Optomechanical Frequency Conversion: Fundamentals and Applications in Photonics and Phononics

Ewold Verhagen
Center for Nanophotonics, AMOLF, Science Park 104, 1098 XG Amsterdam, The Netherlands
verhagen@amolf.nl

In optomechanical systems, radiation pressure couples optical and mechanical degrees of freedom. This interaction has been exploited for extremely sensitive displacement measurements and control over the quantum states of macroscopic objects. Suitable laser drives induce a coherent transfer of optical to mechanical states and vice versa. This simple mechanism leads to a powerful array of applications for quantum and classical information processing. As the photon-phonon conversion spans a wide frequency difference, it allows the realization of coherent interfaces between optical and microwave fields mediated via a mechanical mode, and more generally transduction between various degrees of freedom that couple to nanomechanical resonators. Moreover, since the conversion can break time-reversal symmetry, it allows nonreciprocal functionality such as photonic and phononic isolation and circulation, polarization conversion, unidirectional amplifiers, high-frequency phonon lasing, and the emergence of topological phases of light and sound. I will review the state of the art in the field and our latest advances in these directions.

REFERENCES

[1] A. Laucht et al., Nanotechnol. 32 (2021), 162003.
[2] J. P. Mathew, J. del Pino, and E. Verhagen, Nat. Nanotechnol. 15 (2020), 198.
[3] L. Mercadé, K. Pelka, R. Burgwal, A. Xuereb, A. Martinez, and E. Verhagen, arXiv:2101.10788 (2021).
[4] R. Duggan, J. del Pino, E. Verhagen, and A. Alù, Phys. Rev. Lett. 123 (2019), 023602.
[5] F. Ruesink, J. P. Mathew, M.-A. Miri, A. Alù, and E. Verhagen, Nat. Commun. 9 (2018), 1798.
[6] E. Verhagen and A. Alù, Nat. Phys. 13 (2017), 922.