March 15, 2017

Physical Review Letters

American Physical Society

1 Research Road

Ridge, NY 11961-2701

USA

Dear Editor,

We are submitting the manuscript “Amplitude sensing below the zero-point fluctuations with a two-dimensional trapped-ion mechanical oscillator” for consideration of publication in Physical Review Letters. We include Supplemental Information that provides detailed derivations of theoretical formulas and results used in the main text.

The manuscript describes original, previously unpublished work that demonstrates the ability to measure the center-of-mass motion of a trapped ion crystal below the quantum zero-point fluctuations. We believe this is a significant milestone for trapped-ion sensors. It can enable the trapped ion platform to be used for the detection of extremely weak forces (< 1 yN) and electric fields (< 1 nV/m), providing a sensitivity that is potentially useful for dark matter searches.

We believe this manuscript will be of interest to the general readership of Physical Review Letters. Measuring the amplitude of mechanical oscillators has long engaged physicists. Our technique has some parallels with optomechanical techniques, and we emphasize this in the manuscript. In addition, the topic of quantum sensing is of current wide spread interest.

Thank you for considering our manuscript.

Sincerely,

Kevin Gilmore

Justin Bohnet

John Bollinger

Time and Frequency Division

National Institute of Standards and Technology

Boulder, CO 80305