UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-

MONASH University

October 6, 2017

To the Editors,

While we appreciate the referee's comments and consideration of both of our manuscripts, we find that the referee's core conclusion that our results lack novelty, because they essentially replicate the work of Baumgart *et al.*, PRL 111, 240801 for different quantum quantum systems, to be unfounded.

Baumgart *et al.* address the issue of amplitude (Rabi frequency) instability of the decoupling field(s). We address *inter alia* a different problem, namely whether it is possible to do better than conventional dynamical decoupling even with limited Rabi frequency (conventional CDD becomes arbitrarily effective only with diverging Rabi frequency). Rabi frequency cannot be increased arbitrarily in many applications, including low-frequency ac magnetometry, and in cold-atom experiments. Typical noise levels in unshielded environments are often comparable to these Rabi frequency, and quadratic decoupling is therefore inadequate. Higher-order decoupling offers a new degree of freedom which we demonstrated can be achieved in two ways: by concatenating decoupling fields, or working at 'magic' values of the Rabi frequency and the quadratic Zeeman shift.

Baumgart *et al.*'s demonstration of continuous dynamical decoupling in a qubit embedded in a four-level system is similar in spirit to Sarkany *et al.* Phys. Rev. A 90, 053416 (2014) and Kazakov *et al.*, Phys. Rev. A 91, 023404 (2015), which thanks to the referee, we now cite in our manuscripts. Although these articles are directly relevant for magnetometry and are inspirational beyond, our work constitutes a novel application of CDD in quantum gases outside this established paradigm of improved measurement sensitivity. Our results directly apply to creating a stable and well characterized single particle Hamiltonian as the starting point for studying spinor dynamics, creating artificial gauge fields, or even studying quantum magnetism. Beyond these evident applications to field stabilization, the transition matrix elements between dressed states enable the design of new Hamiltonians with non-trivial topological characteristics.

Given the referee did not have any comments on the validity or presentation of our manuscripts, and to the contrary stated that our 'paper is well written and the conclusions are sound' we hereby resubmit our manuscripts in their original forms, except for the added references noted above, to PRL for additional review.

Sincerely,

I. B. Spielman
National Institute of Standards and Technology
100 Bureau Dr., Stop 8424
Gaithersburg, MD 20899, USA
tel: (301) 975-8664; fax: (301) 975-8272
ian.spielman@nist.gov

L. D. Turner
Monash University
School of Physics & Astronomy
Victoria 3800, Australia
tel: +61 3 9905 1726
lincoln.turner@monash.edu