Topological states of light and sound with multiple quantum wells

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The counterparts of electronic edge states in topological insulators attract now significant attention of researchers. We show here that multiple-quantum-well structures can be used to realize non-trivial topological phases both for light and sound.

Optical response of a quantum well has a resonance at the exciton frequency. An array of quantum wells acts as a one-dimensional resonant photonic crystal. If the unit cell of such crystal contains several quantum wells, the structure can be assigned with non-zero Chern numbers and possess optical edge states. Contrary to the conventional electronic topological states, the optical edge modes are radiative: they decay in time due to the light escape through the structure boundaries.[1] The radiative character of the states opens the way to their detection via time- and frequency-dependent light reflection. Furthermore, winding number of the reflection coefficient phase can be used to deduce Chern numbers of the photonic bands.[2]

Another remarkable feature of the quantum-well structures is the strong acousto-optic interaction. Brillouin scattering experiments have shown that the photoelastic constant in GaAs/AlAs multiple quantum wells is increased by 10^5 at the frequency of exciton-polariton resonance as compared to a typical room-temperature value.[3] The acoustic impedance of a quantum well pumped with laser light has a resonance for the phonons with the energy matching the detuning of laser from exciton resonance frequency. Moreover, quantum wells can amplify or attenuate phonons depending on the sign of the detuning. Thus, laser-pumped multiple-quantum-well structures can be used to build acoustic crystals and quasicrystals, including the parity-time symmetric ones.

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[2] A.V. Poshakinskiy, A.N. Poddubny, M. Hafezi, *Phase spectroscopy of topological invariants in photonic crystals*, Phys. Rev. A **91**, 043830, 2015.

[3] B. Jusserand, A.N. Poddubny, A.V. Poshakinskiy, A. Fainstein, A. Lemaitre, *Polariton resonances for ultrastrong coupling cavity optomechanics in GaAs/AlAs multiple quantum wells*, Phys. Rev. Lett. **115**, 267402, 2015