The 9th International Symposium on Symmetries in Subatomic Physics (SSP2025)

Report of Contributions

Contribution ID: **1** Type: **Oral**

The Neutron Lifetime Puzzle

Wednesday, 24 September 2025 09:00 (30 minutes)

The neutron lifetime is a fundamental parameter in nuclear and particle physics, with implications for Big Bang nucleosynthesis, weak interaction studies, and searches for new physics beyond the Standard Model. Over the past decades, increasingly precise experiments have been performed using two main approaches: the "bottle"method, which traps ultracold neutrons, and the "beam" method, which counts decay products in a cold neutron beam. Despite significant progress, a persistent discrepancy between these techniques remains unresolved. This talk will provide an overview of the experimental principles, recent advances, systematic challenges, and future directions in neutron lifetime measurements.

Primary author: LIU, Chen-yu (University of Illinois Urbana-Champaign)

Presenter: LIU, Chen-yu (University of Illinois Urbana-Champaign)

Session Classification: Scientific Program

Contribution ID: **2** Type: **Oral**

A new results of neutron lifetime measurement with cold neutron beam at J-PARC

Wednesday, 24 September 2025 09:30 (30 minutes)

The “neutron lifetime puzzle” arises from the discrepancy between neutron lifetime measurements obtained using the beam method, which measures decay products, and the bottle method, which measures the disappearance of neutrons. To resolve this puzzle, we conducted an experiment using a pulsed cold neutron beam at J-PARC. In this experiment, the neutron lifetime is determined from the ratio of neutron decay counts to ^{3}He(n,p)^{3}H reactions in a gas detector. This experiment belongs to the beam method but differs from previous experiments that measured protons, as it instead detects electrons, enabling measurements with distinct systematic uncertainties. By enlarging the beam transport system and reducing systematic uncertainties, we achieved a fivefold improvement in precision. Analysis of all acquired data yielded a neutron lifetime of $\tau_{\rm n} = 877.2 \pm 1.7_{\rm (stat.)}\ {}^{+4.0}_{-3.6}{}_{\rm (sys.)}$~s. This result is consistent with bottle method measurements but exhibits a 2.3σ tension with the average value obtained from the proton-detection-based beam method. We will present about the new results.

Primary author: MISHIMA, Kenji (RCNP, Osaka university)

Presenter: MISHIMA, Kenji (RCNP, Osaka university)

Session Classification: Scientific Program

Contribution ID: **3** Type: **Oral**

The Nab neutron beta decay experiment: status and plans

Wednesday, 24 September 2025 10:00 (30 minutes)

The unitarity of the CKM quark mixing matrix can be tested by measuring the unitarity sum of the f irst row, which requires precision extraction of the first element (V_{ud}). V_{ud} can be measured by combining measurement of the neutron lifetime with the axial-vector weak coupling constant. The Nab experiment, located at the Spallation Neutron Source at Oak Ridge National Lab is intended to measure the weak coupling constant by measuring a, the correlation coefficient between the emitted electron and antineutrino momenta in unpolarized neutron beta decay. Nab' s asymmetric spectrometer permits the full kinematic reconstruction of each decay event and thus the measurement of the energies of the coincident proton and electron from neutron beta decay, in turn permitting the reconstruction of the electron-antineutrino correlation. Pixelated silicon detectors at each end of the magnetic spectrometer permit the direct measurement of the electron energies and the time of flight of the coincident protons. In this talk, we will present the status of the Nab experiment, including preliminary results from early data runs, as well as proposed future use of the Nab spectrometer to measure polarized neutron beta decay correlations.

Primary author: SAUNDERS, Alexander (Oak Ridge National Laboratory)

Co-author: THE NAB COLLABORATION

Presenter: SAUNDERS, Alexander (Oak Ridge National Laboratory)

Session Classification: Scientific Program

Contribution ID: **4** Type: **Oral**

Beam EDM –a new pulsed-beam experiment to search for the neutron electric dipole moment

Wednesday, 24 September 2025 11:00 (30 minutes)

The neutron represents a versatile tool in the realm of fundamental particle physics. It is used to perform precision physics measurements at low energies with the goal to search for signals beyond the Standard Model of particle physics. In this respect, the neutron Electric Dipole Moment (EDM) has attracted interest as a promising channel for finding new physics since decades. The existence of a permanent neutron EDM violates the combined symmetries of parity (P) and charge conjugation (C) invoking the CPT symmetry.
A new source of CP violation could help to explain the apparent baryon asymmetry in our Universe.
The Beam EDM experiment aims to measure the neutron EDM using a novel concept. The experiment exploits a time-of-flight Ramsey technique with a pulsed beam which allows to distinguish between time-dependent and time-independent effects –and by this overcoming the previously limiting systematic relativistic vxE-effect. Recently, a proof-of-principle apparatus has been developed to perform detailed systematic investigations for a future full-scale experiment intended for the European Spallation Source in Sweden. In this presentation, the details of the experimental apparatus, future prospects, together with results from a data taking campaign at the Institute Laue-Langevin in France will be presented.

Primary author: PIEGSA, Florian (University of Bern)

Presenter: PIEGSA, Florian (University of Bern)

Session Classification: Scientific Program

Contribution ID: **5** Type: **Oral**

Recent progress of the TRIUMF Ultra Cold Advanced Neutron Source and EDM Experiment

Wednesday, 24 September 2025 11:30 (30 minutes)

Recent progress of the TRIUMF Ultra Cold Advanced Neutron Source and EDM Experiment The TUCAN collaboration is commissioning a world-leading ultracold neutron (UCN) source at TRIUMF, capable of production rates up to 1.6×10^7 UCN/s once completed. Spallation neutrons are cooled in room temperature heavy water and 20K liquid deuterium, followed by UCN production in a spherical volume of superfluid helium at 1K. UCN are extracted from the production volume to experiments using coated vacuum guides. The flagship experiment for this UCN source is a measurement of the neutron electric dipole moment (nEDM); a second experimental port will be made available for other proposals including neutron lifetime. UCN trapped in a storage cell will be used to measure the neutron EDM using Ramsey's method of separated oscillatory fields. Once the UCN source is complete, we anticipate to reach a statistical sensitivity of 10^−27 e·cm within 400 days of data taking. This presentation will cover UCN source commissioning and nEDM experiment progress at TRIUMF, including initial UCN production results from operating the superfluid He-II source prior to installation of the LD2 moderator.

Primary author: MILLER, Eric (University of British Columbia)

Co-author: TUCAN COLLABORATION

Presenter: MILLER, Eric (University of British Columbia)

Session Classification: Scientific Program

Contribution ID: **6** Type: **Oral**

High-sensitivity search for the electric dipole moment of the neutron

Wednesday, 24 September 2025 12:00 (30 minutes)

The search for a permanent electric dipole moment of the neutron (nEDM) has been going on for over 60 years and is still a hot topic with various ongoing efforts worldwide. I will present the status of the work of the nEDM collaboration at PSI. The current best limit resulted from the previous measurement at PSI. The nEDM collaboration has developed a new apparatus ‘n2EDM’, which is being commissioned and is close to data taking aiming at a factor 10 sensitivity increase in its baseline version. I will highlight the status at PSI and also overview some efforts at other UCN sources

Primary author: LAUSS, Bernhard (Paul Scherrer Institut)

Presenter: LAUSS, Bernhard (Paul Scherrer Institut)

Session Classification: Scientific Program

Contribution ID: **7** Type: **Oral**

Muon g-2 at FNAL

Wednesday, 24 September 2025 14:00 (30 minutes)

The Muon g-2 experiment at Fermilab, jointly constructed and operated by Fermilab and an international collaboration involving more than 30 institutions across seven countries, aims to carry out high-precision measurements of the muon's magnetic properties. This enables rigorous testing of the Standard Model of particle physics and the search for signs of new physics. The experiment released measurements of the muon's anomalous magnetic moment in 2021 and 2023, with the 2023 result being the world's most precise measurement to date of the anomalous magnetic moment of the muon (200 ppb). It doubled the precision of the experiment's previous results and set the stage for a long-anticipated confrontation between theory and experiment that has been over 20 years in the making. In this talk, the final results from the Muon g-2 experiment at Fermilab will be presented.

Primary author: SIANG KHAW, Kim

Presenter: SIANG KHAW, Kim

Session Classification: Scientific Program

Contribution ID: **8** Type: **Oral**

Muon g-2 and EDM in the post FNAL era

Wednesday, 24 September 2025 14:30 (30 minutes)

The FNAL muon g-2 experiment has measured the anomalous magnetic moment of the muon with an unprecedented precision of 127 ppb [1]. In parallel, significant theoretical efforts are underway to predict the Standard Model (SM) value of muon g-2 with comparable precision [2]. A new experiment aiming to simultaneously measure the muon g-2 and electric dipole moment (EDM), using the world's first muon LINAC, and a compact storage magnet is being prepared at the Japan Proton Accelerator Research Complex (J-PARC) [3]. The J-PARC experiment will provide an independent determination of muon g-2 with largely different systematics and will search for the muon EDM with a sensitivity 70 times greater than the current limit. This talk will present the current status of the experiment and the prospects for achieving a precision surpassing that of the FNAL measurement.

[1] D.P. Aguillard, et al., Phys. Rev. Lett., 135 (2025).
[2] R. Alberti, et al., Phys. Rep. 1143, 1 (2025).
[3] M. Abe, et al., PTEP, 2019, 053C02 ((2019)

Primary author: MIBE, Tsutomu (IPNS/KEK)

Presenter: MIBE, Tsutomu (IPNS/KEK)

Session Classification: Scientific Program

Contribution ID: **9** Type: **Oral**

Search for the electric dipole moment of the muon using the frozen-spin technique in a compact storage trap

Wednesday, 24 September 2025 15:00 (30 minutes)

Electric dipole moments (EDM) of fundamental particles inherently violate the combined symmetry of charge-conjugation and parity inversion (CP) . At PSI we plan to measure the EDM of the muon using the frozen-spin technique within a compact storage trap. This method exploits the high effective electric field, E = 165 MV/m, experienced in the muon's rest frame with a momentum of about 23 MeV/c when passing through a solenoidal magnetic field of B=2.5 T. In my talk, I will outline fundamental considerations for a muon EDM search and present the status for a demonstration experiment conducted at a secondary muon beamline of the Paul Scherrer Institute in Switzerland. In an initial phase the expected sensitivity to a muon EDM is 4E-21 ecm, assuming 200 days of data. In a subsequent phase, Phase 2, we propose to improve the sensitivity to 6E-23 ecm using a dedicated instrument installed on a different beamline that produces muons of momentum 125 MeV/c.

Primary author: SCHMIDT-WELLENBURG, Philipp (PSI)

Co-author: ON BEHALF OF THE MUEDM COLLABORATIN

Presenter: SCHMIDT-WELLENBURG, Philipp (PSI)

Session Classification: Scientific Program

Contribution ID: **10** Type: **Oral**

Atomic parity violation theory: status, challenges, outlook

Wednesday, 24 September 2025 16:00 (30 minutes)

Studies of fundamental symmetries violations in atoms and molecules provide some of the most confronting tests of the Standard Model and sensitive searches for new physics beyond. In this talk, I will focus on atomic parity violation and give the current status and key challenges of the theory. I will also discuss how atoms may be used to deduce improved nuclear physics properties, essential for reducing theory uncertainties and increasing the discovery potential of current and future experiments.

Primary author: GINGES, Jacinda (The University of Queensland)

Presenter: GINGES, Jacinda (The University of Queensland)

Session Classification: Scientific Program

Contribution ID: **11** Type: **Oral**

Quantification of the flavor diagonal hadronic CP violation

Wednesday, 24 September 2025 16:30 (30 minutes)

The flavor diagonal CP violation of elementary particle physics contributes to the atomic, nuclear, and nucleon electric dipole moments (EDMs), T-violating neutron scattering, and to the angular correlations of beta decay. However, its extraction from experimental data has for long been obstructed by the nonperturbative physics of quantum chromodynamics. Quite recently, there were significant progresses in this subject, notably the resolution of the strong CP problem and the quantification of hadron level CP violation such as the contributions of the quark chromo-EDM and Weinberg operator (CP violating three-gluon interaction) to the CP-odd hadronic interactions. We are therefore almost attaining the quantification era of the CP violating hadronic interaction in the leading order of standard model effective field theory. In this talk, we summarize the current attempt to quantify the hadronic CP violation contribution and with a particular focus on the enhancement mechanisms.

Primary author: YAMANAKA, Nodoka (Tohoku University)

Presenter: YAMANAKA, Nodoka (Tohoku University)

Session Classification: Scientific Program

Contribution ID: **12** Type: **Oral**

Time-Reversal Invariance Violation in nuclear reactions with neutrons

Wednesday, 24 September 2025 17:00 (30 minutes)

Time Reversal Invariance Violating (TRIV) effects in neutron transmission through a nuclei target are discussed. We explore the possibility to search TRI violation using important advantages of neutron nuclei interactions: the enhancement of TRIV observables by many orders of magnitude, the measurements of relative effects (TRIV and parity violating ones at the same resonances) with a cancelation of strong interaction contributions, and the availability of a large number of the nuclear targets, which provides the assurance of avoiding possible "accidental"cancelations of TRIV effects due to unknown structural factors related to the strong interactions. The absence of final state interactions for the set of specific observables makes these neutron experiments very complementary to electric dipole moment (EDM) measurements. Therefore, the expected results in neutron scattering at new high flux Spallation Neutron can essentially improve the current limits on the TRIV interactions.

Primary author: GUDKOV, Vladimir (University of South Carolina)

Presenter: GUDKOV, Vladimir (University of South Carolina)

Session Classification: Scientific Program

Contribution ID: **13** Type: **Oral**

Experimental searches for Beyond-Standard-Model Physics using cold neutron beams

Wednesday, 24 September 2025 18:00 (30 minutes)

Neutron beams can be used to perform high precision probes for a wide variety of new forces or interactions not a part of the standard model of particle physics. The neutron's lack of a net charge, its penetrating power into material targets and the availability of intense beams at neutron scattering facilities provide a number of advantages for neutron beam experiments. In particular, they provide the most stringent probes for new spin-independent and spin-dependent interactions over several different distance scales, and new experiments are being proposed which can provide unique sensitivity to CP-violating and B-violating interactions. A brief overview of some of these on-going and proposed experiments is provided, before focusing on a specific example: pendellosung measurements with thermal and cold neutron beams.

Pendellosung is the result of dynamical diffraction, involving the reflected and transmitted beams in a perfect crystal when the neutron beam is tuned to a Bragg condition. In this case, the eigenstates of the neutron beam are admixtures of reflected and transmitted beams, and the neutron state undergoes oscillations. These oscillations can be detected by monitoring the intensity of beams transmitted through the crystal, and are exquisitely sensitive to the atomic potential in the unit cell of the crystal. Recent experiments using perfect Si crystals were conducted at the National Institute of Standards and Technology (through an international collaboration between U.S. and Japanese groups) which provided the highest precision measurements for structure factors for 3 Bragg conditions <111>, <220>, and <400>. These measurements provided what are currently the strongest constraints on Yukawa-like extensions of gravity as well as a new determination of the "charge-radius" of the neutron. We outline the progress since that time using pulsed neutron beams at the SNS and prospects for improvements in the near future using pendellosung on Si and other crystalline materials.

Primary author: R. YOUNG, Albert

Presenter: R. YOUNG, Albert

Session Classification: Scientific Program

Contribution ID: **14** Type: **Oral**

Search for time-reversal symmetry violation in neutron-nucleus system at J-PARC (NOPTREX: J-PARC E99)

Wednesday, 24 September 2025 18:30 (30 minutes)

The fundamental parity violating effect caused by the hadronic weak interaction is enhanced by up to 10^6 times in neutron absorption reactions of 139La, 131Xe, 117Sn, and other nuclei. This enhancement can be explained by the mixing between s-wave and p-wave amplitudes of the compound nuclear state (s-p mixing model). Similarly, T-violating effect in the nucleon-nucleon interaction can also be largely enhanced in these systems through the same mechanism, suggesting the possibility of conducting a sensitive search for unknown T-violation using compound nucleus reactions. The NOPTREX (Neutron Optical Parity and Time Reversal Experiment) international collaboration is planning an experiment to explore unknown T-violation by measuring the P, T-odd cross-section between a polarized epithermal neutron beam and a polarized target (J-PARC E99). Recently, fundamental studies for the T-violation search experiment have been conducted, including the determination of T-violating enhancement factor using (n,γ) reaction measurements, enhanced P-violation measurements, an experiment using polarized neutrons and a polarized target, and these developments. We will provide an overview of the J-PARC E99 experiment and current status for the Phase-I T-violation search experiment.

Primary author: OKUDAIRA, Takuya (Nagoya University)

Co-author: NOPTREX COLLABORATION

Presenter: OKUDAIRA, Takuya (Nagoya University)

Session Classification: Scientific Program

Contribution ID: **15** Type: **Oral**

A proposed search for spin-velocity-dependent interactions using neutron whispering gallery states

Wednesday, 24 September 2025 19:00 (15 minutes)

We propose an experiment to search for spin-velocity-dependent interactions with an interaction range of roughly 10 nm by exploiting neutron whispering gallery states. These are quantum states in which neutrons are confined near the surface of a concave mirror by the material potential and the centrifugal potential. Because the characteristic interference fringes of neutron whispering gallery states appear as oscillations in the neutron-wavelength spectrum, these states are highly sensitive to additional short-range potentials near the mirror surface. We present the first measurement of the neutron whispering gallery states using a pulsed neutron source and outline how this technique can be applied to probe hypothetical spin-velocity-dependent interactions.

Primary author: ICHIKAWA, Go (KEK)

Co-author: MISHIMA, Kenji

Presenter: ICHIKAWA, Go (KEK)

Session Classification: Scientific Program

Contribution ID: **16** Type: **Oral**

GBAR experiment results and prospects

Wednesday, 24 September 2025 19:15 (15 minutes)

The GBAR experiment is designed to investigate the weak equivalence principle by measuring the free-fall acceleration of antihydrogen in the Earth gravitational field [1]. The goal is to obtain a precision of 1% in a first phase, later to be improved using quantum reflection on a surface [2]. To achieve this, the first step is to produce sympathetically coolable antihydrogen ions, through two successive charge-exchange reactions:
\begin{align}
\bar{\textrm{p}} +\textrm{Ps} \rightarrow \bar{\textrm{H}} + \textrm{e}^− && (1) \newline
\bar{\textrm{H}}+\textrm{Ps} \rightarrow \bar{\textrm{H}}^+ + \textrm{e}^− && (2)
\end{align}
In this contribution, I present the first measurement of the cross-section for the production of antihydrogen using reaction (1), and our first attempts at measuring the cross-section for the matter counterpart of reaction (2).

References
[1] G. Chardin et al., "Gbar proposal to the 2011 cern spsc."http://cds.cern.ch/record/ 1386684/files/SPSC-P-342.pdf.
[2] J. Guyomard, P. Cladé, and S. Reynaud, "Single-bounce quantum gravimeter to measure the free-fall of anti-hydrogen,"2025.

Primary author: PEREZ, Patrice (CEA/Irfu)

Presenter: PEREZ, Patrice (CEA/Irfu)

Session Classification: Scientific Program

Contribution ID: **17** Type: **Oral**

Chiral symmetry of QCD and some of its implications

Thursday, 25 September 2025 09:00 (30 minutes)

In the limit of vanishing quark masses, QCD exhibits a chiral symmetry. This symmetry is not only broken explicitly by the finite physical quark masses, but is also assumed to be broken spontaneously. Chiral symmetry and its breaking form the basis of a series of effective field theories used to describe the low-energy interactions between hadrons and their coupling to external fields. Increasingly, these theories have found applications in nuclear physics, and chiral symmetry is also used to analyze beyond-the-standard-model physics.

Primary author: R. SCHINDLER, Matthias

Presenter: R. SCHINDLER, Matthias

Session Classification: Scientific Program

Contribution ID: **18** Type: **Oral**

Lepton flavor violation of tau decays at Belle and Belle II

Thursday, 25 September 2025 09:30 (30 minutes)

Charged lepton flavor violation (cLFV) is a clear signature of physics beyond the Standard Model (SM). While cLFV is not expected to be observed in the SM, many new physics models predict reachable branching fractions of cLFV decays in the current and future experiments. The Belle II experiment, located at the SuperKEKB asymmetric-energy e+e− collider, is a "tau factory" and is good place to search for these rare decays. This talk will present a current status of the searches for cLFV tau decays. We will discuss the analysis techniques employed to suppress dominant backgrounds from conventional tau decays and continuum processes, including the use of advanced machine learning algorithms, and the current and future sensitivities.

Primary author: INAMI, Kenji (Nagoya university/KEK)

Co-author: BELLE AND BELLE II COLLABORATION

Presenter: INAMI, Kenji (Nagoya university/KEK)

Session Classification: Scientific Program

Contribution ID: **19** Type: **Oral**

High precision measurement of the weak mixing angle at low energy,

Thursday, 25 September 2025 10:00 (30 minutes)

The theory of elementary particle physics, the Standard Model (SM), provides a successful description of the basic constituents of matter and the forces acting between them. However, it explains only about 15 % of the total mass in the universe, not accounting for the dark matter postulated in the face of astrophysical and cosmological data. The study of the universe at large shows that our theory of the smallest entities of Nature must be extended.
In the absence of a direct observation of new particles it becomes increasingly important to determine the parameters of the SM with the highest possible precision, as new particles and forces would modify their values through quantum effects. The existence of the W and Z bosons, and later the top quark, the tau neutrino, and the Higgs boson - the ultimate discovery of the SM - were all inferred from precision measurements before their direct observations.
A cornerstone parameter of the SM is the so-called weak mixing angle, which relates different sectors of the theory and is particularly sensitive to new physics. We plan on a new measurement of the weak mixing angle by employing parity violating electron scattering at the upcoming MESA accelerator in Mainz. We will report on the experimental setup and the sources of systematic effects.
In combination with the measurements at the Z-pole this comprises a test of the running of the effective weak mixing angle and allows for a sensitive test of the standard model up to a mass schale of 50 TeV.

Primary author: MAAS, Frank (HI Mainz, GSI Darmstadt / JGU Mainz)

Presenter: MAAS, Frank (HI Mainz, GSI Darmstadt / JGU Mainz)

Session Classification: Scientific Program

Contribution ID: **20** Type: **Oral**

The Electron g−2 as a Precision Test of the Standard Model and a Probe of New Physics

Thursday, 25 September 2025 11:00 (30 minutes)

The electron anomalous magnetic moment (g−2) provides one of the most stringent tests of quantum electrodynamics (QED), with both experiment and theory achieving sub-part-per-billion precision. This exceptional accuracy stems from the simplicity of the single-electron system and the small mass of the electron. Beyond testing QED, the electron g−2 is sensitive to possible contributions from physics beyond the Standard Model. Enhancing this sensitivity requires further advances in higher-order QED calculations and in the precision of key input parameters. This talk will discuss current challenges and prospects in this precision frontier.

Primary author: NIO, Makiko (RIKEN)

Presenter: NIO, Makiko (RIKEN)

Session Classification: Scientific Program

Contribution ID: **21** Type: **Oral**

Toward high-precision spectroscopy of muonium hyperfine structure at J-PARC with high magnetic field

Thursday, 25 September 2025 11:30 (20 minutes)

Muonium is a pure leptonic binary system consisting of a positive muon and an electron, and its level structure can be calculated with high precision. The Muonium Spectroscopy Experiment Using Microwave (MuSEUM) experiment aims to verify the quantum electromagnetic dynamics theory and determine the positive muon magnetic moment and mass by precise measurements of the ground-state hyperfine structure of muonium. There are two methods to measure the hyperfine structure of muonium: Spectroscopy of the energy level differences at zero magnetic field and those between Zeeman splitting sublevels in high magnetic field. Hyperfine structure of muonium can be determined in both methods and the muon-proton magnetic moment ratio can be determined from the two transition frequencies between two pairs of sublevels measured in high magnetic field. The most precise value of the hyperfine structure of muonium was determined from high field experiment at LAMPF, an accelerator facility in Los Alamos in 1999. We aim to improve the precision of this value by an order of magnitude using the high-intensity pulsed muon beam at Japan Proton Accelerator Research Complex (J-PARC) in 1 MW operation. The zero field experiment at J-PARC MLF MUSE D-Line was completed with a precision of 160 ppb in 2021, and the first high field measurement under 100 kW operation was performed at MUSE H-Line, the new high intensity beamline, from February to March this year. We plan to conduct long-time measurements aiming at updating the precision of the previous study from November of this year. This talk will report on the current state of preparation including the latest results.

Primary author: GOTO, Yu (Nagoya University)

Co-author: MUSEUM COLLABORATION

Presenter: GOTO, Yu (Nagoya University)

Session Classification: Scientific Program

Contribution ID: **22** Type: **Oral**

Muonic Helium HFS Measurements at J-PARC

Thursday, 25 September 2025 11:50 (20 minutes)

Microwave spectroscopy of the ground-state hyperfine structure (HFS) of muonic helium atoms is underway at J-PARC Muon Experimental Facility (MUSE) to determine the magnetic moment and mass of the negative muon with high precision. Muonic helium is a hydrogen-like atom composed of a helium atom with one of its two electrons replaced by a negative muon. Its ground-state hyperfine structure, resulting from the interaction of the magnetic moments of the negative muon and the remaining electron, is very similar to muonium HFS but inverted. Already, new precise measurements of the muonic helium HFS at zero magnetic field were performed using the high-intensity pulsed negative muon beam at MUSE D-line. Our new result is more precise than both previous measurements at weak and high fields done 40 years ago, and the first realized with CH4 admixture to form neutral muonic helium atoms efficiently. High-field measurements are now in preparation at MUSE H-line, using ten times more muon beam intensity than at the D-line, and with decay electrons being more focused on the detector due to the high magnetic field, we aim at improving the accuracy of previous measurements nearly a hundred times for muonic helium HFS. To improve further the measurement precision, a new hybrid-SEOP technique to repolarize muonic helium atoms by spin-exchange optical pumping (SEOP) has been developed and successfully demonstrated. This could significantly enhance accuracy, where a direct improvement by a factor of ten may be realized. In the future, we aim to implement this technique in spectroscopic measurements to verify the CPT invariance by comparing the masses of positive and negative muons, and to compare the measured values of the hyperfine structure with precise calculations of the quantum three-body system to verify quantum electrodynamics. An overview of the different features of these new muonic helium atom HFS measurements and the latest results will be presented.

Primary author: STRASSER, Patrick (KEK-IMSS)

Co-author: MUSEUM COLLABORATION

Presenter: STRASSER, Patrick (KEK-IMSS)

Session Classification: Scientific Program

Contribution ID: **23** Type: **Oral**

Laser Spectroscopy of Muonium

Thursday, 25 September 2025 12:10 (30 minutes)

It is crucial to explore physics beyond the Standard Model (BSM) because the Standard Model is incomplete in explaining questions that arise from cosmological observations, such as the existence of dark matter and the matter-antimatter asymmetry in our universe. Precise spectroscopy of muonium is a powerful way to search for BSM because of muonium's simple energy structure. Muonium is a purely leptonic atom that consists of a positive muon and an electron, both of which can be viewed as point charges. The absence of internal structure provides stringent tests of the Standard Model by comparing theoretical predictions of the energy levels with precise measurements. For these tests, it is crucial to reduce the muon mass uncertainty, which currently dominates the uncertainty in the energy level calculation. The muon mass can be precisely determined from the transition frequency of the 1S-2S levels using laser spectroscopy. We have developed a suitable environment for the precision laser experiment at J-PARC, and performed the Doppler-free two-photon laser spectroscopy of the 1S-2S transition in muonium. We developed a narrowlinewidth, pulsed 244 nm laser system, a highly efficient muonium generation target made by laser-ablated silica aerogel [1], and a detection system (Fig. 1) with a high detection efficiency and low background noise. With these improvements, we achieved a laser excitation rate of 1S-2S ($F = 1 \longrightarrow F' = 1$) transition more than 300 times higher than that of the previous experiment [2]. We also observed, for the first time, the transition of 1S-2S ($F = 0 \longrightarrow F' = 0$), where F is the total angular momentum. Such a high signal rate enables us to reduce the muon mass uncertainty in the future experiment. [1] J. Beare et al., PTEP 2020, 123C01 (2020) [2] V. Mayer et al., Phys. Rev. Lett. 84, 1136 (2000)

Primary author: UETAKE, Satoshi (Okayama University)

Presenter: UETAKE, Satoshi (Okayama University)

Session Classification: Scientific Program

Contribution ID: **24** Type: **Oral**

Quark confinement due to unified magnetic monopoles and vortices reduced from symmetric instantons with holography

Thursday, 25 September 2025 14:00 (30 minutes)

We present a new rigorous scheme for understanding quark confinement based on the non-perturbative vacuum disordered by some topological defects. We start from the 4-dim. Euclidean Yang- Mills theory and require the conformal equivalence between the 4- dim.Euclidean space and the possible curved spacetimes with some compact dimensions. This requirement forces us to restrict the gauge configurations of 4-dim.Yang-Mills instantons to those with some space symmetries (called symmetric instantons) which are identified with magnetic monopoles and vortices living in the lower-dimensional curved spacetime with non-zero curvature through the dimensional reduction. The new scheme gives the direct built-in equivalence between (3-dim.hyperbolic) magnetic monopoles (of Atiyah type) and (2-dim.hyperbolic) vortices (of Witten-Manton type), which have been assumed without any rigorous proof to be the dominant contributors to quark confinement. This unified treatment of two topological defects is shown to give the semi-classical picture for quark confinement in the sense of Wilson. At the same time, this scheme caused by the dimensional reduction give a holographic description of magnetic monopole dominance on AdS3 in the rigorous way without any further assumptions. Moreover, the asymptotic freedom is also shown to be derived by performing the pertutbative deformation on the vacuum with these topological defects. [Paper in preparation to be submitted to ArXiv]

Primary author: KONDO, Kei-Ichi (Chiba University)

Presenter: KONDO, Kei-Ichi (Chiba University)

Session Classification: Scientific Program

Contribution ID: **25** Type: **Oral**

Ab Initio Nuclear Theory for Tests of Fundamental Symmetries

Thursday, 25 September 2025 14:30 (30 minutes)

First principles, or ab initio, nuclear theory describes atomic nuclei as systems of nucleons interacting by QCD-based chiral effective field theory (EFT) nucleon-nucleon and three-nucleon forces. In combination with chiral EFT electroweak currents, ab initio nuclear calculations can provide model-independent results with quantifiable uncertainties relevant for tests of fundamental symmetries involving atomic nuclei. I will review recent and new results obtained within the ab initio no-core shell model (NCSM) [1] for parity violating anapole [2], electric dipole [3], and nuclear Schiff moments in atomic nuclei with the nuclear Green's function obtained using the Lanczos strength algorithm [4]. I will discuss ongoing effort to compute nuclear structure corrections for the extraction of the Vud matrix element from the superallowed Fermi transition measurements in 10C [5] and 14O. Finally, I will highlight NCSM calculations of the β-decay electron spectrum of the Gamow-Teller transition 6He(0+) ⟶ 6Li(1+) [6] and the unique first-forbidden β-transition 16N(2-) ⟶ 16O(0+). This work was supported by the NSERC Grant No. SAPIN-2022-00019. TRIUMF receives federal funding via a contribution agreement with the National Research Council of Canada. Computing support came from an INCITE Award on the Frontier supercomputers of the Oak Ridge Leadership Computing Facility (OLCF) at ORNL, form Livermore Computing, and from the Digital Research Alliance of Canada.

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Primary author: NAVRATIL, Petr (TRIUMF)

Presenter: NAVRATIL, Petr (TRIUMF)

Session Classification: Scientific Program

Contribution ID: **26** Type: **Oral**

GRASIAN: Shaping and characterization of the cold hydrogen beam for the forthcoming first demonstration of gravitational quantum states of atoms.

Thursday, 25 September 2025 15:00 (15 minutes)

A low energy particle confined by a horizontal reflective surface and gravity settles in gravitationally bound quantum states. These gravitational quantum states (GQS) were so far only observed with neutrons [1,2]. However, the existence of GQS is predicted also for atoms. The GRASIAN collaboration pursues the first observation of GQS of atoms, using a cryogenic hydrogen beam. This endeavor is motivated by the higher densities, which can be expected from hydrogen compared to neutrons, the easier access, the fact, that GQS were never observed with atoms and the accessibility to hypothetical short range interactions [3]. In addition to enabling gravitational quantum spectroscopy, such a cryogenic hydrogen beam with very low vertical velocity components - a few cm/s, can be used for precision optical and microwave spectroscopy. We report on our methods developed to reduce background and to detect atoms with a low horizontal velocity, which are needed for such an experiment. Our recent measurement results on the reduction of background and improvement of signal-to-noise will be presented.

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Session Classification: Scientific Program

Contribution ID: **27** Type: **Oral**

Proton decays at JUNO

Thursday, 25 September 2025 15:15 (20 minutes)

The Jiangmen Underground Neutrino Observatory (JUNO) is a large liquid scintillator detector designed to explore many topics in fundamental physics. One of the capabilities of the JUNO detector is to search for the baryon number violation processes, which would be a crucial step towards testing the Grand Unified Theories and explaining the matter-antimatter asymmetry of the Universe. The large liquid scintillator detector of JUNO has distinct advantages in the search for some proton decay modes. This talk reports the JUNO potential to search for $p \to \bar{\nu} K^+$ and neutron invisible decays (e.g., $n \to 3\nu$ or $nn \to 2\nu$). Both of them can produce time-, energy- and space-correlated triple coincidence signals, which may be used to effectively suppress backgrounds. It has been found that the expected sensitivities for JUNO with 10 years of data are $\tau/B(p \to \bar{\nu} K^+) > 9.6 \times 10^{33}$ years, $\tau/B(n \to inv) > 5.0 \times 10^{31}$ years and $\tau/B(nn \to inv) > 1.4 \times 10^{32}$ years at the 90\% confidence level, which are better than the current best limits.

Primary author: GUO, Wanlei

Presenter: GUO, Wanlei

Session Classification: Scientific Program

Contribution ID: **28** Type: **Oral**

Toward Positronium Bose-Einstein Condensation: Laser Cooling in Vacuum and Challenges in Nanoporous Materials

Friday, 26 September 2025 09:00 (30 minutes)

Positronium (Ps), a purely leptonic bound state of an electron and a positron, offers a unique platform for testing fundamental physics, including gravity on antiparticles [1] and a gamma-ray laser [2]. Achieving Bose-Einstein condensation (Ps-BEC) would be a breakthrough, requiring ultracold temperatures (approximately 10 K) and a dense state (around 10^{18} cm^{-3}) Ps within its short lifetime of 142 ns [3]. As a first step toward Ps-BEC, we recently demonstrated one-dimensional laser cooling of Ps in vacuum, reducing its velocity spread to ~1 K within 100 ns using a chirped laser pulse train [4]. This achievement marks the first successful laser cooling of Ps. To achieve Ps-BEC, laser cooling must be applied to dense Ps confined in nanoporous materials. While silica aerogels allow efficient Ps formation and thermalization [5,6], we found that Ps excited to the 2P state exhibits unexpectedly short annihilation lifetimes in nanopores, hindering cooling cycles [7]. We will present an overview of our Ps-BEC project, including the vacuum laser cooling experiment, the challenges of 2P-Ps annihilation in confinement and the ongoing development of nanoporous media optimized for Ps formation, condensation, and cooling. These advances pave the way toward Ps condensation and, ultimately, a gamma-ray laser.
Acknowledgements: This work was partially supported by JST FOREST Program (Grant Number JPMJFR202L), JSPS KAKENHI Grant Numbers JP16H04526, JP17H02820, JP17H06205, JP17J03691, JP18H03855, JP19H01923, JP23H05462, MATSUO FOUNDATION, Mitutoyo Association for Science and Technology (MAST), Research Foundation for Opto-Science and Technology, The Mitsubishi Foundation, TIA Kakehashi TK17-046 and TK19-016. This work was performed under the approval of the Photon Factory Program Advisory Committee (Proposal No. 2017P009, 2018G100, 2020G101, 2020G631, 2022G087, 2023G157, 2024G143, 2025G151).

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Presenter: ISHIDA, Akira (National Institute of Advanced Industrial Science and Technology (AIST))

Session Classification: Scientific Program

Contribution ID: **29** Type: **Oral**

Opening a New Frontier in Precision Spectroscopy of Muonic Atoms with Superconducting X-ray Calorimeters

Friday, 26 September 2025 09:30 (30 minutes)

Atomic physics with negatively charged muons provides a powerful approach to probing fundamental physics because their mass is about 200 times heavier than that of ordinary electrons. When a negative muon is captured by a light nucleus, it rapidly strips off all bound electrons through the muon-induced Auger process, creating an isolated muonic atom consisting only of the nucleus and the bound muon. Because the muon orbits so close to the nucleus, it experiences an extremely strong electromagnetic field—far beyond what can be artificially generated—which makes muonic atoms highly sensitive probes for testing quantum electrodynamics (QED) in regimes where perturbative approaches fail. Our initial goal was to explore such untested regions of QED [1].
Until recently, producing isolated exotic atoms/ions in a vacuum and measuring their transition energies with high precision had not been feasible. This situation changed with the advent of the intense, slow negative muon beam at J-PARC, combined with high-resolution multi-pixel TES (Transition Edge Sensor) microcalorimeters, achieving energy resolutions of a few eV with high efficiency. Using this system, we realized a proof-of-principle experiment by preparing a two-body quantum system—muonic neon (μNe)—and precisely measuring its muonic x rays with a superconducting calorimeter [2].
During this campaign, we also discovered that electronic characteristic x rays emitted from muonic atoms can be measured with similar precision. For example, spectra from muonic iron (μFe) revealed a characteristic structure with significant broadening, which, when compared with theoretical simulations, uncovered ultrafast (tens of femtoseconds) dynamics involving the muon and bound electrons processes that can be extended to condensed matter physics [3,4]. Likewise, measurements of electronic x rays from muonic argon (μAr) demonstrated the existence of few-body exotic ions (H-like, He-like, and Li-like), in which a muon shields the nuclear charge while a small number of electrons remain bound. Theoretical analysis showed that these K x rays are emitted following slow charge transfer processes occurring on the order of hundreds of nanoseconds [5].
Thus, by combining intense slow muon beams with state-of-the-art superconducting x-ray calorimeters, we have established a new capability to precisely measure both muonic and electronic x rays from muonic atoms. This interdisciplinary approach opens novel pathways in fundamental physics, atomic physics, condensed matter, and even astrophysics.

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Primary author: AZUMA, Toshiyuki

Presenter: AZUMA, Toshiyuki

Session Classification: Scientific Program

Contribution ID: **30** Type: **Oral**

Muonium Atom Interferometry for High-precision Studies of Symmetries and Interactions

Saturday, 27 September 2025 16:45 (15 minutes)

Muonium, a hydrogen-like atom consisting of a positive muon and an electron, is a purely leptonic system. Since it contains no composite nucleons, theoretical calculations of its energy levels are free from finite-size effects, making precision spectroscopy of muonium a powerful tool for testing the Standard Model. However, the sensitivity of new physics searches using muonium spectroscopy is often limited by the uncertainty in the muon mass. A new, high-precision determination of the muon mass, independent of muonium spectroscopy, would therefore be highly beneficial for new physics searches. We propose a novel method to measure the muon mass using muonium atom interferometry. In this experiment, the muon mass will be determined by inducing transitions in muonium atoms with a series of laser pulses and quantifying the phase shift between atomic wave packets caused by the associated photon recoils. Realizing this interferometer requires a high-brightness, low-velocity muonium beam. We are currently developing an apparatus for a multi-stage cooling scheme for muons, which combines a solid rare-gas moderator with laser ionization of muonium, to produce such a beam. In this presentation, we will report on the project's overview and the current status of the experimental apparatus and simulations.

Primary author: KANDA, Sohtaro (KEK)

Presenter: KANDA, Sohtaro (KEK)

Session Classification: Scientific Program

Contribution ID: **31** Type: **Oral**

A slow antihydrogen beam for ground-state hyperfine spectroscopy

Saturday, 27 September 2025 17:00 (15 minutes)

The ASACUSA Cusp antihydrogen experiment aims to test CPT symmetry through spectroscopic studies of antihydrogen ground-state hyperfine splitting. Planned antiatomic beam spectroscopy will be conducted in an environment where a perturbing magnetic field is small. The experiment recently upgraded the antiproton trap, the positron trap, and the Double Cusp trap in order to produce slow and intense antihydrogen atomic beams. Plasmas of positrons and antiprotons are mixed under a cusp magnetic field to produce cold antihydrogen atoms. The cusp magnetic field polarises the spin state of antiatoms by focusing low field seeking states of antihydrogen along the beam axis while defocusing high field seeking states if antiatoms are slow enough. Therefore, the preparation of colder plasmas in the double Cusp trap is crucial for producing slow antihydrogen atoms. Recent progress on preparing cold plasmas, improvements in antihydrogen yield, and the production of slow antiatomic beams will be presented.

Primary author: KURODA, Naofumi

Presenter: KURODA, Naofumi

Session Classification: Scientific Program

Contribution ID: **32** Type: **Oral**

Charactarization of the 229Th nuclear clock transition in solid state hosts

Friday, 26 September 2025 11:00 (30 minutes)

The 229mTh isomeric state has the lowest known energy for a nuclear transition and is a candidate for a clock disciplined by an atomic nucleus. After demonstrating the absolute transition frequency measurement, we now move on to characterizing its environmental sensitivity as a clock, and present preliminary results regarding the effect of resonant microwaves. A clock based on this transition would be sensitive to nuclear and beyond standard model physics[1], while performing as a solid-state clock[2].
Keywords—clock; nuclear; spectroscopy; fundamental physics; crystal
Due to the insensitive nature of the nucleus to the chemical environment, the host atom may be doped into a crystal[3] in order to obtain many orders of magnitude more oscillators probed than other platforms, while still maintaining a narrow linewidth; untrue for electrical transitions. This being said, narrow atomic transitions such as those in ion or quantum gas platforms have made strides both as frequency references and stringent tests of the standard model. [4]

Nuclear energy levels are set by competition between the coulomb force and the strong force. If fundamental constants were changing over time, one could expect that the fortuitous cancellation of Coulomb and strong nuclear forces resulting in the low energy isomeric state would change, resulting in a different nuclear clock operation frequency, detectable by a clock based on coulomb force.

We characterize the effect the calcium fluoride host crystal environment has on the nuclear transition.[5] This allows us to extract both crystal and nuclear parameters, vital for understanding the performance of a nuclear clock. We also present a measurement of the long-term stability of the transition.[6]

The laser used is a VUV frequency comb generated via the 7th harmonic of an IR comb. The comb is locked to the JILA strontium clock, allowing a stable reference for measuring small changes in frequency due to doping concentration or temperature.[7]

A "zero shift temperature"is identified, where there is zero first order shift in frequency due to fluctuations in temperature. We will also present preliminary results on the effect of microwave frequencies resonant with the splitting due to the interaction between the nuclear quadrupole moment and the electric field gradient within the crystal.

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Presenter: DOYLE, Jack (JILA, NIST, University of Colorado Boulder)

Session Classification: Scientific Program

Contribution ID: **33** Type: **Oral**

Trapping and laser spectroscopy of triply charged thorium-229 for a nuclear clock

Friday, 26 September 2025 11:30 (30 minutes)

The nuclear transition between the nuclear ground state and the isomer of thorium-229 offers a unique opportunity for direct laser spectroscopy of the atomic nucleus. One of the applications is a high-accuracy nuclear clock based on the resonance frequency of this nuclear transition. We developed an ion trap for triply charged thorium-229 obtained as recoil ions from the ⍰-decay of uranium-233. From uranium-233, we can obtain thorium-229 isomers with a branching ratio of approximately 2%. We developed a nuclear-state-selective laser spectroscopy technique to detect and investigate detailed properties of triply charged thorium-229 isomers in a trap. We will also report our recent activities towards laser cooling of triply charged thorium-229 in a trap.

Primary author: YAMAGUCHI, Atsushi (RIKEN)

Presenter: YAMAGUCHI, Atsushi (RIKEN)

Session Classification: Scientific Program

Contribution ID: **34** Type: **Oral**

Laser spectroscopy of a nucleus

Friday, 26 September 2025 12:00 (30 minutes)

In 1976 Kroger and Reich established the existence of a low-lying nuclear excited state in 229Th through the spectroscopy of gamma-rays emitted following the alpha-decay of 233U. The prospects of a laser-accessible nuclear transition touched off a flurry of proposals to utilize this apparently unique nuclear transition as a sensitive probe of both nuclear structure and chemical environment, to constrain physics beyond the Standard Model, and to construct a clock with unprecedented performance. Unfortunately, Kroger and Reich could only tell us that the transition energy was less than about 100 eV and therefore scientists have spent the intervening 48 years searching for the thorium nuclear transition. I'll describe our efforts over the last 16 years to construct the first thorium-doped crystals and their use to perform nuclear laser spectroscopy, resulting in a measurement of the nuclear transition energy as 8.355733(2)stat(10)sys eV in 229Th:LiSrAlF6. I will also discuss recent work observing the nuclear transition in thin films of 229ThF4; the first observation of laser conversion electron Mossbauer spectroscopy using 229ThO2; ongoing work to understand and harness the effect of the crystalline host on the isomeric transition; and the next steps for using this transition to probe new physics and build better clocks. This work was funded by the NSF, DARPA, and ARO.

Primary author: HUDSON, Eric (UCLA)

Presenter: HUDSON, Eric (UCLA)

Session Classification: Scientific Program

Contribution ID: **35** Type: **Oral**

Theory of Baryon and Lepton Number Violation

Saturday, 27 September 2025 09:00 (30 minutes)

We propose new axion models in which the Peccei–Quinn (PQ) symmetry is identified with baryon and/or lepton number symmetries. By extending the KSVZ axion model with higher- dimensional operators, we develop a general method to fix the baryon and lepton numbers of new scalar fields. This framework naturally predicts distinctive baryon-number violating processes such as nucleon decays, neutron–antineutron oscillations, and di-nucleon decays.
We present UV-complete examples and show that their predicted rates can be probed by current experiments such as Super-Kamiokande and Hyper-Kamiokande, as well as future dedicated searches for neutron–antineutron oscillations.

Primary author: TSUMURA, Koji (Kyushu University)

Presenter: TSUMURA, Koji (Kyushu University)

Session Classification: Scientific Program

Contribution ID: **36** Type: **Oral**

Neutrinoless Double-Beta Decay

Saturday, 27 September 2025 09:30 (30 minutes)

In the early universe, matter and anti-matter, produced equally in high-temperature density, are assumed to annihilate one another. However, the current universe is dominated by only matter. The “mystery of matter-dominated universe”is one of the big problems in particle physics and cosmology, and neutrinos are expected to be a key to the solution. More than 80 years ago, the physicist Ettore Majorana hypothesized that neutrino could be its own antiparticle, however, there has been no experimental evidence so far. The only practical experiments to test the Majorana nature of neutrinos is the search for neutrinoless double-beta decay, which has been a major challenge for nuclear and particle physicists. In this talk, the current status of the neutrinoless double-beta decay searches will be summarized, reviewing the progress of KamLAND-Zen, which recorded the world best sensitivity in the effective Majorana neutrino mass limit.

Primary author: SHIMIZU, Itaru (Tohoku University)

Presenter: SHIMIZU, Itaru (Tohoku University)

Session Classification: Scientific Program

Contribution ID: **37** Type: **Oral**

The NNBAR Experiment: A Search for Free Neutron–Antineutron Oscillations

Saturday, 27 September 2025 10:00 (30 minutes)

The European Spallation Source (ESS), currently under construction in Lund, Sweden, will become the world's most powerful neutron research facility. The proposed NNBAR experiment aims to perform the first search in over three decades for free neutron–antineutron oscillations. Such a transformation would constitute direct evidence of baryon number violation, a phenomenon anticipated by several extensions of the Standard Model and a key component for explaining the observed matter–antimatter asymmetry of the Universe. NNBAR is designed to improve the sensitivity to free neutron-antineutron transitions by over three orders of magnitude. This leap is enabled by the high-intensity cold neutron beam from a liquid deuterium moderator, a 200-meter magnetically shielded beamline held below 10 nT, and a carbon annihilation target. The surrounding annihilation detector, combining a time projection chamber, calorimetry, and cosmic veto systems, is optimised for detecting the distinctive multi-pion annihilation signature with high efficiency and full background rejection. Supported by an INFRADEV design study from the European Commission, a conceptual design report for the experiment has been delivered [1], demonstrating its feasibility and possible integration into the ESS infrastructure. In this talk, I will describe the scientific motivation behind the search for neutron–antineutron oscillations, the experimental strategy and design choices of NNBAR, and the simulation-driven performance estimates that demonstrate its potential. I will also outline the next steps toward realisation of this flagship fundamental physics experiment at ESS. [1] V. Santoro et al. HighNESS conceptual design report: Volume II. The NNBAR experiment. Journal of Neutron Research. 2024;25(3-4):315-406. doi:10.3233/JNR-230951

Primary author: PERSSON, Linus (Lund University)

Presenter: PERSSON, Linus (Lund University)

Session Classification: Scientific Program

Contribution ID: **38** Type: **Oral**

Searches for Nucleon Decay and Baryon Number Violation with Super-Kamiokande Experiment

Saturday, 27 September 2025 11:00 (30 minutes)

tbd

Primary author: TAKHISTOV, Volodymyr (QUP, KEK)

Presenter: TAKHISTOV, Volodymyr (QUP, KEK)

Session Classification: Scientific Program

Contribution ID: **39** Type: **Oral**

Theoretical overview on EDM

Saturday, 27 September 2025 11:30 (30 minutes)

I will give a theoretical overview talk about EDM.

Primary author: FUYUTO, Kaori

Presenter: FUYUTO, Kaori

Session Classification: Scientific Program

Contribution ID: **40** Type: **Oral**

Quantum sensing of the electron's electric dipole moment using ultracold Fr atoms

Saturday, 27 September 2025 12:00 (30 minutes)

The search for the fundamental physics using atoms and molecules have been widely investigated [1]. The discovery of the electron's electric dipole moment (EDM) sheds light on new physics beyond the standard model. The upper limit of EDM has been reported [2]. We propose a novel experimental technique to measure the electron EDM using ultracold Fr atoms based on the combined principles of quantum sensing and optical lattice [3]. Our method enables a search for the electron EDM at a level below 10−30 ecm. Fr isotopes with relatively long lifetimes show increasing nuclear octupole deformation with more neutrons, further enhancing Schiff moments in addition to the electron EDM. We produce two Fr isotopes using distinct methods: Fr-210 via nuclear fusion reactions with an accelerator and Fr-221, with strong octupole deformation, via radiochemical techniques using Ac-225 as its generator. Laser beams were delivered from the laser room to the Fr room via 400-m optical fibers [4]. Fr was generated [5], neutralized [6], laser cooled and trapped [7]. We demonstrated Faraday rotations by Rb and Cs trapped in an optical lattice, to measure Zeeman and vector light shifts simultaneously which are the systematic errors in EDM measurements. We also report the experiment of an atomic vapor magnetometer, and measurement of Ramsey resonance using ultracold atoms for the EDM measurement.

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Presenter: AOKI, Takatoshi (The University of Tokyo)

Session Classification: Scientific Program

Contribution ID: **41** Type: **Oral**

Production and spectroscopy of cold radioactive molecules for precision measurement

Saturday, 27 September 2025 14:00 (30 minutes)

Molecules containing radioactive nuclei are being pursued for a wide range of applications, from fundamental symmetries to nuclear astrophysics. However, their study is made challenging by the combination of limited quantity and the difficulty of working with even the simplest molecules. Here I will describe the production and spectroscopy of cold, stopped 226RaOH, 226RaOD, and 226RaF in a tabletop apparatus, and ongoing efforts to laser cool these species. By combining novel target production methods, cryogenic buffer gas cooling, optically driven resonant chemical production, and bandwidth-tunable low-background spectroscopy methods, we can rapidly scan a wide range and then narrow in on molecular features to perform high resolution spectroscopy with trace quantities of material. Radium-containing molecules have extremely high sensitivity to CP-violating physics and are amenable to laser cooling and trapping for advanced quantum control; since the molecules that we create are in the same starting condition as current molecular laser cooling experiments, this opens a new path for quantum sensing of exotic nuclei. Furthermore, the production and spectroscopy approaches are generic and can be applied to a wide range of species.

Primary author: HUTZLER, Nicholas (Caltech)

Presenter: HUTZLER, Nicholas (Caltech)

Session Classification: Scientific Program

Contribution ID: **42** Type: **Oral**

Proton EDM in Storage Ring

Saturday, 27 September 2025 14:30 (30 minutes)

The storage ring proton electric dipole moment (pEDM) experiment aims to probe the proton EDM with a sensitivity of $10^{-29}\, e \cdot \text{cm}$. This effort is complementary to neutron and atomic, molecular, and optical EDM searches, and will constitute the first direct measurement of the proton EDM—improving constraints on θ_{QCD} by three orders of magnitude beyond the current best limit. To maximize sensitivity while suppressing systematic uncertainties, the experiment employs several innovative techniques. These include the frozen-spin method with a 0.7 GeV/c magic-momentum proton beam, an all-electric ring with strong magnetic focusing, and counter-rotating beams to cancel dominant systematic effects. In this talk, I will outline the conceptual design and operating principles of the pEDM experiment, highlight recent progress and prototyping efforts at BNL, and discuss the outlook for future developments.

Primary author: KIM, On

Presenter: KIM, On

Session Classification: Scientific Program

Contribution ID: **43** Type: **Oral**

Measurement of the deuteron static and oscillating electric dipole moment at the COoler SYnchrotron COSY

Saturday, 27 September 2025 15:00 (30 minutes)

Electric dipole moments (EDMs) play a central role in searches for CP violation beyond the Standard Model.
This talk reviews activities at the COoler SYnchrotron COSY at Forschungszentrum Juelich in Germany.
A series of milestones in the preparation for electric dipole measurements
of charged hadrons in storage rings have been achieved in recent years at COSY.
These include the measurement of spin tune, reaching spin coherence times
of over 1000 seconds, operating a feedback system to control the spin precession
in storage rings and the operation of radio-frequency devices to manipulate the spin motion.

These achievements led to a first search for axion-like particles in a storage rings
and a first measurement of the deuteron's EDM. The talk discusses the main results obtained at COSY
and plans for future developments.

Primary author: PRETZ, Jörg (Forschungszentrum Juelich/RWTH Aachen University)

Presenter: PRETZ, Jörg (Forschungszentrum Juelich/RWTH Aachen University)

Session Classification: Scientific Program

Contribution ID: **44** Type: **Oral**

Exquisitely Precise Tests of the Standard Model (SM) and Probes for BSM Physics Using the Electron's Two Dipole Moments

Saturday, 27 September 2025 16:00 (30 minutes)

Two new tabletop measurements promise to each increase by an order of magnitude the sensitivity for testing the SM and for probing for BSM (beyond the SM). For the electron magnetic moment, a one-electron relativistic quantum cyclotron already provides the most precise measurement —the most precisely measured property of any elementary particle —to test the most precise prediction of the SM. Quantum non-demolition (QND) measurements using quantum limited detectors and special relativity are at the heart of the new generation of measurements. For the electron electric dipole moment, new ACME measurements with an electron in a ThO molecule have achieved the longer coherence time, higher flux and more efficient quantum state detection needed to also increase the sensitivity to BSM CP violation that may be missing from the SM.

Primary author: GABRIELSE, Gerald (Center for Fundamental Physics at Northwestern University)

Presenter: GABRIELSE, Gerald (Center for Fundamental Physics at Northwestern University)

Session Classification: Scientific Program

Contribution ID: **45**   Type: **Oral**

Measuring the Electron's Electric Dipole Moment Using Ultracold YbF Molecules

Saturday, 27 September 2025 16:30 (15 minutes)

The standard model predicts a value for the electron's electric dipole moment (eEDM, d_e), $d_e \sim 10^{-35}$ e cm [1], far smaller than what is predicted by theories beyond the standard model, typically $d_e \approx 10^{-31} - 10^{-24}$ e cm. To date, the current experimental upper limit is set at $d_e < 4.1 \times 10^{-30}$ e cm [2]. Further improvements in experimental precision are likely to discover new physics or rule out much of the parameter space of popular theories. The eEDM can be measured through the precession of the electron spin in an applied electric field. The precision is enhanced enormously when the electron is bound into a heavy polar molecule. The statistical precision depends on the spin precession time so a slow, ultracold beam of molecules has the potential to measure the eEDM to greater precision than the current limit. We use a beam of collimated ultracold YbF molecules produced by a cryogenic buffer gas source and then laser cooled to 100 μK in the two transverse axes [3]. Such cooling increases beam brightness and spin-precession time, leading to a projected statistical uncertainty below 10^{-30} e cm [4]. However, magnetic field noise can severely limit the precision of our phase sensitive measurement of de. To overcome this source of noise, we have developed and characterised a novel spin precession region, including ceramic electric field plates, a glass vacuum chamber, magnetometry, and a four-layer magnetic shield with a shielding factor $> 10^5$ [5]. We prepare the eEDM-sensitive state using stimulated Raman adiabatic passage and detect the molecules with near unit efficiency. We are currently working to reach the shot noise limit of statistical sensitivity.

References

[1] Ema Y. et al, 2022, Phys. Rev. Lett., 129, 231801 [2] Roussy T. et al, 2023, Science, 381, 46-50 [3] Alauze X. et al, 2021, Quantum Sci. Technol., 6, 044005 [4] Fitch N. J. et al, 2021, Quantum Sci. Technol., 6, 014006 [5] Collings F. et al, 2025, arXiv:2503.21725v1

Primary author: JENKINS, Rhys (Imperial College London)

Co-authors: SAUER, B. E.; WURSTEN, E.; CASTELLINI, F.; COLLINGS, F.; LIM, J.; TARBUTT, M. R.; ZIEMBA, M.; ZHENG, S.

Presenter: JENKINS, Rhys (Imperial College London)

Session Classification: Scientific Program

Contribution ID: **46** Type: **Oral**

Effective Theory of Muon-to-Electron Conversion: Applications to Mu2e and COMET

Saturday, 27 September 2025 18:00 (30 minutes)

An e ective theory of charge lepton flavor violation (CLFV) was recently developed, yielding a complete set of nucleon-level operators through linear order in the nucleon and muon velocities. The embedding of this operator basis in a nucleus then determines what can and cannot be learned about CLFV from muon-to-electron conversion. Due to several technical tricks introduced, we were able to treat the associated nuclear responses completely, e.g., with the inclusion of all distorted partial waves of the electron. The EFT was then extended in two important ways. One was its generalization to include inelastic nuclear contributions, where it emerged that Mu2e and COMET may be able to place multiple constraints on CLFV given anticipated backgrounds, due to the fortuitous choice of 27Al as a target. The second was the linking of the nuclear-level EFT to a tower of EFTs constructed for higher energy scales, so that constraints obtained from next

generation experiments can be "ported up"to SMEFT scales and beyond. 1. Evan Rule, WCH, Ken McElvain: "Nuclear-level e ective theory of muon-to-electron conversion,"Phys. Rev. Lett. 130 (2023) 131901
2. WCH, Evan Rule, Ken McElvain, Michael J. Ramsey-Musolf: "Nuclear-level e ective theory of muon-toelectron conversion: Formalism and Applications,"Phys. Rev. C 107 (2023) 035504
3. WCH, Evan Rule: "Distinguishing charged lepton flavor violation scenarios with inelastic muon-to-electron conversion,"Phys. Rev. Lett. 133 (2024) 261801
4. WCH, Kenneth McElvain, Tony Menzo, Evan Rule, and Jure Zupan: "E ective theory tower for muon-toelectron conversion,"JHEP 11 (2024) 076
5. WCH, Evan Rule: Nuclear-level e ective theory for muon-to-electron conversion: inelastic process,"Phys. Rev. C 111 (2025) 025501

Primary author: HAXTON, Wick (University of California, Berkeley)

Presenter: HAXTON, Wick (University of California, Berkeley)

Session Classification: Scientific Program

Contribution ID: **47** Type: **Oral**

The new result on the mu e gamma search with the MEGII experiment

Friday, 26 September 2025 10:00 (30 minutes)

This talk reports the result of the search for the decay \mu+->e+\gamma undertaken at the Paul Scherrer Institut in Switzerland with the MEG II experiment using the data collected in the 2021-2022 physics runs. The sensitivity of this search is 2.2x10-13, a factor of 2.4 better than that of the full MEG dataset and obtained in a data taking period of about one fourth that of MEG, thanks to the superior performances of the new detector. The result is consistent with the expected background, yielding an upper limit on the branching ratio of B(\mu+->e+\gamma)<1.5 x 10-13 (90 % C.L.). Additional improvements are expected with the data collected during the years 2023-2024. The data-taking will continue in the coming years. A status of other searches and of the experiment will be given.

Primary author: PAPA, Angela (PSI&UNIPI-INFN)

Presenter: PAPA, Angela (PSI&UNIPI-INFN)

Session Classification: Scientific Program

Contribution ID: **48** Type: **Oral**

Search for muon to electron conversion with COMET experiment at J-PARC

Saturday, 27 September 2025 18:30 (30 minutes)

The COMET experiment at J-PARC aims to search for the coherent, neutrinoless conversion of a muon into an electron in the field of an aluminium nucleus. This process violates charged lepton flavor conservation and is forbidden in the Standard Model, so its observation would be a clear indication of new physics. COMET targets an ultimate single-event sensitivity of 10^{-17}, improving the current limit by four orders of magnitude. The experiment is being conducted in two stages: the first phase (COMET Phase-I) will characterize the high-intensity muon beam and measure background processes, while already achieving a sensitivity of around 10^{-15}. All the superconducting magnets required for COMET have now been delivered and their installation is well under way, accompanied by steady progress in the construction of the detector systems. This presentation will provide an update on the current status of the facility and detector construction, and outline the plans toward the forthcoming Phase-I data taking and the full-sensitivity search.

Primary author: UENO, Kazuki (The University of Osaka)

Presenter: UENO, Kazuki (The University of Osaka)

Session Classification: Scientific Program

Contribution ID: **49** Type: **Oral**

Overview and status of the Mu2e experiment

Saturday, 27 September 2025 19:00 (30 minutes)

Neutrino oscillations have shown that lepton flavor is not a conserved quantity. Charged lepton flavor violation (CLFV) is suppressed by the small neutrino masses well below what is experimentally observable, while new physics models predict higher rates of CLFV. The CLFV μ− ⟶ e− conversion process is sensitive to a wide range of new physics models. The upcoming Mu2e experiment at FNAL will search for this CLFV process with unprecedented sensitivity.
The Mu2e experiment is currently under construction at FNAL. I will present an overview of the experiment and the current status as we prepare for the first physics run (Run 1) in 2027 before the long accelerator shutdown at FNAL. Mu2e will then continue running after the shutdown, collecting the remainder of its dataset in Run 2. Mu2e will improve the current sensitivity to μ− ⟶ e− conversion by a factor of 10,000 using the complete Run 1+2 dataset.

Primary author: MACKENZIE, Michael (Yale University)

Presenter: MACKENZIE, Michael (Yale University)

Session Classification: Scientific Program

Contribution ID: **51** Type: **Oral**

CERN: Antimatter Under The Microscope

Sunday, 28 September 2025 09:00 (30 minutes)

n this contribution I will review the experimental efforts currently operated at the antimatter factory of CERN to test the fundamental charge, parity, time reversal invariance and other fundamental symmetries using antiprotons, antiprotonic atoms, and antihydrogen. The talk will review several world-class precision spectroscopy results, including proton/antiproton charge-to-mass ratio and magnetic moment comparisons, as well as results of antihydrogen precision spectroscopy. I will also talk about most recent results on studying gravity with baryon antimatter systems, and will give an outline on the future of the program, that will e.g. include antiproton transport and spectroscopy of the antihydrogen molecular ion.

Primary author: ULMER, Stefan (HHU Duesseldorf, RIKEN, CERN)

Co-author: ON BEHALF OF THE AD/ELENA COLLABORATIONS

Presenter: ULMER, Stefan (HHU Duesseldorf, RIKEN, CERN)

Session Classification: Scientific Program

Contribution ID: **52** Type: **Oral**

New Era in Fundamental Physics with Antihydrogen

Sunday, 28 September 2025 09:30 (30 minutes)

Antihydrogen—a bound state of an antiproton and a positron—offers a viable platform for precision tests of fundamental symmetries in nature. Over the past two decades, experimental progress has transformed antihydrogen studies from the demonstration phase into the precision measurement phase. In this talk, I will review recent advances in antihydrogen research, with a focus on results from the ALPHA experiment. I will also share my personal perspectives on future directions, including efforts toward the simultaneous confinement of antihydrogen and hydrogen ("ALPHA Next Generation"), and the development of antihydrogen fountains and interferometers through the HAICU project at TRIUMF.

Primary author: FUJIWARA, Makoto

Presenter: FUJIWARA, Makoto

Session Classification: Scientific Program

Contribution ID: **53** Type: **Oral**

Microwave Spectroscopy of Antihydrogen in the ALPHA Experiment

Sunday, 28 September 2025 10:00 (15 minutes)

Antihydrogen, the bound state of an antiproton and a positron, o ers a unique platform for testing fundamental symmetries in physics [1]. Measurements of the antihydrogen atomic spectrum can allow for stringent testing of CPT symmetry as the transition frequencies are predicted to be identical to hydrogen. Among the most sensitive tests is the measurement of ground-state hyperfine splitting, a transition well-characterized in hydrogen and now accessible in antihydrogen through precision microwave spectroscopy. The Antihydrogen Laser PHysics Apparatus (ALPHA) has produced, trapped, and studied antihydrogen through spectroscopic and gravitational measurements [2,3]. Through microwave spectroscopy, the hyperfine structure of the ground state of antihydrogen has been investigated [4]. Recent advances in antihydrogen production and magnetic field control have enabled a new protocol for such a microwave experiment. In this talk, I will discuss the latest hyperfine measurements in ALPHA and prospects for improved measurements.

[1] M. Charlton, S. Eriksson, and G. M. Shore. "Antihydrogen and Fundamental Physics"(Springer Cham, 2020).
[2] ALPHA Collaboration. Precision spectroscopy of the hyperfine components of the 1S–2S transition in antihydrogen. Nature Physics 21, 201 (2025).
[3] ALPHA Collaboration. Observation of the e ect of gravity on the motion of antimatter. Nature 621, 48 (2023).
[4] ALPHA Collaboration. Observation of the hyperfine spectrum of antihydrogen. Nature 548, 66–69 (2017). https://doi.org/10.1038/nature23446

Primary author: POWELL, Adam (CERN)

Presenter: POWELL, Adam (CERN)

Session Classification: Scientific Program

Contribution ID: **54** Type: **Oral**

Search for new gravity-like short range interactions in the submicron range by means of neutron-nanoparticle scattering

Sunday, 28 September 2025 10:45 (30 minutes)

In modern physics, four fundamental interactions—electromagnetic, strong, weak, and gravitational—are being studied under a unified framework known as the Theory of Everything. Among them, gravity is significantly weaker than the others, which has been known as the hierarchy problem. One proposed solution is the Large Extra Dimension (LED) model, which suggests that additional spatial dimensions exist beyond our familiar three. Graviton can propagate through these extra dimensions, but in our observable 3D space, it manifests itself as a Yukawa-type interaction. This leads to possible deviations from Newtonian gravity at short distances, which can be experimentally probed. To search for such deviations, experiments have been carried out at the laboratory level using torsion balances and cantilevers, or limits on the unknown force have been obtained by reanalyzing the results of existing experiments, such as the Casimir force measurement experiment. In our study, we focus on small-angle neutron scattering (SANS) as a tool for investigating deviations in the submicron scale. SANS measures the momentum transfer distribution, which is the Fourier transform of the scattering potential. When a Yukawa potential is added to the nuclear potential, a characteristic momentum transfer distribution emerges. Since the Yukawa interaction of the present interest is a gravity-like one, its strength is proportional to the target mass. In addition, the scattering intensity is enhanced in the case of coherent scattering by many particles contained in a volume corresponding to the momentum transfer in the scattering. Since this enhancement is useful to improve the sensitivity of the measurement, we conducted SANS experiments using nanoparticles, whose sizes are well-suited to probe interactions in submicron scales. In the case of coherent scattering, the background due to nuclear scattering is also enhanced. To suppress nuclear scattering, the nanoparticle target had to be made with an element with small coherent scattering length such as vanadium. Recently, we have succeeded in producing real nanopowder made of vanadium for the first time, and using it as the target, a SANS measurement was carried out at the J-PARC spallation neutron facility. In addition, we are working on the development of hydrogenabsorbing vanadium nanoparticles to further reduce nuclear force scattering. This presentation will explain the theoretical background, experimental methods, target development, and results of our neutron scattering experiments, as well as discuss future directions for probing short-range modifications to gravity.

Primary author: KONDO, Ryota (RCNP, Osaka University)

Co-authors: YOUNG, Albert; HADDOCK, C. C.; SHIMIZU, Hirohiko M.; HIROTA, Katsuya; MISHIMA, Kenji; KITAGUCHI, Masaaki; HIROMOTO, Masayuki; NAKABE, Rintaro; INO, Takashi; YOSHIOKA, Tamaki; SHIMA, Tatsushi; SNOW, W. Michael; YOSHIKAWA, Yuki

Presenter: KONDO, Ryota (RCNP, Osaka University)

Session Classification: Scientific Program

Contribution ID: **55** Type: **Oral**

LEMING - towards measuring the gravitational acceleration of muonium

Sunday, 28 September 2025 11:15 (30 minutes)

The LEMING experiment at PSI aims for measuring the gravitational acceleration of muonium (Mu), and to carry out next generation laser spectroscopy experiments in search for beyond SM physics. We developed a novel cold muonium source by converting conventional (sub)surface muons in a thin layer of superfluid helium, resulting in a high brightness atomic beam. The new conversion method using high intensity continuous muon beams available at PSI allows the event-by-event probing of a large yield of Mu atoms in an atomic interferometer.
In this talk, the latest progress and future plans are presented.

Primary author: SOTER, Anna

Presenter: SOTER, Anna

Session Classification: Scientific Program

Contribution ID: **56** Type: **Oral**

Review on Gravitational Inverse Square Law and Lorentz Violation

Sunday, 28 September 2025 11:45 (30 minutes)

To experimentally make breakthroughs in exploring quantum gravity, searching for the violation of the gravitational inverse square law to probe large extra dimensions predicted by string theories, and the violation of Lorentz symmetry, is attracting significant interest. Recent progress on these fields and their interpretations will be presented in this talk. Especially, the gravitational inverse square law is tested on a wide variety of scales, from laboratory to quark scales, but their mutual interpretation in physics models is confusing. Their comparison in the same parameter spaces will be shown to introduce the experimental attempts.

Primary author: MURATA, Jiro (Rikkyo University)

Presenter: MURATA, Jiro (Rikkyo University)

Session Classification: Scientific Program

Contribution ID: **60** Type: **Poster**

Scattering length measurements using Multilayer Neutron Interferometer at J-PARC.

Thursday, 25 September 2025 16:05 (1 minute)

The coherent scattering length (b_c) is a key parameter for neutron experiments. In addition, the b_c for some nuclei have important physical significance. The b_c is measured by several methods, including cross-section measurements and diffraction, and is mainly measured using a neutron interferometer(NI). However, the sensitivity of conventional NI, which is made of Si crystal, has been limited by its experimental setup. Therefore, we developed a multilayer NI. Utilizing the multilayer NI with the pulsed neutron source supplied by J-PARC and the time-of-flight method, we can simultaneously use a wide range of neutron wavelengths. We observed an interferogram along wavelengths with higher sensitivity than conventional NI. In this presentation, we will report the latest results of the b_c measurements.

Presenter: NAMBU, Taro (Nagoya Univ., RIKEN)

Session Classification: Poster flash

Contribution ID: **61** Type: **Poster**

COW Experiments Using Multilayer-type Neutron Interferometer

Thursday, 25 September 2025 16:06 (1 minute)

The COW experiment conducted in 1974 was the first to observe the gravitational interaction of neutrons as quantum particles. In this experiment, the phase shift was measured between neutron waves traveling along two paths at different heights in an interferometer, reflecting the difference in gravitational potential. Precise measurements of gravitational effects on neutrons can test the equivalence principle and explore possible modifications to gravity, opening new opportunities to search for physics beyond the standard model. To investigate these phenomena, we are performing follow-up experiments to the original COW experiment using a multilayer-type neutron interferometer developed in 2024. Unlike previous studies employing silicon single crystals, our interferometer uses multilayer neutron mirrors to control the neutron waves, enabling longer wavelengths and larger path separations, which improve measurement precision. In February 2025, we successfully observed gravitationally induced phase shifts for the first time using this multilayer cold neutron interferometer at the pulsed neutron source at J-PARC. At this conference, we will present our experimental results and discuss future prospects for precision studies of gravity with the neutron interferometer.

Presenter: FUJIIE, Takuhiro (Rikkyo Univ.)

Session Classification: Poster flash

Contribution ID: **62** Type: **Poster**

Validation of optically polarized alkali metal atoms for muonic helium measurements

Thursday, 25 September 2025 16:07 (1 minute)

Muonic helium is an exotic atom with one of the two electrons replaced by a negative muon. This three-body atomic system provides opportunities to precisely study the negative muon magnetic moment and mass as well as bound-state QED through the hyperfine structure interval. Muonic helium atoms are formed by stopping a negative muon beam in dense helium gas. Although the muon beam is primarily spin-aligned, the resulting muonic helium atoms lose their polarization by a factor of ten or more in the capturing process. The muon spins can, however, be repolarized by spin-exchange collisions with polarized alkali metal atoms [1], which is essentially the same as spin-exchange optical pumping used to polarize noble gas nuclei [2]. This experiment is now underway at the J-PARC Muon Science Facility (MUSE) [3]. To efficiently repolarize muonic helium atoms, it is essential to maximize the number of spin-polarized alkali metal atoms by optimizing the optical pumping conditions. The alkali metal state can be spectroscopically validated with a wavelength tunable laser. We have recently developed a probe laser that covers a wide wavelength range from 762 nm to 790 nm. It successfully accommodates the K D2 line (766.701 nm), K D1 line (770.108 nm), and Rb D2 line (780.241 nm) so that their absorption spectra and other properties can be studied at the same time and in the same condition. We present our newly developed wavelength tunable laser and some spectral measurements that evaluate the number densities and polarizations of alkali metal atoms. [1] A. S. Barton et al., Phys. Rev. Lett. 70, 758 (1993). [2] T. R. Gentile, P. J. Nacher, B. Saam, and T. G. Walker, Rev. Mod. Phys. 89, 045004 (2017). [3] P. Strasser et al., Eur. Phys. J. D 79, 20 (2025).

Presenter: INO, Takashi (KEK)

Session Classification: Poster flash

Contribution ID: **63** Type: **Poster**

Study of temperature dependence of adsorption rate of OTS coatings and optimization for trapping of Fr

Thursday, 25 September 2025 16:08 (1 minute)

Francium (Fr), the heaviest alkali element, is predicted to exhibit the largest enhancement factor of electron electric dipole moment (EDM) among alkali atoms, making it a promising candidate for probing physics beyond the standard model. To realize a high-precision EDM measurement with Fr, laser cooling and quantum control techniques are typically employed. In our experiment, we aim to trap Fr atoms in an optical lattice. A crucial requirement for this approach is the ability to confine many Fr atoms in a localized measurement region for an extended period. To increase the number of trapped atoms, we utilize a coated glass cell. The coating material used is octadecyltrichlorosilane (OTS: C18H37SiCl3), which can be chemically applied and is known as its anti-adsorption properties for glass surface.
In this context, we consider four key factors: (1) the adsorption rate of Fr atoms on the coating surface, (2) potential contamination caused by evaporation or degradation of the coating material (particularly during a vacuum bake out), (3) the reflection behavior of Fr atoms in the absence of adsorption, and (4) scattering of external light (e.g., optical lattice beams) from the coated surface.
This study focuses particularly on the second issue, investigating the temperature dependence of adsorption rate and thermal stability of the OTS coating. Our goal is to optimize system conditions for effective trapping of Fr and thereby improve the overall performance of EDM measurements using Fr atoms.

Presenter: TSUTSUI, Ryosuke (The University of Tokyo)

Session Classification: Poster flash

Contribution ID: **64** Type: **Poster**

A plan for antineutron-nucleus scattering experiments toward neutron-antineutron oscillation searches

Thursday, 25 September 2025 16:09 (1 minute)

Neutron-antineutron oscillations, which violate both B and B-L, have attracted attention in the context of baryogenesis to explain the matter-dominated universe. In searches for the oscillations, the antineutron-nucleus scattering length is one of the important parameters. We plan to perform scattering experiments using low-energy antineutron beams at the CERN AD.

Presenter: FUJIOKA, Hiroyuki (Institute of Science Tokyo)

Session Classification: Poster flash

Contribution ID: **65** Type: **Poster**

Trapping of francium-221 atoms for the measurement of the electron's electric dipole moment

Thursday, 25 September 2025 16:10 (1 minute)

The electron's electric dipole moment (EDM) is a parameter that violates CP symmetry assuming the CPT invariance. Measuring the EDM provides constraints on the theories beyond the Standard Model of particle physics. Francium (Fr) is expected to exhibit the largest enhancement factor for the electron EDM among all alkali atoms. Because Fr has no stable isotope, we adopted Fr-221 produced via alpha-decay from actinium-225 (225Ac) with a half-life of 9.9 days. For precise spectroscopic measurements, yttrium was deposited on the 225Ac source by argon sputtering to slow down and neutralize the emitted Fr atoms. In this presentation, we will report the results of our recent experiment.

Presenter: NAKASHITA, Teruhito (Graduate School of Arts and Sciences, The University of Tokyo)

Session Classification: Poster flash

Contribution ID: **66** Type: **Poster**

Laser frequency stabilization using saturated absorption spectroscopy and magneto-optical trap of Rubisium in glass cell.

Thursday, 25 September 2025 16:11 (1 minute)

In order to measure the electron's electric dipole moment (eEDM), a sufficient number of atoms must be trapped to reduce statistical uncertainty. In particular, to realize it, stabilizing laser frequency is required.
In this experiment, saturated absorption spectroscopy (SAS) was employed with
techniques of frequency modulation spectroscopy (FMS) and modulation transfer spectroscopy (MTS) to extract signals which are essntial for controlling laser frequency. The signals from SAS were processed via a servo circuit and the feedback signals were transfered to a piezoelectric device which manipulates the frequency. Moreover, magneto-optical trap (MOT) was implemented with the frequency-stabilized laser, and 87Rb atoms were successfully trapped in a glass cell.
We will report an overview of the entire stabilization system, and a quantitative
evaluation of the number of trapped atoms in this presentation.

Presenter: NEZU, Yu (Rikkyo University)

Session Classification: Poster flash

Contribution ID: **67** Type: **Poster**

A comagnetometer using 87Rb and 133Cs atoms in an optical lattice trap

Thursday, 25 September 2025 16:12 (1 minute)

The electric dipole moment (EDM) has been investigated as a highly sensitive probe for physics beyond the standard model. The EDM of francium (Fr) has attracted attention as a target for measurements of electron's EDM because the enhancement factor of electron's EDM for Fr is 799 [1] and laser cooling and trapping of Fr elongates the interacting time with electric fields.
To evaluate the sources of systematic errors in EDM measurements for Fr, the Zeeman shifts and the light shifts of Rb, and Cs trapped with Fr were simultaneously measured by using Faraday rotations of probe beams. We demonstrated a proof-of-principle experiment using 87Rb and 133Cs trapped in an optical lattice as a comagnetometer. In this presentation, We will report the result of the recent experiment.

[1] N. Shitara, N. Yamanaka, B. K. Sahoo, T. Watanabe, and B. P. Das, J. High Energy Phys. 2021, 124(2021)

Presenter: ABE, Kota (Rikkyo University)

Session Classification: Poster flash

Contribution ID: **68** Type: **Poster**

Nuclear laser spectroscopy of thorium-229 doped in CaF2

Thursday, 25 September 2025 16:13 (1 minute)

"The thorium-229 nucleus possesses a first excited isomeric state with an excitation energy of 8.36 eV, which is extremely low for an atomic nucleus.
In 2024, laser excitation was achieved using a vacuum ultraviolet (VUV) laser[1][2][3], raising expectations for applications such as high-precision frequency standards.
We performed comprehensive spectroscopy experiments of 229Th-doped CaF2 crystals using a VUV pulsed laser with a linewidth of about 30 MHz and a detector system that can significantly reduce background.
This combination enables us to identify four distinct dopant sites within the CaF2 lattice, each with a characteristic electric field gradient.
In this poster, the VUV laser and the detection system, measured spectra, lifetime measurement, and laser-induced quenching of the isomeric state will be presented.

[1] J. Tiedau et al., Phys. Rev. Lett. 132, 182501 (2024).
[2] R. Elwell et al., Phys. Rev. Lett. 133, 013201 (2024).
[3] C. Zhang et al., Nature 633, 63 (2024)."

Presenter: HIRAKI, TAKAHIRO (Okayama University)

Session Classification: Poster flash

Contribution ID: **69** Type: **Poster**

Muon Penning Trap at J-PARC

Thursday, 25 September 2025 16:14 (1 minute)

We are developing a device to trap muons in a Penning trap at J-PARC. Recently, we succeeded in trapping negative muons in vacuum using a pulsed electric field and a static magnetic field. Although a negative muon stopped in matter is captured by its atomic nucleus and its lifetime gets shorter than in vacuum, we can measure the lifetime of the negative muon directly using our muon trap technique. In addition, we aim to observe anti-muonium for the first time by trapping negative muons and positrons simultaneously, which will lead to precision spectroscopy measurements of anti-muonium and CPT tests in the muon sector by comparing basic parameters (mass, lifetime, energy levels, etc.) of the positive and negative muons. This poster will report on the latest results and status of our muon Penning trap project.

Presenter: YAMAZAKI, Takayuki (KEK/J-PARC)

Session Classification: Poster flash

Contribution ID: **70** Type: **Poster**

Quantum Gravitational Signatures in Neutrino Oscillations

Thursday, 25 September 2025 16:15 (1 minute)

Neutrinos undergoing stochastic perturbations as they propagate may experience decoherence which leads to a damping in the neutrino oscillation probability over distance. Such perturbations may result from quantum gravitational effects such as neutrino-virtual black hole interaction scenarios. My project is about investigating the resulting signals in DUNE and T2K and test the sensitivity of future measurements.

Presenter: BATHE-PETERS, Lars (University of Oxford)

Session Classification: Poster flash

Contribution ID: **71** Type: **Poster**

Double resonance spectroscopyof ^4^F_5/2_ state in Er:YSO crystal for coherence generation

Thursday, 25 September 2025 16:16 (1 minute)

Coherent amplification is useful to detect very weak signals, like signals from axions, dark photons, etc. Because its signal intensity is proportional to the square of the atoms inside the system. Ion-doped crystal is a very good material for coherent amplification due to its dense number of atoms inside the crystal. In order to detect such a weak signal, one must generate a coherence between two excited states. The efficient way to generate such coherence is double resonance. We used 640nm ring dye laser and 1538nm ECLD for the double resonance pumping. The lasers excites the ions on the ground state ^4^I_1 5/2 to the 1st excited state ^4^I_1 3/2, and again excites the ions up to ^4^F_5/2 . In order to observe the potentially weak signal, we used photomultiplier tube to measure the fluorescence. In this poster, we present the absorption spectrum and the fluorescence emission spectrum of the transition between ^4^I_1 3/2 state and ^4^F_5/2 state.

Presenter: HAN, Junseok (Seoul National University)

Session Classification: Poster flash

Contribution ID: **72** Type: **Poster**

Evaluation of Actinide-Doped Crystals via X-ray Spectroscopy for Solid-state Nuclear Clock

Thursday, 25 September 2025 16:17 (1 minute)

The thorium-229 nucleus has an exceptionally low first excited isomeric state at around 8 eV. As it can be excited by laser light, it is expected to be used in the development of nuclear clocks. In particular, solid-state nuclear clocks employing crystals doped with thorium-229 are anticipated to enable compact and outstandingly stable time standards as they can simultaneously excite a large number of nuclei. An excitation scheme with a narrow-band laser must be tuned to a transition in the nuclear level scheme, which is strongly influenced by the surrounding crystal structure. In this study, we conducted X-ray absorption fine structure (XAFS) measurement on calcium fluoride (CaF_2) crystals doped with thorium and uranium to investigate their charge states and local structures in the solid state. In this presentation, we will provide an overview of the XAFS experiments and the results of the characterization evaluation.

Presenter: TAKATORI, Sayuri (Okayama univ.)

Session Classification: Poster flash

Contribution ID: **73** Type: **Poster**

Cryogenic Buffer Gas Cooling of Tungsten Carbide

Thursday, 25 September 2025 16:18 (1 minute)

"The existence of a permanent electric dipole moment of the electron (eEDM) would violate time-reversal symmetry and suggest new physics beyond the Standard Model.
Recently, polar molecules have been widely used in eEDM research because they generate strong internal effective electric fields and can offer quantum states that help suppress systematic errors. In particular, beam-based experiments such as ACME use polar molecules in high-flux molecular beams to probe the eEDM with high precision[1].

With such an approach in mind, we are exploring alternative molecular candidates that may further enhance sensitivity. One promising candidate is tungsten carbide (WC). In eEDM measurements, sensitivity improves with the strength of the internal effective electric field, the interaction time, and the number of detected molecules. WC offers a favorable combination of these factors.
Compared to ThO, which utilizes a metastable excited state, WC can be used in its ground state, enabling longer interaction times and improved statistical sensitivity[2]. Moreover, WC is non-radioactive, making it easier and safer to handle in experiments.

We are currently developing a cryogenic buffer gas beam source to produce WC. In this technique, molecules are generated via laser ablation and then cooled through collisions with a cryogenic rare gas, such as helium.
Furthermore, achieving longer interaction times requires decelerating heavy polar molecules. To this end, we are exploring the use of centrifuge deceleration.

In this presentation, we report our progress in developing a cold WC beam, including the design of the source and detection method."

Presenter: UCHIMURA, Haruto (Okayama University)

Session Classification: Poster flash

Contribution ID: **74** Type: **Poster**

Simulation study of a centrifuge deceleration for heavy polar molecules

Thursday, 25 September 2025 16:19 (1 minute)

Deceleration of heavy polar molecules is one of the critical steps toward future searches for the electric dipole moment (EDM) using molecules [1], enabling extended coherence times or efficient trap loading. Among various techniques developed for molecular slowing, such as laser slowing [2], Stark deceleration [3,4], and Zeeman Sisyphus methods [5], centrifuge deceleration [6] offers distinct advantages. It is insensitive to molecular internal structure and operates continuously, making it well suited for diverse species and compatible with Cryogenic Buffer Gas Beam (CBGB) sources. However, its application to heavy molecules remains unexplored. We performed a Monte-Carlo simulation of centrifuge deceleration for heavy polar molecules to investigate the feasibility of this scheme for future EDM searches. The molecule studied is tungsten monocarbide (WC), which has a 3Δ1 electronic state, preferred state for electron EDM measurement for the same reason as ThO [8] and HfF+ [9]. In WC, the 3Δ1 electronic state is the ground state, allowing the decelerated beam to achieve longer coherence times.
The simulation result is shown in Fig. 1. Our results demonstrate that, for an initial peak velocity below 135 m/s, a decelerator with a 40 cm radius can decelerate the molecules to below 30 m/s with an efficiency of ~0.1 %. We also found that YbF, another EDM measurement candidate, can be decelerated under similar conditions. These findings highlight the potential of centrifuge deceleration as a practical and versatile tool for future EDM measurements.

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Presenter: MASUDA, Takahiko (RIIS, Okayama University)

Session Classification: Poster flash

Contribution ID: **75** Type: **Poster**

Investigating energy exchange dynamics in trapped antihydrogen for precision tests of fundamental symmetries

Thursday, 25 September 2025 16:20 (1 minute)

"The ALPHA (Antihydrogen Laser PHysics Apparatus) experiment uses magnetically trapped antihydrogen to test fundamental matter–antimatter symmetries. As the simplest anti-atom, antihydrogen is a promising candidate for testing CPT symmetry in an atomic system and the Weak Equivalence Principle (WEP) with antimatter. ALPHA has already achieved major milestones, including the first observation of gravity's effect on the motion of antimatter [1], the first precision measurement of the 1S-2S transition frequency [2], spectroscopy of the 1S-2P transitions [3], and observation of ground state hyperfine splitting [4] in antihydrogen.

Moving forward, ALPHA aims to improve experimental precision for more stringent tests of CPT symmetry and the WEP. Many of ALPHA's measurements critically rely on simulations to extract fundamental physics parameters or interpret spectroscopic line shapes. These simulations make intriguing predictions about the non-linear dynamics of trapped anti-atoms that are not currently well understood. In particular, simulations predict that some anti-atoms exchange energy between degrees of freedom, while others do not [5]. The existence of these two categories of anti-atoms has not previously been observed experimentally. Furthermore, the energy distributions of trapped anti-atoms are not well understood but are a crucial variable for future precision experiments. Laser cooling of antihydrogen, microwave and 1S-2S spectroscopy, and measurements of the gravitational acceleration of antimatter all rely on understanding energy exchange and distributions in ALPHA.

This poster presents the first direct experimental evidence differentiating anti-atoms that exchange energy components from those that do not. The technique used to distinguish these two categories of anti-atoms is also presented as a new method to characterize energy distributions of trapped antihydrogen. These studies work toward a comprehensive understanding of energy exchange dynamics in ALPHA, both benchmarking simulations against experiments and informing future high precision tests of fundamental symmetries.

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Presenter: SWADLING, Abbygale (University of Calgary)

Session Classification: Poster flash

Contribution ID: **76** Type: **Poster**

Development of a Multi-particle Imager for Exotic Atom Spectroscopy and Interferometry

Thursday, 25 September 2025 16:21 (1 minute)

Precision spectroscopy of exotic atoms, such as muonium and antihydrogen, is a powerful method for testing the Standard Model of particle physics and searching for new physics beyond it. For example, measurements of the muonium hyperfine structure provide the most stringent tests of bound-state quantum electrodynamics (QED), while spectroscopy of antihydrogen allows for high-precision tests of CPT invariance. However, the precision of measurements involving excited states, such as the muonium Lamb shift, remains at the sub-percent level. This is primarily due to the challenge of detecting the vacuum ultraviolet (VUV) photons (at 122 nm) emitted during atomic de-excitation. Conventional detectors like photomultipliers and microchannel plates (MCPs) have a quantum efficiency of only a few percent for VUV light, making it challenging to distinguish the signal from background events, such as positrons from muon decay. A similar challenge limits non-destructive comparative studies between antihydrogen and hydrogen, and muonium interferometry involving muonium in excited states. To overcome this limitation, we are developing a multi-particle imager specifically designed for next-generation exotic atom experiments. The core of the detector is a "tapered" MCP (T-MCP) combined with a resistive anode encoder. The T-MCP features an optimized surface geometry that achieves high detection efficiency for VUV photons, while the complete imager is designed to distinguish these photons and neutral atoms from charged particle backgrounds and provide position information for each. In this contribution, we present the development status and test beam results.

Presenter: KANDA, Sohtaro (KEK)

Session Classification: Poster flash

Contribution ID: **77** Type: **Poster**

Development of in-situ 3He spin filter for epithermal neutrons to search for unknown T-violation using compound nuclei

Thursday, 25 September 2025 16:22 (1 minute)

A significant enhancement of parity violation in the nucleon-nucleon interaction has been observed in compound nuclei formed when medium-mass nuclei such as 139La and 131Xe capture neutrons at specific resonance energies. This enhancement is considered to result from the mixing of s and p wave neutron amplitudes. Theoretically, similar mechanisms are also expected to greatly amplify T-violation effects. Utilizing this amplification, we are planning an experimental search for unknown T-violation in the nucleon-nucleon interaction using polarized nuclear targets and polarized neutrons.

We have selected 139La as the candidate for the polarized nuclear target, as it exhibits a large enhancement effect and has a p-wave resonance at 0.75 eV. For neutron polarization, we plan to use a 3He spin filter, which polarizes neutrons based on the spin dependence of the 3He nuclear absorption cross section. Although 3He spin filters are already used in various experiments at J-PARC, their neutron polarization at 0.75 eV is currently limited to approximately 30–40%.

To address this, we are developing a 3He spin filter for epithermal neutrons, capable of achieving up to 80% polarization at 0.75 eV. We fabricated a 20 cm long, 3-atm 3He cell, about two to three times longer than those currently used. In addition, we optimized the magnetic field uniformity, which is one of the factors in 3He polarization relaxation, using finite element simulations to design a new coil system and evaluated the performance of the 3He spin filter for epithermal neutrons. Furthermore, we are developing a compact system for in-situ 3He polarization at neutron beamlines, incorporating a 100 W laser and optical components housed in a light-shielded enclosure. We have conducted 3He polarization tests with this system off-beamline and achieved the polarization sufficient for the planned experiment. In this presentation, we report the detailed status of these developments.

Presenter: ASAI, Kanta (Nagoya University)

Session Classification: Poster flash

Contribution ID: **78** Type: **Poster**

Frequency stabilization of 221Fr D2-line laser using iodine spectrum

Thursday, 25 September 2025 16:23 (1 minute)

Francium (Fr) is expected to exhibit the largest atomic electric dipole moment (EDM) among alkali atoms, making it an ideal candidate for probing physics beyond the standard model. In particular, 221Fr is of interest due to its potential for continuous extraction from 225Ac and its enhanced sensitivity to quark EDMs through nuclear octupole deformation. To achieve high-precision EDM measurements, laser cooling and quantum control are essential. For this purpose, a narrow-linewidth laser is required to operate a magneto-optical trap (MOT) for 221Fr. The MOT trap transition of 221Fr D2 line (417.399579(50) THz) lies only 0 – 0.2 GHz away from a peak in R(133) 3-10 lines of molecular iodine (Atlas line number 380) (Fig. 1). A CW-mode Ti:sapphire laser is successfully locked to this iodine absorption line for more than 10 hours, achieving a frequency fluctuation within 2 MHz (Fig. 2). This laser system will be used for MOT of 221Fr. In addition, we plan to implement offset-locking techniques to generate repumping and auxiliary beams necessary for full laser trapping and measurement.

Presenter: NAKAZAWA, Masaki (The University of Tokyo)

Session Classification: Poster flash

Contribution ID: **79** Type: **Poster**

Laser Diagnositic System Design and Simulation of Ultra-slow Muon Generation for the J-PARC Muon g-2/EDM Experiment

Thursday, 25 September 2025 16:24 (1 minute)

"The ultra-slow muon (USM), developed for the J-PARC Muon g-2/EDM experiment, is produced through the ionization of muonium at room temperature using a combination of 122 nm and 355 nm laser—a process known as muon cooling. The first beam test employing this laser setup is scheduled at the end of 2025. Despite its crucial role in determining USM yield, the laser system has several challenges for proper diagnostics due to its short wavelength (122 nm), short pulse duration (2 ns FWHM), and high pulse energy (10 μJ).
To address these challenges, a laser diagnostic system has been developed to adjust and monitor the optical path, and measure key laser parameters such as spot size and pulse energy. This poster first outlines the design principles and functionalities of the diagnostic system. Utilizing this system, a series of laser parameter scans are planned to extract indirectly measurable quantities such as pulse timing, spatial overlap, and linewidth. Simulation studies for each scan, along with the expected outcomes, will also be presented."

Presenter: LYU, Meng (University of Tokyo)

Session Classification: Poster flash

Contribution ID: **80** Type: **Poster**

Development of a Cryogenic insert for polarized nuclear target for NOPTREX Phase-1 Experiment

Thursday, 25 September 2025 16:25 (1 minute)

The NOPTREX collaboration aims to search for time-reversal symmetry violation (T-violation) beyond the Standard Model using compound nuclear reactions. For a high-sensitivity T-violation search, the spins of polarized neutrons and polarized nuclear targets must be aligned perpendicularly. However, transporting neutron spin orientation is technically challenging. As a Phase-1 experiment, we plan to perform measurements with a configuration that allows easier neutron spin transport, albeit with reduced sensitivity: the spins of the neutrons and target nuclei are parallel, and the neutron spins are rotated by a fixed angle relative to the neutron momentum. To realize this, we require a superconducting magnet that can generate a magnetic field parallel to the neutron momentum and a cryogenic system that can operate in conjunction with it. We are currently designing and developing a dilution refrigerator insert capable of reaching temperatures below 0.1 K. In this presentation, we will report on the current preparation status for the Phase-1 experiment at J-PARC MLF ANNRI (BL04), focusing on the design and development of the cryogenic insert for the polarized nuclear target system.

Presenter: KAWAMURA, Shiori (Nagoya university)

Session Classification: Poster flash

Contribution ID: **81** Type: **Poster**

Development of a Polarized ^{139}La Target for the NOPTREX Experiment

Thursday, 25 September 2025 16:26 (1 minute)

"The NOPTREX collaboration is planning to explore time-reversal invariance violation (T-violation) in neutron compound nuclear resonances using a polarized ^{139}La target. For this purpose, we are developing a polarized target system based on dynamic nuclear polarization (DNP), in which a single crystal of $LaAlO_3$ doped with a small amount of Nd^{3+} ions is used as a target material.

The NOPTREX project is proceeding in two steps: a preparatory Phase I and a full-scale Phase II. As a preparation for the Phase I, we tested a 15 mm cubic $LaAlO_3$ single crystal doped with 0.03 mol\% of Nd, which was grown by a company. Using the DNP method, we achieved the polarization of 36% in ^{27}La and the relaxation time of 60 minutes at 1.3 K and 2.335 T. These results show this crystal is practically available for Phase I since the target material will be cooled down at 0.1 K, where the relaxation time is expected to be longer.

In parallel, to study the effect of Nd concentration on the DNP performance, we are growing $LaAlO_3$ crystals by the floating zone (FZ) method at Tohoku University. The DNP experiment with the 0.01 mol% crystal at Yamagata University showed the relaxation time of 375 minutes in ^{27}Al under the same environment, which means that the longest relaxation time observed so far and the crystal is more suitable to the target material. The remaining problem is the crystal size, which is currently limited to, which is actually about 5 mm in diameter. Therefore, we are planning to use an assembled target with multiple crystals in Phase I or Phase II or producing a larger bulk crystal with the CZ method.

In this presentation, we report the current status of polarized ^{139}La target development, the recent DNP results, and future plans."

Presenter: OKUIZUMI, Mao (Nagoya University)

Session Classification: Poster flash

Contribution ID: **82** Type: **Poster**

Development of LBO glass scintillator for high-counting rate neutron detection for the NOPTREX experiment

Thursday, 25 September 2025 16:27 (1 minute)

"The NOPTREX collaboration is planning to search for time-reversal symmetry violation(T-violation) in nucleon-nucleon interaction at J-PARC. The search for T-violation involves measuring the T-odd cross-section between polarized neutrons and polarized nuclei. For highly-sensitive T-violation search, we require neutron detectors capable of operating under high flux conditions without degradation in performance. At J-PARC, where the T-violation experiment will be conducted, the neutron flux can reach up to Gcps, and γ-ray background is also present.
^{6}Li-glass scintillator is a strong candidate as a neutron detector. It has a light emission time constant of approximately 70 ns. Additionally a thickness of at least 1 cm is required to achieve sufficient neutron absorption for T-violation search, which in turn increases sensitivity to γ-ray background.
We propose LBO glass as a new scintillator, composed of B_2O_3 and Li_2O doped with CeO_2. This scintillator has several features: a faster light emission time constant of 5 ns and 40 ns, and larger neutron absorption cross section and effective detection with a reduced thickness of 1 mm with natural abundance of ^{6}Li and ^{1}0B, which also reduces γ-ray sensitivity. The light output of the LBO glass scintillator is about 10\% of that of the ^{6}Li-glass scintillator. Furthermore, LBO glass scintillator with low or zero CeO_2 concentration may eliminate the 40 ns slow component and exhibit lower sensitivity to γ-rays.
We are evaluating the properties of LBO glass scintillator using α-ray at Nagoya University. In addition, we fabricated LBO glass without Ce and measured light emission time constant at Saitama University. In this presentation, we report the detailed status of these developments."

Presenter: KUDO, Sota (Nagoya University)

Session Classification: Poster flash

Contribution ID: **83** Type: **Poster**

Precision Spectroscopy of Antiprotonic Atoms for Investigation of Low-energy Antinucleon–nucleus Interactions

Thursday, 25 September 2025 16:28 (1 minute)

Spectroscopy of hadronic atoms, where a negatively charged hadron such as π −, K−, or ̄p replaces an electron, offers a unique way to study the strong interaction. Among them, x-ray spectroscopy of antiprotonic atoms provides in-formation on antinucleon–nucleus interactions at low energy. Although a model exists based on global fits to data acquired up to the 1980s, it is limited by uncertainties in nucleon distributions in nuclei [1]. We propose new measurements using calcium isotopes, for which nucleon densities are well known, to reduce these uncertainties. Superconducting microcalorimeter transition-edge sensors offer a resolution of 50–70 eV, which will allow us to determine strong-interaction shifts and widths with an order-of-magnitude improvement over previous studies [2]. The results will refine antinucleon–nucleus optical potential models and have implications for future experiments searching for neutron–antineutron os-
cillations [3, 4].
In this contribution the background of the research will be described, and the status of the recent test experiments will be reported.

References

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Presenter: HIGUCHI, Takashi (KURNS, Kyoto U. / RCNP, Osaka U.)

Session Classification: Poster flash

Contribution ID: **84** Type: **not specified**

Introduction and Instructions

Thursday, 25 September 2025 16:00 (5 minutes)

Presenter: KITAGUCHI, Masaaki (Nagoya University)

Session Classification: Poster flash

Contribution ID: **85** Type: **Poster**

Emergence of magnetic monopoles for quark confinement due to violation of the non-Abelian Bianchi identity

Thursday, 25 September 2025 16:29 (1 minute)

The dual superconducting picture is one of the most promising scenario for quark confinement, where magnetic monopoles play a dominant role for confinement. Indeed, we have shown numerical evidence for the magnetic monopole dominance in the string tension on the lattice in gauge invariant way based on the the gauge-covariant decomposition due originally to Cho-Duan-Ge-Shabanov and Faddeev-Niemi.
In this presentation, we show a direct relation between the violation of the non-Abelian Bianchi identity (NABI) and the emergence of the magnetic monopole which is drived through the non-Abelian Stokes theorem. As a consequence, emergence of magnetic monopoles relates to violation of the NABI's.
Finally, we apply this formula to the SU(2) gauge-scalar model to reexamine the phase transition between the confinement and Higgs phases in the gauge independent way in view of higher form symmetry. We will further investigate the connection between the mass gap of the gauge field and the emergence of the magnetic monopoles.

Presenter: SHIBATA, Akihiro (KEK)

Session Classification: Poster flash

Contribution ID: **86** Type: **Poster**

A slow antihydrogen beam for CPT symmetry tests

Thursday, 25 September 2025 16:30 (1 minute)

The ASACUSA-Cusp collaboration intends to perform precision microwave spectroscopy of the antihydrogen ground-state hyperfine splitting to compare with analogous measurements in hydrogen [1]. This comparison can place limits on CPT violation and probes the matter-antimatter asymmetry. The beam needs to be spin polarised in the ground-state, with a velocity of <1500 m/s, to be compatible with our spectroscopy apparatus [2].
The beam is produced using the slow-merge mixing technique of combining antiproton and positron plasmas inside a Penning-Malmberg trap [3], where antihydrogen is formed primarily through three-body recombination [4]. A small fraction of the antihydrogen escapes out of the trap into the beamline, which is free of strong electric or magnetic fields. The beam has approximately 320 antihydrogen atoms per 15 minute experimental cycle, and is primarily comprised of Rydberg atoms. Using modulated electric field ionisation we have measured the velocity and quantum number distribution of the beam using time-of-flight techniques. These results will be presented, along with the requirements for producing an antihydrogen beam in this manner.

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Presenter: SHELDON, Ross (Austrian Academy of Sciences)

Session Classification: Poster flash

Contribution ID: **87** Type: **Poster**

Towards constraining short range forces by whispering gallery states of neutrons and hydrogen atoms

Thursday, 25 September 2025 16:31 (1 minute)

Whispering gallery states (WGS) of neutrons and cold atoms, as well as their interferences, are a very powerful tool to probe surface potentials in a curved wave guide. They form in slow particle beams that are confined by the quasi-centrifugal potential generated by the curvature of the wave guide, and the surface interaction exerted from the atoms of the wave guide on the particle beam. Compared to other methods relying on quantum states (such as gravitational quantum states (GQS)), WGS allow us observation of quantum states at higher beam velocities, and they also probe surface potentials at much smaller lengthscales [1, 2].
Short range interactions (SRI), mediated by unknown particles between the particle beam and the wave guide, will modify these surface potentials, and leave their imprint on the interferences of the WGS, manifesting as a small observable shift in the interference pattern of several states. WGS measurements are sensitive to SRI at typical lengthscales down to several 10s of nanometers, which is larger than the expected length scale of surface contact interactions, allowing us to eliminate false effects [3]. When placed in a gravitational field, WGS can also be used as a measurement of the gravitational acceleration.
We present results from our last beamtime of neutron WGS, as well as our newly developed analysis method, which enables us to detect small shifts in two-dimensional interference patterns, and that we have tested with very small, artificially induced magnetic shifts in polarized neutron beams at the Institut Laue-Langevin (ILL). Within the GRASIAN collaboration we prepare unprecedented WGS measurements with hydrogen atoms, to be carried out in 2026, utilizing a cryogenic hydrogen beam with slow horizontal velocities. A short overview of the preparation of this experiment will be presented.

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Presenter: SCHREINER, Katharina (Stefan Meyer Institute - Austrian Academy of Sciences)

Session Classification: Poster flash

Contribution ID: **88** Type: **Poster**

The Gamma Total Absorption Facility (GTAF) at CSNS Back-n: Enabling High-Precision (n,γ) Studies and Fundamental Symmetry Research

Thursday, 25 September 2025 16:32 (1 minute)

"The Gamma Total Absorption Facility (GTAF) is a high-efficiency gamma-ray spectrometer comprised of 40 BaF_2 (Barium Fluoride) scintillation crystals configured to achieve nearly 4π solid-angle coverage with approximately 90% gamma detection efficiency. This design enables the precise measurement of neutron capture events via coincidence detection of cascade gamma rays from (n, γ) reactions.
The Back-n white neutron beamline at the China Spallation Neutron Source (CSNS) delivers a high-flux pulsed neutron beam covering a wide energy range from 0.3 eV to 200 MeV. The combination of CSNS Back-n and GTAF enables precise measurements of (n,γ) reaction events through coincidence detection of cascade gamma rays, facilitating experiments to determine neutron radiative capture cross-sections and gamma-ray angular distributions, particularly sensitive in the eV region.
Also, GTAF with CSNS Back-n serves the international NOPTREX (Neutron Optical Parity and Time Reversal EXperiment) collaboration a platform to conduct experiments providing information to T-violating enhancement factors via precise measurements on angular distribution of (n, γ) reactions and performing enhanced measurements of P-violation with great statistics."

Presenter: LUAN, Guangyuan

Session Classification: Poster flash

Contribution ID: **89** Type: **Poster**

Status of DeeMe Experiment

Thursday, 25 September 2025 16:33 (1 minute)

The DeeMe experiment is planned at J-PARC MLF H-Line.
The experiment aims to search for the muon to electron conversion in the nuclear field, which is one of the charged lepton flavor violating processes that are forbidden in the Standard Model and expected to be highly sensitive to search for new physics.
The DeeMe experiment will be the first search with using muonic carbon atoms.
We aim to search with a single event sensitivity of O(10^-13).
DeeMe spectrometer commissioning and performance tests are ongoing.
In this presentation, we will describe the overview and current status of the DeeMe experiment.

Presenter: HIGASHINO, Yuta (The University of Osaka)

Session Classification: Poster flash

Contribution ID: **91** Type: **Poster**

Design study of a white muon beamline at RCNP for radioisotope production via muon capture reaction

Thursday, 25 September 2025 16:34 (1 minute)

The MuSIC beamline at the Research Center for Nuclear Physics (RCNP), Osaka University, provides a high-intensity continuous muon beam using proton beam (392MeV, 1.1 μA). Pions and muons generated in the graphite target are efficiently captured by the large solid angle superconducting solenoid magnet and are transported to the downstream[1] . At the experimental port located at the end of the beamline, monochromatic muon beam can be selected using dipole magnets. In contrast, a broad momentum muon beam, namely "white muon beam"was observed just downstream of the solenoid magnet[2] . Since negative muons are efficiently captured by target nuclei once stopped, the white muon beam is particularly advantageous for radioisotope (RI) production via the muon-induced capture reactions. We therefore explore the feasibility of modifying the existing muon beamline to provide a dedicated white muon beam and to enable efficient RI production via muon capture reaction. This study focuses on two objectives using a radium (226Ra) target.
The first objective is the production of francium isotopes (221Fr-225Fr), which are of particular interest for electron electric dipole moment (EDM), due to their high sensitivity[3] . Since francium isotopes do not occur naturally, a stable and high-intensity production method is required for practical use.
The second objective is the production of Actinium-225 (225Ac) for medical applications, which is utilized for an α-emitting radioisotope for alpha targeted therapy[4] . With the future development of an extremely high-intensity muon source, it could open the possibility of using white muons as a novel production method.
In this presentation, we investigate the beam characteristics of the white muon beam at the MuSIC beamline with the aim of optimizing beam parameters through Monte Carlo simulations. Furthermore, we evaluate the production yields of francium isotopes and actinium via muon-induced capture reaction using the same white muon beam.

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Presenter: YOKOTA, Keisuke (Osaka University)

Session Classification: Poster flash

Contribution ID: **92** Type: **Poster**

Nondestructive Depth Profiling on Roman Coins by Muon Induced X-rays in Japan Proton Accelerator Research Complex (J-PARC)

Thursday, 25 September 2025 16:35 (1 minute)

We conducted a non-destructive elemental depth analysis of a Roman silver coin excavated from the Tell Mishrifat Hajj Ali Issa, located in northern Syria, housed at the Ancient Orient Museum, using the negative muon beam at the Muon Science Laboratory (MSL), J-PARC. The developed detection system measured muonic X-rays induced at various implantation depths of negative muons, enabling evaluation of the depth profile of silver concentration down to approximately 1 mm from the surface. The results revealed a higher silver concentration near the surface and a lower concentration in deeper regions. For comparison, Edo-period Japanese silver currency ("Chogin") is known to have undergone a surface treatment called irotsuke, in which silver was enriched only at the outer layer due to depletion of silver resources. Previous non-destructive muon analyses successfully identified evidence of such treatments. In contrast, the Roman coin exhibited a distinctly different silver depth profile, raising discussion on whether the enrichment is due to intentional surface processing or the result of long-term corrosion and copper dissolution. In this poster, we also present recent progress in evaluating the depth distribution of oxygen, providing new insights into surface alteration mechanisms.

Presenter: TAMPO, Motonobu (KEK)

Session Classification: Poster flash

Contribution ID: **93** Type: **Poster**

Precise measurement of the parity violating asymmetry in the ^{139}La(n,γ)^{140}La^{*} reaction

Thursday, 25 September 2025 16:36 (1 minute)

Presenter: HAYASHI, Sodai (Nagoya University)

Session Classification: Poster flash

Contribution ID: **94** Type: **Poster**

Current Status and Prospects for Long-Term Precision Measurements of Muonium Hyperfine Structure in High Magnetic Field

Thursday, 25 September 2025 16:37 (1 minute)

Presenter: FUKUI, Kengo (Nagoya University)

Session Classification: Poster flash

Contribution ID: **95** Type: **Poster**

Development of 2 stage Ultra-slow muon generation target toward Muon transmission microscope

Thursday, 25 September 2025 16:38 (1 minute)

High-efficiency muonium production targets are a key element in research utilizing ultra-slow muon (USM) generation, such as the g-2/EDM experiment and transmission muon microscope. In particular, applications like transmission muon microscope require not only small-emittance sources, traditionally realized with planar silica aerogels, but also spatial convergence of USM beams. To address this need, we propose a novel 2 stage USM source based on engineered silica aerogel targets designed to achieve spatial focusing. We also present the development of femtosecond laser microfabrication techniques for precise surface structuring of aerogels, which are expected to enhance muonium emission yields and beam convergence.

Presenter: OOBE, Chikahiro (Ibaraki University)

Session Classification: Poster flash

Contribution ID: **96** Type: **Poster**

Laser wavelength tuning for (Anti) Hydrogen and/or Muonium resonant ionization

Thursday, 25 September 2025 16:39 (1 minute)

To advance the development of the Lyman-α light source for generating ultra-slow muons at J-PARC, as well as for spectroscopy and experiments involving muonium, hydrogen, and antihydrogen, it is essential to control not only spectral stability but also linewidth. In previous ultraslow muon experiments, the Lyman-α wavelength was tuned to the muonium 1s-2p resonance transition, and the spectral width was optimized to match the Doppler broadening of muonium by adjusting the wavelength-tunable Ti:sapphire laser in the light source system. In preparation for future applications, this study explores two approaches:
(i) designing and installing a solid etalon inside the Ti:sapphire resonator to enable precise wavelength control around 820 and 845 nm, and (ii) developing a feedback system to stabilize the RF power applied to the acousto-optic tunable filter (AOTF). These improvements enhance spectral control of the Lyman-α source, thereby establishing it as a reliable tool for resonant ionization of (anti-) hydrogen and muonium.

Presenter: SAKAMOTO, Shingo (Ibaraki University)

Session Classification: Poster flash

Contribution ID: **97** Type: **Poster**

World's most powerful pulsed Lyman-αlight source for Ultra-slow muon generation

Thursday, 25 September 2025 16:40 (1 minute)

The world's most powerful pulsed Lyman-α light source has been constructed at J-PARC, enabling research on the ultra-slow muon generation and its applications. To date, however, there have been no reports on the long-term generation and utilization of high-intensity Lyman-α pulse. In this study, we investigated the generation and propagation process and examined the impact of time-dependent degradation of the optical components employed. The reduction in available Lyman-α intensity was found to originate primarily from the deterioration of the Kr–Ar gas mixture used for nonlinear wavelength conversion and from the degradation of optical components caused by the vacuum window and residual gases in the chamber.

Presenter: OISHI, Yu (KEK)

Session Classification: Poster flash

Contribution ID: **98** Type: **Poster**

Current Status and Prospects for Long-Term Precision Measurements of Muonium Hyperfine Structure in High Magnetic Field

Muonium is a pure leptonic bound system consisting of a positive muon and an electron, whose energy level structure can be calculated with extremely high precision based on quantum electrodynamics (QED). The MuSEUM experiment aims to measure the ground-state hyperfine structure of muonium by microwave spectroscopy, thereby testing QED and determining the muon magnetic moment and mass with high precision. In 2017, a zero-field measurement at the J-PARC D-Line achieved a relative precision of 160 ppb. More recently, in January–February 2025, our first high-field measurement was conducted at the newly constructed H-Line.
We are now preparing for long-term measurements in the future, aiming to surpass the world's best precision achieved at LAMPF in 1999. In this presentation, I will report on the development of a stabilized microwave resonance system for long-term operation and on background evaluation through simulations.

Presenter: FUKUI, Kengo (Nagoya University)

Session Classification: Poster flash

Contribution ID: **99** Type: **Poster**

J-PARC muon g-2/EDM experiment: Test Operation of a Positron Tracking Detector and Consideration of Its Application to the MuSEUM Experiment

Thursday, 25 September 2025 16:41 (1 minute)

The anomalous magnetic moment (g−2) and the electric dipole moment (EDM) of the muon provide sensitive probes of physics beyond the Standard Model. While the muon g−2 shows a potential discrepancy between theory and experiment, the EDM is predicted to be vanishingly small, making any observation a clear sign of new physics.

The J-PARC muon g−2/EDM experiment aims to provide an independent g−2 measurement and improve the EDM sensitivity to 10!”# # · cm. Using a 300 MeV/c low-emittance muon beam stored in a compact 3 T storage ring, decay positrons are tracked by silicon strip detectors installed inside the storage region to precisely extract both g−2 and EDM. The detector consists of 40 modules arranged radially around the center of the ring. The detector system must satisfy stringent requirements, including high-rate capability, minimal disturbance of the magnetic field, and precise sensor alignment.

We report on a beam test conducted in collaboration with the MuSEUM experiment, which performs a precision measurement of the muonium hyperfine structure, at the H1 area of the J-PARC MLF. A single test module, corresponding to the smallest unit of the silicon strip detector, was operated under a magnetic field of 1.7 T to verify its performance. Furthermore, by varying the aperture size of the upstream slit, we evaluated the detector response under three different beam-rate conditions. We present the results on signal–noise discrimination and performance evaluation in high-rate environments, and discuss future prospects for the application of this detector in the MuSEUM experiment.

Presenter: SATO, Taiki (The University of Tokyo)

Session Classification: Poster flash

Contribution ID: **100** Type: **Poster**

Precise measurement of the parity violating asymmetry in the ^{139}La(n,γ)^{140}La^{*} reaction

"The P-violating effect in compound nuclear states in medium heavy nuclei is amplified by up to approximately 10^{6} times compared to nucleon-nucleon scattering. This phenomenon is observed when the p-wave resonance lies at the tail of the s-wave resonance. It arises from the mixing of two resonant states with different parity in a compound nuclear state due to weak interactions (s-p mixing model).
This study aims to improve the precision of the asymmetry A_{L} of emitted γ-ray counts with respect to neutron helicity in (n,γ) reactions, which serves as fundamental data for verifying the s-p mixing model. In April 2025 at J-PARC MLF ANNRI (BL04), we measured the final state dependence of A_{L} in the ^{139}La(n,⊠)^{140}La^{*} reaction using a neutron polarization device (^{3}He spin filter) and a large solid angle Ge detector. We will report on the measurement results of A_{L} for each final state.
"

Presenter: HAYASHI, Sodai (Nagoya University)

Session Classification: Poster flash

Contribution ID: **101** Type: **not specified**

γ angular distribution analysis in (n, γ) reactions of the low energy neutron resonances of natLa and NaI using the GTAF BaF2 array at CSNS Back-n White Neutron Source

Thursday, 25 September 2025 16:42 (1 minute)

The angular distribution of individual γ-transitions from neutron-induced compound nuclear state via (n, γ) reaction in p-wave resonances of 139La[1], 131Xe[2], 117Sn[3] and other nuclei has been studied using the ANNRI HpGe detector array at J-PARC BL-04 with precise γresolution. Such angular distributions in p-wave resonances may arise from the mixing between s- and p-wave amplitudes[4].
An analysis method based on the asymmetry parameter ALH —defined as defined as ALH = (NL - NH)/ (NL + NH) for NL and NH are the integrals over the lower and higher energy regions of a neutron resonance, respectively, separated by the resonance center —has been employed. ALH can be fitted with A·cos(θ) + B, where θ is the emission angle of the γ-rays.
Certain resonances of interest, such as the low-energy p-wave resonances in 127I, exhibit a high density γ-transitions that cannot be resolved even by the HpGe detectors. Measuring the angular distribution of the summed γ-transitions in 127I using a 4π BaF2 array with high counting statistics in these resonances could provide new insights into the s–p mixing model supplementary to single γ-transition studies using a HpGe array.
In January 2024, we measured the γ angular distributions of 139La and 127I at the Back-n beamline of China Spallation Neutron Source (CSNS), using the Gamma Total Absorption Facility (GTAF) — a 4π BaF_2 array offering high detection efficiency and excellent neutron energy resolution owing to the long neutron flight path of approximately 75 meters. This experiment was carried out within the framework of the newly established China NOPTREX collaboration with CSNS Back-n team and Chinese Institute of Atomic Energy (CIAE) GTAF team.
Moreover, the summed γ-transition measurement in nuclei such as 127I, which feature numerous s- and p-wave resonances at low neutron energies, may enable a novel statistical approach for identifying suspected weak p-wave resonances—a method previously unfeasible due to insufficient neutron energy resolution or limited counting statistics.

Reference:
[1]. T. Okudaira, et al. Phys. Rev. C 109, 029903 (2024)
[2]. T. Okudaira, et al. Phys. Rev. C 107, 054602 (2023)
[3]. J. Koga, et al. Phys. Rev. C 105, 054615 (2022)
[4]. V. P. Gudkov, Phys. Rep. 212, 77 (1992).

Presenter: ZHANG, Mofan (Indiana University)

Session Classification: Poster flash