# Searches for new sources of CP violation using molecules as quantum sensors

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# *The physics / basic idea of the LOI*

*Please summarize the basic idea of your LOI*

- Molecules combine orders of magnitude intrinsic enhancement of CP violating effects with coherent, quantum control methods in tabletop experiments.
- Recent advances have made these searches the most sensitive for the electron EDM, and are poised to expand to other sectors and higher energies.

*What is the physics reach / outcome*

- Current experiments probe the ~10 TeV scale in multiple sectors.
  - Leptonic via electron EDM (molecules), hadronic via nuclear Schiff moment (atoms)
  - Effectively free of SM backgrounds
- Advanced quantum control being developed/implemented will advance this to the ~1,000 TeV scale within ~decade.
  - Driven by recent advances in cooling, trapping, controlling molecules.
  - AMO is one of the major drivers of experimental QIS, which is being adapted to the needs of precision measurements
- Highly complementary to other searches (accelerator, flavor, …)

*Does your LOI cross frontiers?*

  - CF, EF, CompF, TF, IF
  - Significant overlap with QIS in both theory and experiment.
  - Many connections to DM, DE, PV, EW, fundamental constants, clocks, gravity, nuclear structure, sensing, many-body, …

# *What is required for the LOI to succeed*

*What are the common data sets, joint efforts, and/or benchmarks that you need to accomplish your plans?*

- Many interesting molecular species have no known spectroscopy, and nearly all are incomplete. This requires both theory and experimental efforts to accomplish.
- Theory of many varieties is needed to interpret results
  - Molecular structure, nuclear structure, BSM extensions, baryogenesis, …
- EDM data sets are increasingly being re-analyzed to look for additional effects, such as axion(-like) fields

*Does your LOI require new detector technologies, instrumentation, facilities, computing, etc. to succeed?*

- New techniques to create, cool, trap, control molecules.
  - Rapidly advancing, but still primary limitation
  - Some tools: lasers, cryogenics, electromagnetic fields, photon detection, …
- Laser technology is a big limitation (wavelengths, power, stability, …)
- Molecular and nuclear calculations require advanced computing resources.
- Some species need isotope facilities.
  - Heavy, octupole deformed nuclei in molecules offer ~$10^6$ intrinsic enhancement over current best experiments.

# What do you plan to do during Snowmass

*Please describe your plans for participation / studies / simulation / contributed papers in the Snowmass process*

I am finding out! Snowmass is entirely new to me and I am learning how to contribute. I am helping with RF03 and #29 and am excited to learn about and contribute to the community.

# What do you hope to get out of Snowmass

*Describe what you would like to see emerge from the Snowmass process for this LOI or in general*

- Improved and expanded communication and interaction between the AMO Precision and Particle Physics Communities.  I think we can all learn a lot from each other!
- Personally – learn some new science and approaches