

# Single-Photon Percussion

A. G. White

*Center for Engineered Quantum Systems, University of Queensland, Brisbane, Australia*  
director@equs.org

Massive systems in the quantum regime [1] offer significant potential for the development of powerful new quantum-enhanced technologies—such as ultra-precise sensors [2], and new types of transducers [3]—and for quantum foundations—by observing how quantum superpositions behave at a large scale [4].

We adapted a trick from optical quantum computing to help us play a quantum drum: introducing an optomechanical scheme that can prepare non-Gaussian quantum states of motion of a mechanical resonator [5] using photonic quantum measurements [6]. Our method is capable of generating nonclassical mechanical states without the need for strong single-photon coupling, is resilient against optical loss, and offers more favourable scaling against initial mechanical thermal occupation than existing schemes.

We show our scheme can generate quantum multipolar states—states with sub-Planck features in phase space, such as the compass state. We explore the measurement precision and sensitivity of these states to sub-Planck perturbations in different regimes of temperature and optical coupling, finding that their sensitivity is surprisingly robust [7]. We also experimentally observe a signature lobe structure of these states in the high temperature regime.

## References

- [1] Aspelmeyer, Kippenberg, and Marquardt, *Reviews of Modern Physics* **86**, 1391 (2014)
- [2] Rugar, Budakian, Mamin, and Chui, *Nature* **430**, 329 (2004)
- [3] Andrews, Peterson, Purdy, Cicak, Simmonds, Regal, and Lehnert, *Nature Physics* **10**, 321 (2014)
- [4] Pikovski, Vanner, Aspelmeyer, Kim, and Brukner, *Nature Physics* **8**, 393 (2012)
- [5] Ringbauer, Weinhold, Lewis, White, and Vanner, *New Journal of Physics* **20**, 053042 (2018)
- [6] Knill, Laflamme, and Milburn, *Nature* **409**, 46 (2001)
- [7] Howard, Combes, Ringbauer, Weinhold, Shahandeh, Vanner, and White, *in preparation* (2018)