterns based on local Hilbert transform

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Abstract: We propose a new approach based on a local Hilbert transform to design non-Hermitian potentials generating arbitrary vector fields of directionality, $\vec{p}(\vec{r})$, with desired shapes and topologies. We derive a local Hilbert transform to systematically build such potentials, by modifying background potentials (being either regular or random, extended or localized). In particular, we explore particular directionality fields, for instance in the form of a focus to create sinks for probe fields (which could help to increase absorption at the sink), or to generate vortices in the probe fields. Physically, the proposed directionality fields provide a flexible new mechanism for dynamically shaping and precise control over probe fields leading to novel effects in wave dynamics.

Classical Hilbert transform (in optics also called Kramers-Kronig relation) is closely related with the directionality of time. Directionality of time, in other words the causality, generates a pair of integral relations between the real and imaginary part of the spectra.

Our proposal is based on the same idea – we break the invariance of space in a similar way. We introduce the transform, similar to Hilbert transform which ensures the unidirectionality of space.

The basic idea is illustrated in fig.1.

In simplest case of one-directional system we can construct pieces (domains) of space with alternatingly broken left-right unidirectionality. This creates sources and sinks of the probe field.

In two dimensional case it is more complicated. We can construct potentials with arbitrary configurations of directionality field. For instance we can build sinks, chiral fields and others. Then the Hilbert transform is defined at every space point with required directionality. This mathematically introduces the local Hilbert transform.

The idea can find many applications in optics. For instance the potentials can be constructed so, ensuring accumulations of laser fields into desired ranges of space [1]. The potentials can be as well build to create an invisibility on demand – absence of scattering to some particular direction [2].

In the presentation the basic idea will be discussed, together with possible application. In particular simulations of a VCSEL laser with specially designed potential will be demonstrated, which ensure an efficient accumulation of the generated field.

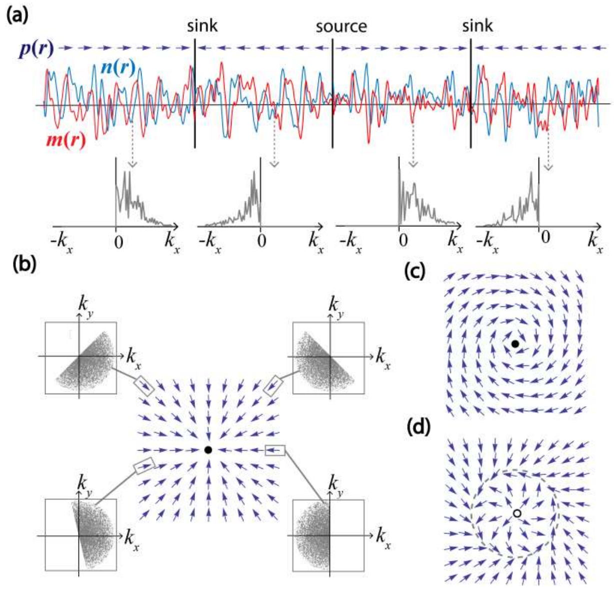

Fig.1. Directionality fields. (a) One-dimensional directionality field consisting of spatial domains of different parity, containing sinks, and sources between the domains. The first row represents a random complex potential with given real, $n(x)$ and imaginary part, $m(x)$ (blue, and red, respectively) with corresponding Fourier spectra of each domain shown in the second row. (b) Vector field to generate a complex directionality field in two spatial dimensions in form of a focus, which may eventually create a sink for the probe field. The insets schematically represent the Fourier transforms of an arbitrary random directionality potential at several points. (c,d) Vector fields in form of a node and an antinode, resulting in vortex with sink and a circular flow channel for the probe field. In all cases, the vector fields, $\vec{p}(\vec{r})$, are denoted by the dark blue arrows

Reikšminiai žodžiai: Laser pattern formation, Hilbert transform.

Literatūra

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