Minicolloque n° PMQ29 ■ **Oral** ☐ **Poster**

Phonon localization in 1D quasi-periodic structures

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Acoustic heterostructures operating at GHz-THz range [1] involving shorter wavelengths (~10 nm) and longer mean free paths constitute a suitable platform to study localization phenomena in quasi-periodic structures. The localized acoustic phonons and its dynamical interactions can be experimentally accessed in ultrafast pump-probe spectroscopy and inelastic Brillouin scattering measurements. The one-dimensional (1D) quasiperiodic structures based on the Aubry-André (AA) model and the Fibonacci sequence have been studied in multiple physical platforms to address many-body localization. Despite the differences between the two models [2,3], a smooth localization/delocalization transition was recently demonstrated in quasiperiodic structures ruled by the interpolating Aubry-André-Fibonacci (IAAF) model [4]. We theoretically address the 1D tight-binding IAAF model to study this localization transition for phonons in the 20-200 GHz frequency range in 1D AlGaAs/GaAs superlattices.

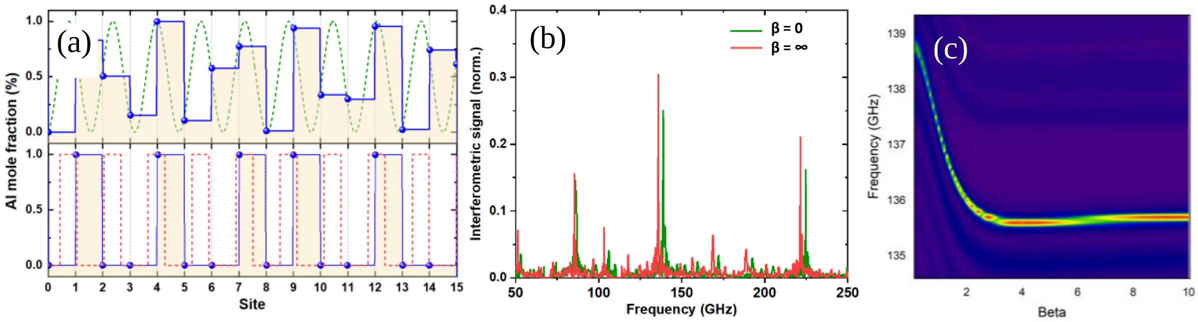

Figure 1: (a) Spatial variation of Al mole fraction in the lattice structure for two limiting cases i.e. $\beta = 0$ (top) and $\beta = \infty$ (bottom). (b) Simulated pump-probe interferometric spectrum for the two cases. (c) Evolution of localized acoustic mode at 136 GHz for the structures at different values of β.

Figure 1(a) shows the spatial variation of the Al mole fraction across the structure designed to localize acoustic modes at 100 GHz. The structure develops as pure AA and Fibonacci sequence model as a function of tunable parameter β [4] which allows to interpolate between limiting cases of β = 0 and ∞, respectively. The simulated pump-probe interferometric spectrum based on photoelastic interactions for the two structures are shown in Fig.1(b). The pump-probe spectrum reveals the presence of three localized modes at 85, 136, and 221 GHz, as the AA model transforms into Fibonacci sequence. Fig.1(c) shows the evolution of the second localized acoustic mode in the pump-probe spectrum is studied as a function of β. The calculated localized phonon mode spectrum highlights the potential of using acoustic superlattices to study localization phenomena at nanoscale. We have theoretically studied the localized acoustic modes generated due to on-site potential modulation in complex 1D quasi-periodic structures based on IAAF model. These arrays can be easily implemented in nanoacoustic structures. We demonstrate the use of nearly linear dispersion of acoustics phonons that allows direct modelling of the complex array structure dynamics.

[1] O. Ortíz, et al, Phys. Rev. B 100, 085430 (2019)
[2] Y. Lahini, et al, Phys. Rev. Lett. 103, 013901 (2009)
[3] D. Tanese, et al, Phys. Rev. Lett. 112, 146404 (2014)
[4] V. Goblot, et al, Nat. Phys. 16, 832-836 (2020)