NASA EPSCoR
Research Performance Progress Report (RPPR) Seed Award

I. Products:
Publications, conference papers, and presentations

M. Varela, J. Betz, E. M. Wright, D. Grin, S. Singh, Searching for Chameleon Dark En- ergy with levitated Optomechanical Systems, APS Mid-Atlantic Section Meeting, Newark DE, November 2023. (Oral Presentation).

S. Singh, Searching for Chameleon dark energy with mechanical systems, SPIE Photonics Meeting on Optical Trapping & Optical Micromanipulation, San Diego CA, August 2023. (Oral Presentation-Invited).

II. Participants & Other Collaborating Organizations:
University Research Team Members

1. Name ..... *Swati Singh*
2. Project Role.....*Principal Investigator*
3. Nearest person month worked:....*1*
4. Contribution to Project.....*Prof. Singh overviewed the entire effort, and gave feedback to the students regarding research direction and sharing early results at conferences.*
5. Funding Support ..... *NSF, AFOSR, NASA*

1. Name ..... *Melissa Varela*
2. Project Role..... *Undergraduate Student*
3. Nearest person month worked:....*5*
4. Contribution to Project.....*Ms. Varela did the early chameleon force calculation.*
5. Funding Support ..... *NASA*

III. Changes/Problems

Changes in approach and reasons for change

I could not recruit a graduate student who was trained in cosmology and optics for this effort. Also, it took a long time for my undergraduate student, Melissa Varela to understand and start to get new results. She had to return just as she was starting to be productive.

Actual or anticipated problems or delays and actions or plans to resolve them

The lack of personnel was the biggest challenge. Fortunately, the undergraduate student I trained on this problem agreed to come back for another 6 month term this summer, and we are hoping to make progress on this project this year.

Changes that have a significant impact on expenditures

By recruiting Melissa back on the project, the expenditures were changed to support another undergraduate exchange student instead of a graduate student to this project.

IV. Impact:

Even twenty-five years after the observation of accelerated expansion of the Universe, there is no consensus on the theoretical framework for the composition, properties or production of dark energy. Dark energy is believed to be the source of this observed expansion and is over 70% of the observed energy budget of the Universe. One of the simplest theoretical models involve a new omnipresent field, known as the chameleon, which mediates forces between masses leading to corrections to the Newtonian gravitational law. Such fields can be searched for in precision measurement setups in laboratory and space. This research effort involves finding the optimal setup to search for the chameleon field using laser-levitated silica spheres, a simple setup that provides excellent force sensitivity.

The current undertaking has primarily involved solving the highly non-linear equation of motion for the chameleon field in laboratory environments numerically and analytically in order to evaluating the weak force resulting from this field. We are performing a detailed analysis of how accessible chameleon parameter space is changed by various experimentally tunable parameters (e.g. the size of levitated spheres, distance between masses—see figure 1). In order to make these results widely accessible to the broader research community, we have been performing all these calculations in Python. The project has provided excellent education and training opportunity to Melissa Varela Alvarez, who has been learning concepts from cosmology and quantum optics as she pursues this undertaking.

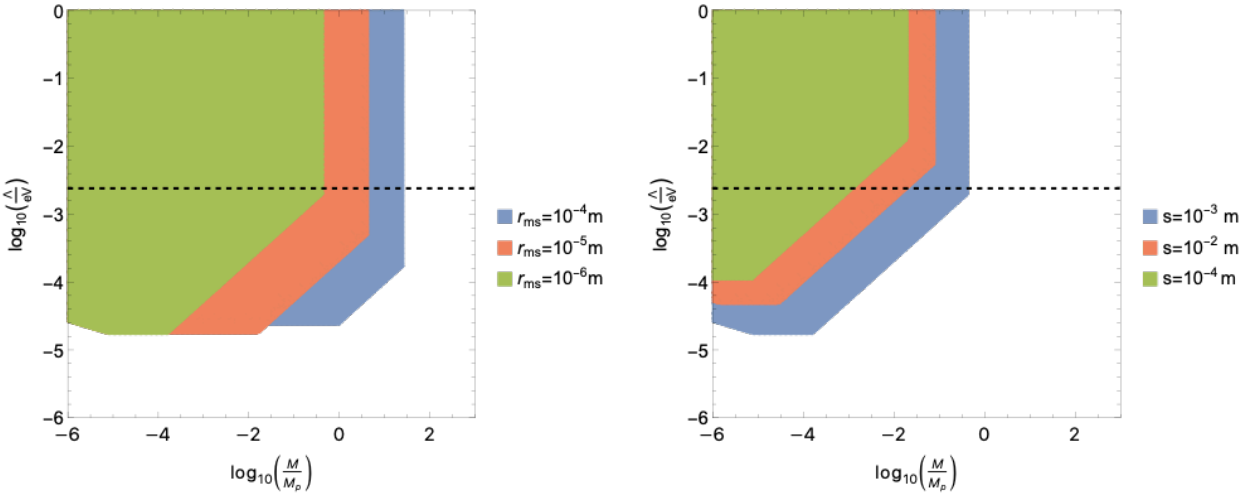

Figure 1. : Initial calculations suggest higher mass levitated systems with mm-scale distances between them might be best suited to probe unconstrained regions of the chameleon dark energy parameter space.