

NOPTREX: Neutron Optics Time
Reversal EXperiment
&
Searches for Weakly-Coupled
Interactions using Slow Neutrons

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Basic idea of NOPTREX

- Some neutron-nucleus resonances are measured to amplify P-odd NN interaction amplitudes by 10^6
- This enables a search for P-odd/T-odd NN interactions in polarized neutron transmission through polarized nuclear targets. The 0.7 eV p-wave resonance in ^{139}La is the best present candidate.
- Pulsed spallation neutron sources (SNS, JPARC, Los Alamos,...) can provide enough eV neutrons. Mode-entangled neutron beams can suppress systematics.
- Physics reach: sensitivity to T violation in nucleon-nucleon interactions complementary to EDM searches. Similar sensitivity is achievable.

What is required for NOPTREX to succeed

- Access to eV-energy neutron beams to develop apparatus components/techniques and to perform the measurements.

Basic idea of slow neutron searches for new weakly-coupled interactions

- (Polarized) slow neutrons can pass through macroscopic amounts of condensed matter with negligible quantum decoherence (recently proved by Bell/GHZ measurements).
- Interferometric measurements sensitive to coherent phase shifts from exotic interactions have been performed to look for chameleons, symmetrons, short-range gravity, light Z' bosons,...
- Constraints on (or discovery of) new weakly-coupled interactions of neutrons with matter for boson masses over ~ 18 orders of magnitude (peV to MeV)

What is needed for slow neutron exotic interaction searches to succeed

- Continued access to neutron beams, sources, [epithermal (eV) neutrons, cold (meV) neutrons, and ultracold (neV) neutrons], and facilities.
- Beamtime to use neutron instruments designed mainly for materials science studies (when possible) for these quite different purposes.
- Open scientific competition for access to/development of new slow neutron facilities/sources for this work

What do you plan to do during Snowmass

- Two major review articles covering these two LOI topics will be completed by ~Feb. 2021.
- Will prepare a one-page summary of future opportunities for both LOIs for Snomass report.

What do you hope to get out of Snowmass

- Acknowledgement that this scientific activity exists and has already provided interesting results.
- Recognition that slow neutrons can provide important information complementary to other probes in the search for new sources of symmetry violation (T violation, B violation, CPT violation) and in searches for weakly-coupled exotic interactions.

NOPTREX Collaboration

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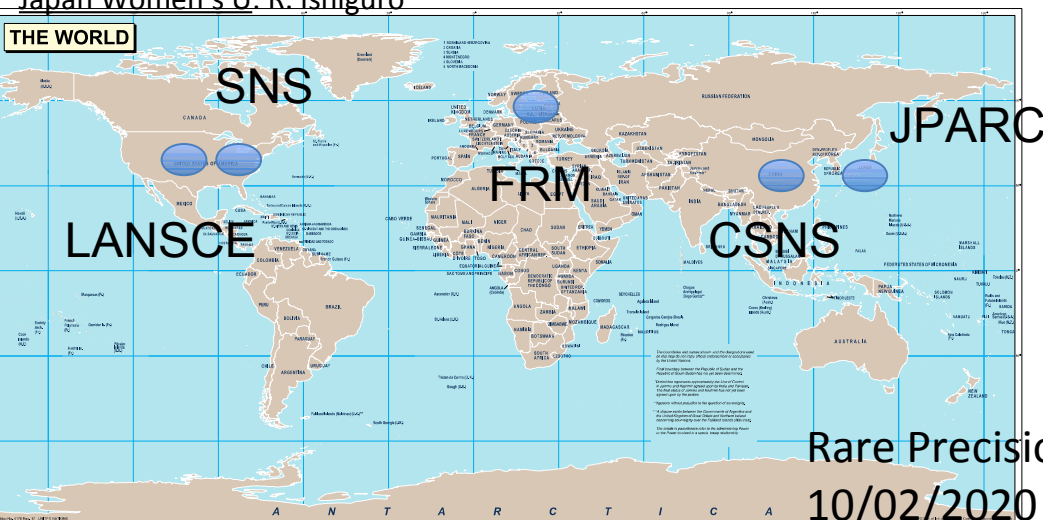
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One experiment:
Five neutron sources

(Some) Relevant Papers

- S. R. Parnell *et al*, Phys. Rev. D **101**, 122002 (2020).
- D. Schaper *et al*, Nucl. Inst. Meth. A **969**, 163961 (2020). arXiv:2001.03432
- S. Lu *et al*, Phys. Rev. A **101**, 042318 (2020). arXiv:1912.10282
- W. M. Snow *et al*, Phys. Rev. D **101**, 062004 (2020)
- J. Shen *et al*, Nat. Comm. **11**, 930 (2020). arXiv: 1908.09823
- T. Okudaira *et al*, Phys. Rev. C **97**, 034622 (2018). arXiv: 1710.03065
- W. M. Snow, Nat. Phys. **14**, 973 (2018).
- C. Haddock *et al*, Phys. Lett. B **783**, 227 (2018). arXiv:1802.05907
- C. Haddock *et al*, Phys. Rev. D **97**, 062002 (2018). arXiv:1712.06351
- R. Lehnert *et al*, Phys. Lett. B **772**, 865 (2017). arXiv:1707.09630
- K. Li *et al*, Phys. Rev. D **93**, 062001 (2016)
- D. Bowman and V. Gudkov, Phys. Rev. C **90**, 065503 (2014). arXiv:1407.7004
- R. Lehnert *et al*, Phys. Lett. B **730**, 353 (2014)
- W. M. Snow, Physics Today **66**, 50 (2013)
- H. Yan and W. M. Snow, Phys. Rev. Lett. **110**, 082003 (2013)