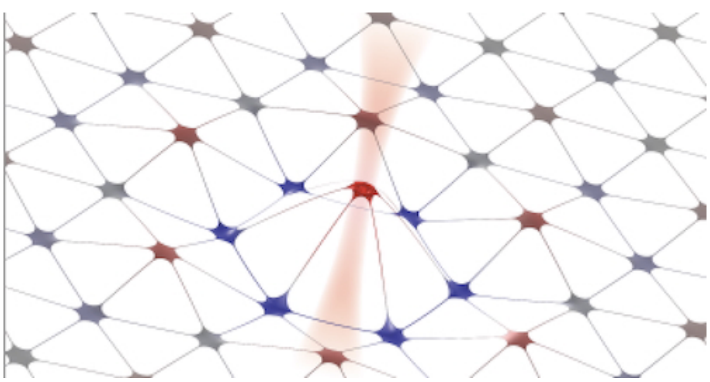
# Programming a Crystal Defect with Light

**Forces imposed by laser light can manipulate the shape of a membrane's vibrational modes.**

By **Rachel Berkowitz**

Disrupting the periodicity in crystals generates localized defects that can provide useful effects. Phononic crystal membranes are 2D metamaterials whose periodic structures are designed to control how waves propagate through them. Creating a defect in these structures can facilitate quantum measurements by isolating specific vibrational modes. But doing so typically requires precise lithography—and these defects are permanent. Now Thomas Clark of McGill University, Canada, and his colleagues introduce a mechanical crystal that features an impermanent, optically programmable defect [**1**]. Using a laser, they transformed a vibrational pattern that spread across the whole membrane into one that occurred only in a small part of it. The reversible effect represents a new form of optical control over motion.

The researchers' phononic crystal consisted of a 3.3-mm by 3.1-mm porous membrane fashioned from 180-nm-thick silicon nitride and patterned into a hexagonal lattice. The membrane was positioned in an optical cavity such that light from the laser, bouncing back and forth within the cavity, applied radiation pressure to a 10-µm-diameter spot that intersected a single unit cell of the crystalline membrane. The beam caused this cell to move out of the membrane plane, and the rest of the membrane pulled it back toward its resting position, like an external spring. A second laser monitored the membrane oscillations in response.



Credit: J. Sankey and T. Clark/McGill University

These measurements revealed that the vibrational energy of one mode was drawn inward toward the laser spot, as evidenced first by a frequency shift in response to the optical spring. The shift's size was far beyond what was expected for a mode that spreads across the whole membrane. More evidence of localization came from further optical prodding, which reduced how much of the membrane was effectively vibrating: The system's inertial mass fell by a factor of 0.03.

The work opens a route toward optically programmable points, waveguides, and other components, which, the researchers say, could serve in new types of on-chip transducers with applications to quantum information and computation.

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## REFERENCES

1. T. J. Clark *et al.*, "Optically defined phononic crystal defect," **Phys. Rev. Lett. 133, 226904 (2024).**