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Bound States in the Continuum in arbitrary anisotropic structures

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Bound states in the continuum (BICs), first predicted in the field of quantum physics [1], are localized radiationless states existing in the part of the parameter space that corresponds to radiative modes. BICs were first demonstrated in acoustic systems and recently in photonic systems [2]. They coexisted in symmetric photonic structures with guided modes as almost-pure transverse-electric (TE) or transverse-magnetic (TM) states, at fixed frequencies and propagation directions [3]. Recently, we have proposed planar waveguiding structures containing anisotropic birefringent materials that support a fundamentally new kind of BIC with unique properties [4]. In particular, anisotropy-induced BICs exist with pure transverse-electric, pure transverse-magnetic or full-vector hybrid polarization. They change propagation direction with frequency and are supported by symmetric and asymmetric geometries. Interestingly, anisotropy-induced BICs may be the only possible bound states in properly designed structures, thus appearing as a discrete, isolated oasis in a desert of radiative states.

Anisotropy-induced BICs appear when the radiation channel in the structure is suppressed, either because the polarization for the corresponding radiating wave is not required to form the BIC, or because of a destructive interference of the radiative waves. Both mechanisms can be induced by using an anisotropic film and substrate where both optical axis are aligned and parallel to the interface of the planar structure. Calculations of the decay length (inverse of the calculated losses) of the leaky modes in terms of the propagation direction and normalized frequency are shown in Fig. 1(a). This figure corresponds to a structure with air as a cladding and a film core with negative birefringence and a substrate with positive birefringence. The blue vertical lines exhibit discrete diverging peak of infinite propagation distance confirming the existence of three BICs in the structure. De-aligning the optical axes of the film and substrate introduces a new free parameter that engenders new practical possibilities, in particular, the propagation tuning of BICs (Fig. 1b-c). These and other new properties originating in the optical axis misalignment may find applications in photonic filters, spatial-light modulators and sensors based on angular selectivity.

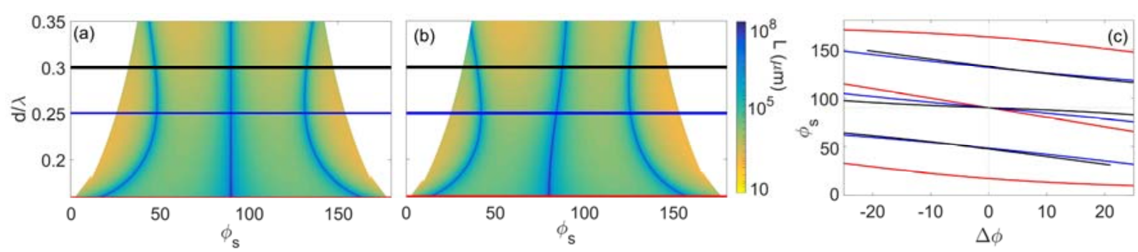

Figure 1. a) Decay length (inverse of the calculated losses) in terms of the propagation direction and the normalized frequencies of d/λ for a system with a positively birefringent substrate (nos=1.25, nes=2), a negatively birefringent core (nos=1.75, nes=1.5) and air as a cladding. The vertical blue lines correspond to the loci of existence of BICs. b) The loci of the BIC can be shifted by de-aligning the film and substrate optical axes with a Δϕ=5º. c) Tuning in terms of Δϕ for three normalized frequencies shown in (a) and (b) as horizontal lines, showing a large tuning in propagation direction.

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