Response to Anonymous Referee #1

Reviewer comments are in black, responses are in blue

General Comments:

The authors discuss eight different turbine groove designs for spherical magic angle spinning rotors. They find that deep turbine grooves do not allow stable spinning, and that some shallow groove designs allow modest increases in spinning speed compared to a groove-free surface. The stability of these spherical ring rotors is discussed in terms of the rotor's principle moments of inertia, and compared to the situation for more conventional cylindrical MAS rotors.

The paper reports progress on the optimization of the very novel magic angle spinning rotor system design that has come out of this laboratory in recent years, and gives a theoretical basis for why the stability of this design is so robust.

The results reported here represent a necessary step in the evolution and optimization of this new spinning system design. While the community of researchers who build their own magic angle spinning systems is rather small, and those who spin with spherical rotors is smaller still, this work represents what I hope will be one of many modest forward steps that will eventually make spherical rotors a compelling alternative to conventional designs.

The paper is logically organized and easy to follow.

Specific comments:

The title seems inappropriate for the work described. While I understand that the fact that groove less rotors perform nearly as well as the best grooved design is one of the significant results, the title ignores most of the experiments described.

While we initially wanted to highlight the most interesting result in our title, we agree that the title as written does have the potential to overshadow the other experiments and discussion. Unless there are restrictions on changing the title after the discussion period, we have proposed a title change to "Highly Stable Magic Angle Spinning Spherical Rotors," in order to de-emphasize the focus on the rotor lacking turbine grooves and instead focus more broadly on the discussion of stability.

In considering moments of inertia, the authors consider empty rotors: spherical rings or cylindrical shells. But some conventional cylindrical rotor designs do not spin well empty - the sample matters. The addition of the sample is considered only cursorily at the end of the manuscript. Presumably if the sample density is much less than the density of the rotor itself things aren't changed much by the sample, but maybe something more could be said?

To address this concern, we have added as supplementary material an interactive Mathematica document which allows the reader to independently adjust the densities for the sample, caps, and rotor in order to see the effect on the moments of inertia as a function of normalized inner radius. We have added additional discussion on this topic to this document.

The discussion of the stability of rotation is somewhat unsatisfying. There is a commonly known theorem about rotation that for objects with three distinct moments of inertia, rotations about the axes having the largest and smallest moments are stable, while rotation about the intermediate axis is not (tennis rackets are a prototypical example). That theorem would suggest that cylinders rotating about their long axes should be stable, as long as both energy and angular momentum are conserved. The situation with both spherical rings and cylinders might be a little different because of the cylindrical symmetry, where there is no intermediate axis. I'd like to see a bit deeper discussion of the stability criteria. While this represents old physics, it would be nice to see a sound discussion in the context of magic angle spinning systems.

We have taken this comment to heart and have now added a discussion with respect to the conditions of stability associated with axially symmetric objects. Using Euler's equations, one can show that a rigid, axially-symmetric object spins stably about its axis of symmetry regardless of whether the moment of inertia about that axis is the greatest or smallest moment. However, due to energy dissipation phenomena, objects tend to prefer to rotate about the axis with the highest moment of inertia.

I wonder if the statement on line 108, that rotation about any axis is stable if there is no energy dissipation, is actually helpful in understanding stability issues?

We have removed this statement in favor of a more rigorous discussion of the rotational dynamics.

Minor issues:

pg 2 line 46. What is meant by 4.7 M-ohm transimpedance amplifier? Does that mean a 4.7 M-ohm resistor in series with the photodiode?

The resistor in this case is in the feedback loop of the amplifier. The size of the feedback resistor relates to the gain of the amplifier and also determines the noise of the amplifier. We have adjusted the text to say "a transimpedance amplifier with a 4.7 M-Ohm feedback resistor" for clarity.

line 51 reference should be parenthesized.

This has now been corrected.

line 162, 175 and others: links to cited doi's appear twice in a number of the references.

We have now corrected these citations.