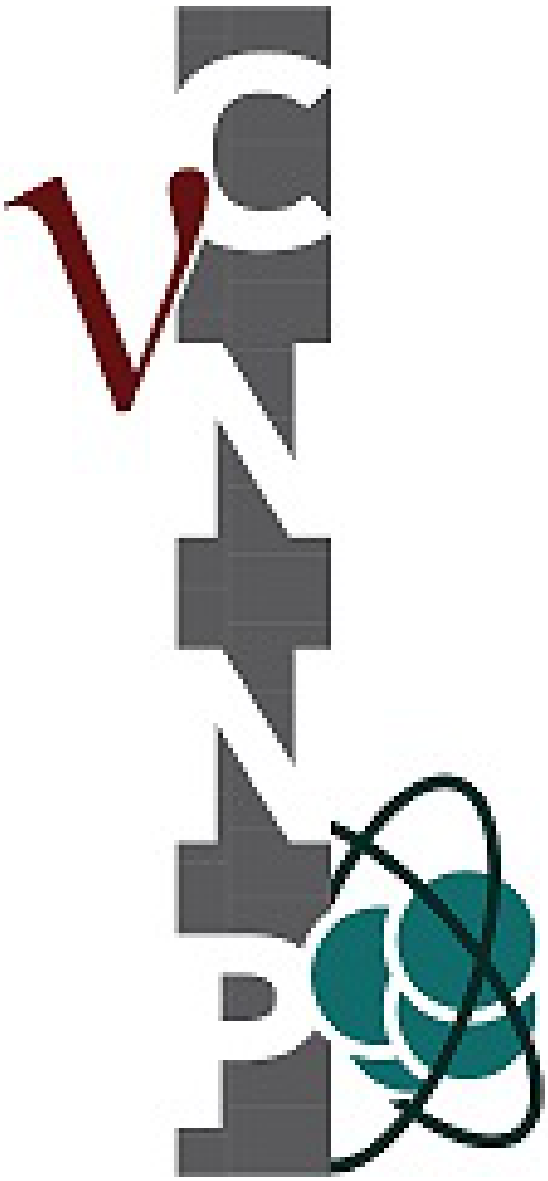
Conference on Neutrino and Nuclear Physics (CNNP2020) Arabella Hotel and Spa, South Africa, 24-28 February 2020



Report of Contributions

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

Deflection of cosmic neutrino by a stellar magnetic field

Thursday, 27 February 2020 13:50 (20 minutes)

Neutrinos in the Standard Model (SM) are considered neutral particles. However, recent experiments showed that the neutrino has infinitesimal electric charge leads to non-zero magnetic moment (μ) with precise constraints on the value, this electromagnetic interaction contribution enhances neutrino properties i.e. Oscillation, Scattering, and Spin. This work discusses the possible neutrino deflection under the influence of Interstellar Magnetic Field (IMF) or at extreme magnetic field condition exists in celestial objects, and for what limit could affect the neutrino flux measured at Earth. The primary results were validated by SN1987A supernovae arrival time data.

Primary author: ISMAIEL, Mohamed (Helwan University)

Presenter: ISMAIEL, Mohamed (Helwan University)

Session Classification: Contributed Talks

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

The SPES RIB facility and program for physics beyond the SM and DM search

The search for physics beyond the Standard Model (SM) is presently a major issue. Despite its spectacular success, it is recognized that the SM could be incomplete and could eventually be incorporated into a more fundamental framework. As an example the excess of matter over anti-matter in the Universe indicates the presence of baryon-number-violating interactions and most likely of new sources of charge conjugation-parity (CP) violation.
The existence of a finite permanent electric dipole moment (EDM) of a particle or an atom would violate time-reversal symmetry (T), and would also imply violation of the combined charge conjugation and parity symmetry (CP) through the CPT theorem [1,2,3]. EDMs are suppressed in the SM of particle physics, lying many orders of magnitude below current experimental sensitivity. Additional sources of CP violation are needed to account for baryo-genesis and many theories beyond the SM, such as supersymmetry [4,5], predict EDMs within experimental reach.
Experimental searches for EDMs have so far yielded no results. The most significant limits have been set on the EDM of the neutron [6], the electron [7] and on the 199Hg atom [8], leading to tight constraints on extensions of the SM [5].
Nuclear structure can strongly amplify the sensitivity of nuclear EDM measurements. In particular the occurrence of octupole correlations in nuclei lead to closely spaced parity doublets and considerably larger Schiff moments. Enhancements factor of 102-104 have been calculated for nuclei with octupole deformation [11,12] or soft octupole vibrations [13]. Actinides atoms as Ra and Pa are among the best candidate in the search for atomic EDM.
These studies are among the objectives of the SPES radioactive ion beam project of INFN. The SPES Radioactive Ion Beam (RIB) facility at INFN-LNL is presently in the construction phase. The aim of the SPES project is to provide high intensity and high-quality beams of neutron-rich nuclei to perform forefront research in nuclear structure, reaction dynamics and interdisciplinary fields like medical, biological and material sciences. The status and the perspectives of the project will be presented together with the program for physics bejond the SM and DM search.

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Session Classification: Contributed Talks

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

Neutrino-induced reactions on ^{13}C and ^{16}O at supernova neutrino energies

Friday, 28 February 2020 09:40 (20 minutes)

Neutrino-nucleus reactions on ^{13}C and ^{16}O at supernova (SN) energies are investigated by shell-model calculations with the use of new Hamiltonian, which can describe spin responses of nuclei quite well. Cabon-based scintillators and water-Cerenkov scintillators relevent to SN observation and experiments at the spallation neutron sources are now available. Cross sections for various particle and γ emission channels are evaluated by the statistical Hauser-Feshbach method.
For ^{13}C, total reaction cross sections at reactor and solar neutrino energies were studied [1]. Here, we extend our study to SN neutrino energies up to ≈50 MeV, and evaluations of partial cross sections for proton and neutron emission channels within the Standard Model [2]. Among them, a reaction channel ^{13}C ($\bar{\nu}$, $\bar{\nu}$'n) ^{12}C (2^+, 4.44 MeV) followed by prompt 4.44 MeV γ emission is discussed in relation to the shape distortion in the 5-7 MeV range in the measured neutrino spectrum in the short-baseline reactor neutrino experiments [3]. The cross section is too small to explain the extra enhancement in the spectrum.
Coherent elastic scattering cross section is obtained for 13C, and compared with that for ^{12}C. Nuclear structure effects in the cross sections are pointed out [2]. Possible merit of large recoil momenta in light nuclei for the study of neutron distributions in nuclei is discussed.
For ^{16}O, spin-dipole strength, which are the dominant contributions to the cross sections, and neutrino-induced reaction cross sections on ^{16}O are investigated [4]. Charged-current cross sections induced by SN neutrinos and their dependence on Mikheyev-Smirnov-Wolfenstein neutrino oscillations are discussed for a future SN burst [5].

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Presenter: SUZUKI, Toshio (Nihon University)

Session Classification: Contributed Talks

Contribution ID: **4** Type: **Invited Talk**

Precision mass measurements for nuclear and neutrino physics studies

Tuesday, 25 February 2020 09:30 (30 minutes)

Rapidly developing neutrino physics has found in Penning-trap mass spectrometry a staunch ally in investigating and contributing to a variety of fundamental problems. The most familiar are the absolute neutrino mass and the possible existence of resonant neutrinoless double-electron capture / double-beta dacay and of keV-sterile neutrinos. This review provides an overview on the latest achievements and future perspectives of Penning-trap mass spectrometry on short-lived as well as stable nuclides with applications in nuclear structure, neutrino physics and most recently even in dark matter searches where relative mass uncertainties at the level of 10-11 and below are required.

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Session Classification: Invited Talks

Contribution ID: **5** Type: **Invited Talk**

Study of kinematic factors in double-beta decay

Friday, 28 February 2020 12:20 (30 minutes)

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Until the recent past not to much importance was given to the kinematic factors related to the double-beta decay, i.e. the phase space factors, electronic spectra and angular correlations between the emitted electrons. The reason was largely because on the one side they were considered to be calculated/predicted with enough precision (in comparison for example with the nuclear matrix elements) and, on the other side, the experimental measurements had not reached a sufficient degree of accuracy to be able to distinguish fine details of them. This situation is changing now. A detailed analysis of the DBD electron spectra and angular correlations can provide us with useful information on transitions to excited states, on decay modes and mechanisms contributing to neutrinoless DBD and, very recently on possible effects of Lorentz symmetry violation in the neutrino sector.
In my presentation I will give first a short review about the challenges in computation of the space phase factors, electron spectra and electron angular correlations. Then, I refer to the analysis of observable effects of Lorentz violation (LV) in two-neutrino DBD in the framework of the Standard Model Extension (SME) and I present a comparison between the methods of calculation the summed electron spectra including the deviations due to LV associated to the like-time component of the so-called countershaded operator.
Finally, I show that our predictions regarding electronic spectra correlated with their precise measurements that are currently being done in DBD experiments (like EXO-2000, SuperNEMO, etc.) for searching LV effects, can improve with up to 30% the actual upper limits of the (ä)3of coefficient that governs the LV contribution.

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Presenter: STOICA, Sabin (International Centre for Advanced Training and Research in Physics)

Session Classification: Invited Talks

Contribution ID: **6** Type: **Invited Talk**

Annual modulation with DAMA/LIBRA-phase2

Tuesday, 25 February 2020 12:00 (30 minutes)

Abstract: The new results obtained by the first 6 independent annual cycles of DAMA/LIBRA–phase2 experiment deep underground at Gran Sasso are presented; they correspond to a total exposure of 1.13 ton × yr. The improved experimental configuration with respect to the phase1 allowed a lower energy threshold. The DAMA/LIBRA–phase2 data confirm the evidence of a signal that meets all the requirements of the model independent Dark Matter annual modulation signature, at high C.L. The model independent DM annual modulation result is compatible with a wide set of DM candidates. In this talk we summarize some of them and perspectives for the future will be outlined.

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Presenter: BELLI, Pierluigi (INFN Roma Tor Vergata)

Session Classification: Invited Talks

Contribution ID: **7** Type: **Invited Talk**

Heavy ion charge exchange reactions as probes for nuclear β-decay

Thursday, 27 February 2020 11:30 (30 minutes)

The status and prospects of heavy ion charge exchange reactions are discussed. Their important role for nuclear reaction, nuclear structure, and beta-decay investigations is emphasized. Dealing with peripheral reactions, direct reaction theory gives at hand the proper methods for single (SCE) and double charge exchange (DCE) ion–ion scattering. The microscopic descriptions of charge exchange ion–ion residual interactions and the reaction mechanism are obtained by distorted wave theory. Ion–Ion optical potentials and reaction form factors are determined in a folding approach by using NN T-matrices and microscopic ground state and transition densities, respectively. The theory of onestep direct and two-step transfer reaction mechanisms for SCE reactions is discussed and illustrated in applications to data. Specific SCE reactions are discussed in detail, emphasizing the versatility of projectile–target combinations and incident energies. SCE reactions induced by 12C and 7Li beams are presented as representative examples. Heavy ion DCE reactions are shown to proceed in principle either by sequential pair transfer or two kinds of collisional NN processes. Double single charge exchange (DSCE) is given by two consecutive SCE processes, resembling in structure 2ν2β decay. A competing process is a two-nucleon mechanism, relying on short range NN correlations and leading to the correlated exchange of two charged mesons between projectile and target. These Majorana DCE (MDCE) events are of a similar diagrammatic structure as 0ν2β decay. The similarities of the DSCE and MDCE processes to pionic DCE reactions are elucidated. An overview on recent applications to heavy ion DCE data is given.

Primary author: LENSKE, Horst (U. Giessen)

Presenter: LENSKE, Horst (U. Giessen)

Session Classification: Invited Talks

Contribution ID: **8** Type: **Invited Talk**

MAJORANA, LEGEND, and the future of the search for Neutrinoless Double-Beta Decay in Ge-76

Monday, 24 February 2020 12:30 (30 minutes)

The MAJORANA collaboration is searching for neutrinoless double-beta ($0\nu\beta\beta$) decay in ^{76}Ge using modular arrays of enriched, high-purity Ge detectors. The MAJORANA DEMONSTRATOR consists of an array of 44 kg of high-purity Ge detectors with a p-type point contact geometry currently operating in the Sanford Underground Research Facility in Lead, South Dakota. The ultra-low background and world-leading energy resolution achieved by the MAJORANA DEMONSTRATOR enable a sensitive $0\nu\beta\beta$ decay search, as well as additional searches for physics beyond the Standard Model. The Large Enriched Germanium Experiment for Neutrinoless Double-Beta Decay (LEGEND) will combine the best techniques from the DEMONSTRATOR and the Germanium Detector Array (GERDA) to reach even higher sensitivities to $0\nu\beta\beta$ decay. The LEGEND collaboration is pursuing a phased approach to a tonne-scale ^{76}Ge experiment, with ultimate discovery potential at a half-life beyond 10^{28} years. The first phase, LEGEND-200, is the deployment of 200 kg of enriched ^{76}Ge detectors in the existing GERDA cryostat at the LNGS underground lab in Italy. LEGEND-200, scheduled to start operation in 2021, will use GERDA and MAJORANA enriched detectors and newly developed inverted coax point contact detectors. The MAJORANA DEMONSTRATOR's latest results will be presented as well as the construction status of LEGEND-200, ongoing LEGEND tonne-scale R&D, and the physics outlook of the LEGEND experimental program.

Primary author: HERVAS, David (University of North Carolina at Chapel Hill)

Presenter: HERVAS, David (University of North Carolina at Chapel Hill)

Session Classification: Invited Talks

Contribution ID: **9** Type: **Invited Talk**

New results from the CUORE experiment

Monday, 24 February 2020 11:00 (30 minutes)

The Cryogenic Underground Observatory for Rare Events (CUORE) is the first bolometric experiment searching for neutrinoless double-beta decay ($0\nu\beta\beta$) that has been able to reach the one-ton scale. The detector, located at the Laboratori Nazionali del Gran Sasso in Italy, consists of an array of 988 TeO_2 crystals arranged in a compact cylindrical structure of 19 towers. The construction of the experiment was completed in August 2016 with the installation of all towers in the cryostat. CUORE achieved its first physics data run in 2017 corresponding to a TeO_2 exposure of 86.3 kg·yr and a median statistical sensitivity to a ^{130}Te $0\nu\beta\beta$ half-life of 7.0×10^{24} yr. Following multiple optimization campaigns in 2018, CUORE is currently in stable operating mode and has accumulated data corresponding to a TeO_2 exposure approaching 500 kg·yr. In this talk, we present the updated $0\nu\beta\beta$ results of CUORE, as well as review the detector performance. We finally give an update of the CUORE background model and the measurement of the ^{130}Te two neutrino double-beta decay ($2\nu\beta\beta$) half-life.

Primary authors: Dr FUJIKAWA, Brian (Lawrence Berkeley National Laboratory); CUORE SPEAKERS BOARD; BENATO, Giovanni (LNGS-INFN)

Presenter: BENATO, Giovanni (LNGS-INFN)

Session Classification: Invited Talks

Contribution ID: **10** Type: **Invited Talk**

Status of the SuperNEMO Experiment

Monday, 24 February 2020 11:30 (30 minutes)

The SuperNEMO Experiment is designed to search for neutrinoless double beta decays of the Se-82 isotope. The detector employs the multi-observable tracking-and-calorimetry technique pioneered by the NEMO-3 Experiment. Electrons originating from double beta decays of an isotope in thin isotopic foils are tracked in wire tracking chambers and their energy is measured by large scintillator blocks. The topology, timing, and energy provide a powerful means of identifying and measuring the final state of decays. The technique is also very effective in rejecting backgrounds due mostly to traces of natural radioactivity in foils and detector materials. The SuperNEMO Demonstrator module is currently being commissioned at the Modane Underground Laboratory in the Frejus Tunnel. We will discuss details of the detector elements, the latest status of the experiment, and the physics reach.

Primary author: SUPERNEMO COLLABORATION

Co-author: Prof. LANG, Karol

Presenter: MINOTTI, Alessandro (LAPP - IN2P3)

Session Classification: Invited Talks

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

Implications of new theoretical calculations on reactor antineutrino and gallium anomalies

Friday, 28 February 2020 09:20 (20 minutes)

The reactor antineutrino and gallium anomalies have been long unexplained. Possible explanations for both of these anomalies include new physics, such as the existence of one or more eV-scale sterile neutrino [Ga15]. However, the previous theoretical calculations, which do not replicate the experimental results, rely on many simplifying approximations [Ba97,Ha19].

In the reactor-antineutrino analysis the beta decays contributing to the cumulative electron spectrum are usually assumed to have allowed spectral shapes. However, many of these decays are actually first-forbidden. Moreover, these decays dominate the experimentally observable region. In some cases, like in the case of the ground-state-to-ground-state decay of ^{140}Cs (see figure), this is found to be a rather poor approximation. Based on the recent results, the use of this allowed approximation can at least partially explain the so called reactor antineurtino anomaly.

Our new large-scale shell model calculations regarding the neutrino-nucleus scattering cross section off ^{71}Ga shows no statistical difference to the experimental results of GALLEX and SAGE experiments. Conflict between charge-exchange BGTs and the neutrino-nucleus cross sections can to some extent be explained by destructive interference between Gamow-Teller and tensor contributions. A Bayesian approach to estimating the significance of the gallium anomaly is discussed.

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Presenter: KOSTENSALO, Joel (University of Jyvaskyla, Finland)

Session Classification: Contributed Talks

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

Nuclear responses for double beta decay and muon capture

Friday, 28 February 2020 11:50 (30 minutes)

To describe the double beta decay processes reliably one needs a possibility to test the involved virtual transitions against experimental data. In this work we manifest how to utilise the nuclear and lepton (μ) charge-excange reaction data in the study of $0\nu\beta\beta$ decay and astro-neutrinos. In my contribution I will cover the theoretical aspects of ordinary muon capture (OMC) as well as the recent studies of (3He,t) and charge-echange studies at RCNP, Osaka 1.

The OMC strength function in 100Nb was computed in the pnQRPA framework [2], and compared with the experimental strength function measured at RCNP in Osaka [3]. The calculated first OMC giant resonance in 100Nb is in agreement with the experimental value. However, the computed total OMC strength is higher than the measured strength, which refers to quenched g_A value. Furthermore, the OMC rates to the daughter nuclei of the $0\nu\beta\beta$ decay triplets of immediate experimental interest are computed [4] and compared with available data of [5].
The capture rates to the low-lying states of 76As are in accordance with the data. The OMC rates to
the daughter nuclei of $0\nu\beta\beta$ decay triplets are also compared with the corresponding $0\nu\beta\beta$ matrix elements in order to find possible connections between them [6].

Eventually, the OMC process can be used to probe the structure of the intermediate states appearing in the
double-beta-decay process. Future experiments can help fine-tune the nuclear-structure parameters for the
double-beta-decay calculations.

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Presenter: JOKINIEMI, Lotta (University of Jyväskylä)

Session Classification: Invited Talks

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

JUNO (Jiangmen Underground Neutrino Observatory), its design and status

Jiangmen Underground Neutrino Observatory (JUNO), a next generation underground reactor antineutrino experiment, is proposed to determine the
neutrino mass hierarchy and precisely measure neutrino oscillation parameters using a massive liquid scintillator detector underground. The experimental
hall, spanning more than 50 meters, is under a granite mountain of over 700 m overburden. The central antineutrino detector, built with 35.4-meter
diameter acrylic sphere, contains 20 kilotons of liquid scintillator and ~18,000 20 inch PMTs (and ~25,000 3 inch PMTs). The antineutrino detector is placed
in a water pool shielding system which also functions as an active water Cherenkov veto detector. On the top of water pool is a Top Tracker system which
further improves the muon track reconstruction. The talk will present the project design and status.

Primary authors: LI, Xiaonan (Institute of High Energy Physics, Chinese Academy of Sciences); LI, Xiaonan (Institute of High Energy Physics, Chinese Academy of Sciences)

Presenter: LI, Xiaonan (Institute of High Energy Physics, Chinese Academy of Sciences)

Session Classification: Contributed Talks

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

CUPID-0: a double-readout cryogenic detector for DBD

Monday, 24 February 2020 14:20 (20 minutes)

A convincing observation of neutrino-less double beta decay (0DBD) relies on the possibility of operating high-energy resolution detectors in background-free conditions.
Scintillating cryogenic calorimeters are one of the most promising tools to fulfill the requirements for a next-generation experiment. Several steps have been taken to demonstrate the maturity of this technique, starting form the successful experience of CUPID-0.
The CUPID-0 experiment demonstrated the complete rejection of the dominant alpha background measuring the lowest counting rate in the region of interest for this technique. Furthermore, the most stringent limit on the Se-82 0DBD was established running 26 ZnSe crystals during two years of continuous detector operation.
In this contribution we present the final results of CUPID-0 Phase I including a detailed model of the background, the measurement of the 2DBD half-life and the evidence that this nuclear transition is single state dominated. The first results obtained after the upgrade of the detector in 2019 are presented as well.

Primary authors: CUPID-0 COLLABORATION; PAGNANINI, Lorenzo

Presenter: PAGNANINI, Lorenzo

Session Classification: Contributed Talks

Contribution ID: **16** Type: **Invited Talk**

Results and future perspectives of Borexino

Thursday, 27 February 2020 16:10 (30 minutes)

The Borexino liquid scintillator neutrino observatory is devoted to perform high-precision neutrino observations: the study of solar neutrinos is the primary goal of the experiment. The exceptional radiopurity together with the good energy resolution (5% at 1 MeV) put Borexino in the unique situation of being able to validate the MSW-LMA oscillation paradigm across the full solar energy range. A comprehensive study of the pp-chain neutrinos was recently released: this new study reports the direct measurements of pp, 7Be and pep neutrino fluxes with the highest precision ever achieved (down to ~2.8% in the 7Be component), the 8B with the lowest energy threshold, the best limit on CNO neutrinos and the first Borexino limit on hep neutrinos. The present talk shows the new results based on the full 10 years data sample and, in particular, on the more radiopure Phase-2 data, taken after the detector purification campaigns in 2010-11 and the perspectives for the final stage of the solar program. The talk will be concluded reporting the latest news on the detection of geoneutrinos with Borexino and the analysis techniques applied.

Primary author: CAMINATA, Alessio (INFN Genoa)

Presenter: CAMINATA, Alessio (INFN Genoa)

Session Classification: Invited Talks

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

Characterization of first prototypes of thin targets for the NUMEN Experiment

The NUMEN Experiment, at INFN-LNS (Catania), aims to get information on the Nuclear Matrix Elements of the Neutrinoless Double Beta Decay, by measuring Double Charge Exchange (DCE) reactions cross-sections 1. The energy of the reaction products must be measured with high resolution. To fulfil this requirement, the target must be thin to minimize dispersion and straggling effects on the ejectile energy; the energy resolution is also influenced by the target thickness uniformity. Due to the small thickness, a mechanical support is necessary for the target. On the other hand, to have a large statistics very intense ion beams are required, which release a large amount of heat inside the target. Therefore the isotope will be deposited on a Highly Oriented Pyrolytic Graphite (HOPG) substrate that quickly transfers the heat outside the target system, thanks to its high surface thermal conductivity [2]. The target thickness will be of a few hundreds of nanometer, while the HOPG will be around 2 micrometers thick [3].
Prototypes of Germanium and Tellurium targets have been deposited with Electron Beam Evaporation process, which parameters have been optimized.
In the NUMEN Experiment the reaction final nuclei can be produced in different final states; a good energy resolution is needed to distinguish between the ground state and the first excited states to deduce the related DCE cross-sections. Unfortunately, the deposition technique does not guarantee a perfectly uniform target thickness. Such surface non-uniformity can be qualitatively inspected by Field Emission Scanning Microscopy (FESEM): images of the best Tellurium and Germanium target prototypes will be presented in the talk.
In order to evaluate both thickness and uniformity of the targets, alpha transmission spectroscopy measurements have been performed. The energy distribution shows a peak, which corresponds to the most frequent thickness; the width is related to the thickness spread. An experimental set-up has been designed, using an 241Am alpha-source and a silicon detector to measure the energy of the transmitted alpha particles. Some tests have been made with Rutherford Backscattering (RBS) technique on the same target samples, to evaluate the systematic error of the alpha-measurements.
In order to evaluate the dispersion and straggling effects due to the thickness and non-uniformity on the resolution of the measurements of the DCE products energy, a Montecarlo code has been implemented. The measured parameters of the thickness distribution have been inserted as input data of the simulation, for different values of the relative branching fractions of ground, first and second excited states. The obtained spectra give information about the resolution between two levels. The results are promising and will be shown in the talk.
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- Laboratori Nazionali di Legnaro, Legnaro, Italy)

Presenter: CAPIROSSI, Vittoria (Polytechnic of Turin - INFN Turin)

Session Classification: Contributed Talks

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

Dark Matter searches at Belle II

Monday, 24 February 2020 14:00 (20 minutes)

The Belle II experiment at the SuperKEKB energy-asymmetric e^+e^- collider is a substantial upgrade of the B factory facility at the Japanese KEK laboratory. The design luminosity of the machine is 8×10^{35} cm^{-2}s^{-1} and the Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than its predecessor. Main operation of SuperKEKB has started in March 2019, with the full detector installed; this first running period ended in July. The machine reached a peak luminosity of 1.2×10^{34} cm^{-2}s^{-1}, and Belle II recorded a data sample of about 6.5 fb^{-1}. Data taking will resume in October 2019. Already this early data set, with specifically designed triggers, offers the possibility to search for a large variety of dark sector particles in the GeV mass range, complementary to LHC and to dedicated low energy experiments; these searches will benefit from more data which will be accumulated in the upcoming Fall/Winter run. This talk will review the state of the dark sector searches at Belle II with a focus on the discovery potential of the early data, and show the first results

Primary authors: PERUZZI, Ida (Laboratori Nazionali di Frascati dell'INFN); CAMPAJOLA, Marcello (INFN-Napoli)

Presenter: CAMPAJOLA, Marcello (INFN-Napoli)

Session Classification: Contributed Talks

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

Sterile neutrino searches with the ICARUS detector

Thursday, 27 February 2020 13:50 (20 minutes)

The ICARUS collaboration employed the 760-ton T600 detector in a successful three-year physics run at the underground LNGS laboratories studying neutrino oscillations with the CNGS neutrino beam from CERN, and searching for atmospheric neutrino interactions. ICARUS performed a sensitive search for LSND-like anomalous ν_e appearance in the CNGS beam, which contributed to the constraints on the allowed parameters to a narrow region around 1 eV^2, where all the experimental results can be coherently accommodated at 90% C.L. After a significant overhauling at CERN, the T600 detector has now been placed in its experimental hall at Fermilab where installation activities are in progress. It will be soon exposed to the Booster Neutrino Beam to search for a sterile neutrino within the Short Baseline Neutrino (SBN) program, devoted to definitively clarify the open questions of the presently observed neutrino anomalies. The proposed contribution will address ICARUS achievements, its status and plans for the new run at Fermilab and the ongoing developments of the analysis tools needed to fulfill its physics program.

Primary author: MENEGOLLI, Alessandro

Presenter: BELLINI, Vincenzo (INFN/Catania)

Session Classification: Contributed Talks

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

DELight – Searching for light dark matter using superfluid helium

Monday, 24 February 2020 14:40 (20 minutes)

The Direct search Experiment for Light Dark Matter (DELight) aims to develop a novel detector technology for the search for light dark matter based on the properties of the superfluid phase of the inert gas 4He. This detector uses the purest material imaginable, provides multiple independent signals for background suppression, has the potential to exploit directionality for event identification, and offers the ability to extend the sensitivity of direct dark matter search to the MeV range. In the first phase, we will build a 10-liter prototype detector with metallic magnetic calorimeters (MMCs) as photon and phonon sensors to investigate the signal threshold that can be reliably detected and to study the directional dependence of the quantum evaporation of He atoms on the energy and mass of the scattering particle. Here we will discuss the physics and the potential of such a detector for light dark matter as well as the goals and long-term perspective of DELight.

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Presenter: ENSS, Christian (Kirchhoff Institute for Physics, Heidelberg University)

Session Classification: Contributed Talks

Contribution ID: **21** Type: **Invited Talk**

The Electron Capture in ^{163}Ho experiment, ECHo

Tuesday, 25 February 2020 10:00 (30 minutes)

The goal of the Electron Capture in ^{163}Ho (ECHo) experiment is the determination of the electron neutrino mass by the analysis of the electron capture spectrum of ^{163}Ho. The detector technology is based on metallic magnetic calorimeters operated at a temperature of about 10 mK in a reduced background environment. For the first phase of the experiment, ECHo-1k, the detector production has been optimized and the implantation process of high purity ^{163}Ho source in large detector arrays has been refined. The implanted detectors have been successfully operated and characterized at low temperatures, reaching an energy resolution below 5 eV. High statistics and high resolution ^{163}Ho spectra have been acquired and analyzed in the light of the recent advanced theoretical description of the spectral shape, considering the independently determined and more precise value of the energy available to the electron capture process, Q_{EC}. We present preliminary results obtained in ECHo-1k so far and discuss the necessary upgrades towards the second phase of the experiment, ECHo-100k.

Primary author: CHRISTIAN ENSS FOR THE ECHO COLLABORATION (Kirchhoff Institute for Physics)

Presenter: CHRISTIAN ENSS FOR THE ECHO COLLABORATION (Kirchhoff Institute for Physics)

Session Classification: Invited Talks

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

Theoretical description of half-lives and electron spectra for higher order forbidden non-unique β decays

Monday, 24 February 2020 14:40 (20 minutes)

Theoretical description of half-lives and electron spectra for higher order forbidden non-unique β decays

Anil Kumar and Praveen C. Srivastava

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In this work we have calculated $\log ft$ and half-lives values of the higher order forbidden β-decays for selected nuclei [for e.g. ^{87}Rb$(3/2^-) \rightarrow {}^{87}Sr(9/2^+)$] in the framework of the nuclear shell model [1-3]. In the present study, we have included next-to-leading-order terms [4-6] in the shape functions to see their effect in the calculated half-lives and β (or electron) spectra. The role of effective value of axial-vector coupling constant (g_A) in half-lives and β spectra for higher-forbidden beta decay are very important. The β^--spectrum of the fourth-forbidden non-unique decays of ^{113}Cd and ^{115}In strongly depends on the effective value of g_A [4,7]. In our study we will report the spectrum-shape method (SSM) for electron spectra with the effective value of g_A. With the SSM, it is possible to extract information of effective value of the weak coupling constant by comparing the theoretical and experimental β electron spectra of forbidden non-unique β-decays.

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Primary authors: KUMAR, Anil (Indian Institute of Technology, Roorkee, India); Dr SRIVASTAVA, Praveen C (Department of Physics, Indian Institute of Technology, Roorkee)

Presenter: KUMAR, Anil (Indian Institute of Technology, Roorkee, India)

Session Classification: Contributed Talks

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

Hints of non-unitarity in the present T2K and NOνA data

Thursday, 27 February 2020 14:10 (20 minutes)

The mixing of three neutrino flavours is parameterised by the unitary
PMNS matrix. If there are more than three neutrino flavours, effective 3×3 neutrino mixing matrix will be non-unitary. In this paper, we have analysed the
latest T2K and NOνA data with the hypothesis of non-unitary mixing matrix.
Present results from NOνA and T2K collaboration have tension between them as NOνA disfavours T2K
best-fit point at $1\,\sigma$ confidence level and vice versa. In this paper we have shown that latest data from both the
experiments disfavour unitary 3×3 mixing at 60% C.L. The combined analysis disfavours unitary mixing
at $1\,\sigma$ C.L. Moreover, the tension between two experiments can also be reduced with the non-unitary approach.

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Presenter: RAHAMAN, Ushak (University of Johannesburg)

Session Classification: Contributed Talks

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

New limits on double beta processes in ^{106}Cd

By comparing rates of neutrinoless double positron emission and electron capture with positron emission one could distinguish mechanism (due to light neutrino exchange or right-handed currents admixture in the weak interaction) of the neutrinoless double beta "minus" decay when observed. However, even the allowed two-neutrino mode of electron capture with positron emission is not observed yet. The nuclide ^{106}Cd is a promising candidate forthe experimental investigations of the double beta "plus"decays (double electron capture, electron capture with positron emission and double positron emission) due to its high energy release 2775.39(10) keV and relatively high isotopic abundance 1.245(22)%. An experiment to search for double beta processes in ^{106}Cd is in progress with the help of $^{106}CdWO_4$ crystal scintillator (enriched in ^{106}Cd to 66%) in coincidence with two large volume $CdWO_4$ scintillation detectors in close geometry at the Gran Sasso Underground Laboratory. The sensitivity of the experiment is approaching the theoretical predictions for the double beta processes in ^{106}Cd at a level of 10^{20}–10^{22} yr that corresponds to the most sensitive double beta-plus experiments. The new limits on different modes and channels of ^{106}Cd were set.

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Presenter: POLISHCHUK, Oksana (Institute for Nuclear Research)

Session Classification: Contributed Talks

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

Study of ^{150}Nd 2β decay to the 0_1^+ excited level of ^{150}Sm

The ^{150}Nd nuclide is one of the most promising ones to search for double beta decay among the 35 naturally occurring double beta isotopes because of the high energy release: 3371.38(20) keV, and of the comparatively high isotopic abundance: 5.638(28)%. The 2β transition to the 740.5 keV 0_1^+ excited level of ^{150}Sm was observed in few experiments with half-lives in a wide range $(7–14) \times 10^{19}$ y. The investigation of this decay is performed at the Gran Sasso underground laboratory (Italy) with a highly purified 2.381-kg Nd_2O_3 sample in the low-background setup with 4 HP Ge detectors (≈225 cm^3 each), mounted in one cryostat. Two gamma-quanta with energies 334.0 keV and 406.5 keV emitted after the deexcitation of the 0_1^+ excited level of ^{150}Sm have been observed in the coincidence spectra accumulated over 25947 h giving the preliminary half-life value of the ^{150}Nd relatively to the decay searched for: $T1/2 = [6.9^{+4.0}_{-1.9}(\text{stat}) \pm 1.1(\text{syst})] \times 10^{19}$ y. The experiment is in progress in order to improve the half-life value accuracy.

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Session Classification: Contributed Talks

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

Q-value measurements of rare weak beta decays with JYFLTRAP

Tuesday, 25 February 2020 15:00 (20 minutes)

Rare weak beta decays can be potentially used in searches for the neutrino mass. These are, *e.g.*, decays between nuclear ground states and excited states in daughter nuclei that have very small (< 1 keV) decay energy (Q-value). The beta decay of ^{115}In $9/2^+$ ground state to $3/2^+$ state in ^{115}Sn currently has the smallest measured Q-value (0.155(24) keV [1,2]) of any beta decay.

There are several more nuclei that potentially possess similarly low Q-values [3]. Those are optimal for experimental neutrino mass determination through distortions in the beta endpoint spectrum. First, before any attempt to measure the endpoint spectrum, it is necessary to confirm whether the Q-value of the decay is positive. The ground-state-to-ground state Q-value can be measured with mass spectrometry while the excitation energy of the excited state in the daughter can be deduced from gamma-ray spectroscopy.
Using the JYFLTRAP Penning trap setup [4,5] at the Accelerator Laboratory of the University of Jyväskylä, we have measured Q-values of several such cases. One of those is the ^{135}Cs decay to ^{135}Ba, which was measured with a precision at the 100-eV level. Along with this Q-value measurement I'll give an overview of the used Phase-Imaging Ion-Cyclotron mass measurement technique [6].

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Presenter: ERONEN, Tommi (University of Jyväskylä)

Session Classification: Contributed Talks

Contribution ID: **28** Type: **Invited Talk**

HALO-1kT - Status and Design

Monday, 24 February 2020 16:40 (30 minutes)

HALO-1kT is a lead-based supernova neutrino detector proposed for the Laboratori Nazionali del Gran Sasso (LNGS). By utilizing lead from the decommissioning of the OPERA detector at LNGS, HALO-1kT will improve of the sensitivity of the Helium and Lead Observatory (HALO), that has been running in SNOLAB in Canada for the past 7 years, by a factor of ~25. The lead-based neutrino detection technology takes advantage of the large neutrino-nuclear cross sections for lead, and Pauli-blocking of the anti-electron-neutrino charged current channel, to offer a robust, low cost and low maintenance electron-neutrino-sensitive detector that complements water Cherenkov and liquid scintillator neutrino detectors. Neutrino detection is through charged and neutral current interactions with the lead nuclei that expel neutrinos that a subsequently detected with high efficiency in Helium-3 proportional counters. The talk will focus on the physics capabilities of the detector; aspects of its design; and its current status.

Primary author: VIRTUE, Clarence (Laurentian University / SNOLAB)

Presenter: VIRTUE, Clarence (Laurentian University / SNOLAB)

Session Classification: Invited Talks

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

Simulation of nuclear reactions for the NUMEN project

The GEANT4 1 Hadrontherapy model [2] was used to predict the outcome of several reactions of interest to the NUMEN project (LNS/INFN, Catania, Italy). In this project, Double Charge Exchange (DCE) reaction matrix elements of interest to neutrino double-beta decay physics are to be experimentally assessed. In the last phase of the NUMEN project, very large intensity beams from the CS cyclotron accelerator (LNS) are to be used. In association with the MAGNEX spectrometer, which will identify the species of the DCE projectile-like fragment (PLF), a gamma-array spectrometer will assist the identification of the specific nuclear state which has been populated, by coincidence/anti-coincidence with the gamma transitions of the PLF. With the high beam intensity, a large random coincidence rate is expected which could contaminate the DCE data. This contamination would come from uncorrelated nuclear reactions of all types of exit channels which can originate from the same beam/target combination of the entrance channel. Besides evaluating the radiation risks to detectors and electronic equipment, GEANT4 simulations help to develop the gamma array project through the prediction of its response to gamma rays and neutrons from all these possible nuclear reactions. In this contribution, the results for several reactions will be shown, providing a general panorama of the issues that can affect the NUMEN project. In an attempt to validate these simulations, the gamma-ray and neutron spectra obtained with the Eden liquid scintillator array was measured during the Numen8 experiment, in which the 18O+76Se reaction was investigated at 15 AMeV. The results show some good correspondence with the simulation in some respects, like the order of magnitude of the gamma-ray rate and spectrum shape, but also puzzling results in other aspects, such as the random coincidence background rates of neutron and gamma and their relative ratios. Other types of simulation software have also been employed by the collaboration and were compared. Further validation tests should be performed for a more general and in depth investigation.

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Session Classification: Contributed Talks

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

GERDA Highlights: Probing the Majorana Neutrino Mass at 100 meV

Tuesday, 25 February 2020 15:20 (20 minutes)

Since 2010, the GERDA project has been operated at Laboratori Nazionali del Gran Sasso (LNGS), searching for the neutrinoless double beta decay (0νββ) of Ge-76 to Se-76. GERDA is nowadays completing its mission, having attained 100 kgy exposure and, as first experiment, surpassed the goal sensitivity of 10^26 yr on the half-life of the searched process. Since its beginning in 2010 GERDA has increased its sensitivity for the measurement of the decay by almost a factor of 5, thanks to excellent passive shield setup, operating procedures, energy resolution, and implementation of active background suppression strategies. The GERDA results allow to directly probe the Majorana neutrino mass down to about 100 meV scale.
In this talk, the GERDA setup, technological features and operation will be summarized, and the above outlined results, based on an exposure of about 85 kgy, will be reviewed in the framework of results from other 0νββ players. The Ge-76 two neutrino double beta decay half-life measured by GERDA, the main detected background sources, the performances and background indexes for the different detector types, the data analysis flow and algorithms will be discussed as well.
The perspectives of the final GERDA data release and the transition to the LEGEND project will be addressed.

Primary author: CATTADORI, Carla Maria (INFN Milano Bicocca)

Presenter: PANDOLA, Luciano (INFN - Laboratori Nazionali del Sud)

Session Classification: Contributed Talks

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

Prospects for pair-transfer reactions at iThemba LABS

Tuesday, 25 February 2020 14:40 (20 minutes)

Pair-transfer reactions such as (p,t) and (³He,n) have been used to probe the pairing in nuclei. The nature of pairing in neutrinoless double-beta decay candidates can strongly impact the predicted nuclear matrix elements linking the ground states of the parent and daughter nuclei in neutrinoless double-beta decay candidates, with various different theoretical approaches such as the QRPA sometimes using the BCS pairing approximation. Evidence from pair-transfer reactions provides evidence for the breaking down of the BCS approximation in some nuclei.

This contribution will discuss experimental developments at iThemba LABS using the K600 magnetic spectrometer to measure (p,t) cross sections, and arrays of HPGe and neutron detectors to measure the (³He,n) reaction, providing an excellent opportunity to probe the nature of pairing in nuclei, including neutrinoless double-beta decay candidates.

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Co-authors: NEVELING, Retief (iThemba LABS); PAPKA, Paul (Stellenbosch University)

Presenter: ADSLEY, Philip (iThemba LABS/Wits)

Session Classification: Contributed Talks

Contribution ID: **32** Type: **Invited Talk**

Constraining electron-capture rates with data from charge-exchange experiments

Charge-exchange reactions have been used for a long time to extract Gamow-Teller transition strengths for a variety of applications in nuclear structure physics, nuclear astrophysics, and neutrino physics. Over the past few years, a dedicated effort has been made to constrain the nuclear structure calculations that are used to estimate electron-capture rates of importance for the late evolution of core-collapse supernovae, in particular in the N=50 region above Nickel-78. This effort involved (t,3He) experiments on Strontium-88, Krypton-86, and Niobium-93. The experimental work was combined with the development of a weak-rate library for astrophysical simulations and one-dimensional sensitivity studies of supernovae and their multi-messenger signals to uncertainties in electron-capture rates using that library. This presentation is an overview of these efforts, which involved a close collaboration between experimentalists and nuclear and astrophysical theorists.

Primary author: ZEGERS, Remco (MSU)

Presenter: ZEGERS, Remco (MSU)

Session Classification: Invited Talks

Contribution ID: **33** Type: **Invited Talk**

Neutrinos from CCSN and the contribution of nuclear experiments

Monday, 24 February 2020 16:10 (30 minutes)

The impact of different microphysics inputs on the dynamics of core collapse
during infall and early post-bounce is studied performing spherically symmetric simulations in general relativity using a multigroup scheme for neutrino transport and full nuclear distributions in extended nuclear statistical equilibrium models.
We show that the individual EC rates are the most important source of uncertainty in the simulations, and establish a list of the most important nuclei to be studied in order to constrain the global rates.
The effect on the collapse dynamics and neutrino luminosity is studied.

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Co-authors: Dr OERTEL, Micaela (LUTH-Meudon); Dr FANTINA, Anthea (GANIL); Mr PASCAL, Aurelien (LUTH Meudon); Dr NOVAK, Jerome (LUTH Meudon); Dr RADUTA, Adriana (IFIN Bucarest)

Presenter: GULMINELLI, Francesca (LPC Caen and University of Caen, France)

Session Classification: Invited Talks

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

ReD: a SiPM based LAr TPC for directionality studies

Monday, 24 February 2020 15:20 (20 minutes)

The Recoil Directionality project (ReD) within the DarkSide Collaboration aims to characterize the light and charge response of a liquid argon (LAr) dual-phase Time Projection Chamber (TPC) to neutron-induced nuclear recoils. The main goal of the project is to probe for the possible directional dependence suggested by the SCENE experiment. Furthermore, ReD will have the possibility to study the response of a LAr TPC to very low-energy nuclear recoils. Sensitivity to directionality and to low-energy recoils are both key assets for future argon-based experiments looking for Dark Matter in the form of WIMPs.

ReD consists in the irradiation of a miniaturized LAr TPC with a neutron beam at the INFN, Laboratori Nazionali del Sud (LNS), Catania. Neutrons are produced via the reaction p(^{7}Li,^{7}Be)n from a primary ^{7}Li beam delivered by the TANDEM accelerator of LNS. A ΔE/E telescope, made by two Si detectors, identifies the charged particles (^{7}Be) which accompany the neutrons emitted towards the TPC. The core detector of ReD is a small custom-made double phase LAr TPC, having sensitive volume of 5×5×5 cm^3. The ReD TPC uses all the innovative features of the DarkSide-20k design: in particular the optoelectronic readout based on SiPM and the cryogenic electronics. It is thus a valuable test bench of the technology which is being developed for DarkSide-20k and for the future project Argo. Neutrons scattered from the TPC are eventually detected by using an array of nine 3-inch liquid scintillator (LSci) detectors. All LSci are placed such to tag recoils having the same energy, i.e. the same scattering angle with respect to the incident neutron, but different angle with respect to the drift field of the LAr TPC, thus allowing to search for a possible directional response. The integration of the three detector systems was performed within several test beams performed in 2018-2019, using the TANDEM accelerator of LNS. Neutrons were produced by sending a ^{7}Li 28 MeV beam onto a set of CH_2 targets having thickness between 250 and 400 μg/cm^2.

The physics measurement is expected to take place during the early months of 2020. This contribution will report about the current status of the project, including the physics results possibly obtained in the meanwhile, and on the short- and medium-term plans. The feasibility is also discussed of a wider-purpose facility at INFN-LNS, targeted to the calibration of detectors of interest for Dark Matter or rare events searches with tagged neutrons.

Primary author: PANDOLA, Luciano (INFN - Laboratori Nazionali del Sud)

Presenter: PANDOLA, Luciano (INFN - Laboratori Nazionali del Sud)

Session Classification: Contributed Talks

Contribution ID: **35** Type: **Invited Talk**

Nuclear processes and effective weak couplings

Monday, 24 February 2020 09:30 (30 minutes)

The axial-type of weak couplings seem to be renormalized in medium-heavy and heavy nuclei as suggested by analyses of nuclear beta and double beta decays, nuclear muon capture, charge-exchange reactions and low-energy neutrino-nucleus scattering 1. Also some calculations suggest that also the vector-type of couplings could attain effective values in nuclei [2,3]. The possible variation of the values of weak couplings as functions of the nuclear mass number affects the information deduced from the possible future measurements of the half-lives of neutrinoless double beta ($0\nu\beta\beta$) decays [4],
nuclear muon captures, electron and antineutrino spectra of medium-mass fission fragments in nuclear reactors, etc. In particular, there could be direct effects on the reactor antineutrino anomaly and the Gallium anomaly 1.

Studies of the $0\nu\beta\beta$ decays of nuclei are of paramount importance in order to learn about the basic properties of the neutrino. An appealing way to probe this decay rather directly is the nuclear muon capture, since it operates in the same momentum-exchange region as the $0\nu\beta\beta$ decays. Recent results on the muon capture rate on ^{100}Mo [5] indicate that the muon-capture calculations are able to reproduce the measured capture strength function in a quite satisfactory way.

In my contribution I present an overview of the problem of effective weak couplings and discuss the relation of the nuclear muon capture to $0\nu\beta\beta$ processes.

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Primary author: SUHONEN, Jouni (University of Jyväskylä)

Presenter: SUHONEN, Jouni (University of Jyväskylä)

Session Classification: Invited Talks

Contribution ID: **36** Type: **Invited Talk**

Status and perspectives of the Hyper-Kamiokande project

Thursday, 27 February 2020 15:40 (30 minutes)

A future neutrino experiment based in Japan, Hyper-Kamiokande (HK) consists of a high-intensity neutrino beam from the J-PARC accelerator targeting a Near Detector suite, an Intermediate Water Cerenkov detector and an underground world-largest Water Cerenkov Far Detector, providing 0.19 Mt (fiducial mass) of ultra-pure water sensed by newly developed photo-sensors with 40%-equivalent photo-coverage, to perform Cerenkov ring reconstruction with a few MeV energy threshold. A second identical far detector may later be added in Korea.
Building on the legacy of Super-Kamiokande and T2K, the HK project will address a broad scientific program and substantially enhance our knowledge of both particle physics and astrophysics. Its objectives include precise measurements of neutrino oscillations and CP-asymmetry (with CPV discovery at 3 sigma for 76% of the phase space), solar neutrino astronomy, determination of supernova burst dynamics, detection of supernova relic neutrinos allowing to study supernova populations, searching for nucleon decay with improved sensitivity (10^{35} years for p->epi0 mode at 90%CL) and finding possible exotic phenomena.
Here we will present the project status and milestones, from the beginning of construction in 2020 towards the commissioning in 2027.

Primary author: NOVA, Federico (Rutherford Appleton Laboratory)

Presenter: NOVA, Federico (Rutherford Appleton Laboratory)

Session Classification: Invited Talks

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

Non-standard mechanisms of neutrinoless double beta decay

Understanding the origin of lepton number violation is one of the major questions in physics today. Neutrinoless double beta decay provides a way in which this violation can be tested. Furthertmore, neutrinoless double beta decay can significantly help to shed light on the issue of nonzero neutrino mass, as the observation of this lepton-number-violating process would imply that neutrinos are Majorana particles. However, the underlying interaction does not have to be as simple as the standard neutrino mass mechanism. Recently, we have derived the form of hadronic and leptonic matrix elements for all possible short-range and long-range mechanisms of neutrinoless double beta decay. With these, we have calculated the numerical values of the nuclear matrix elements (NME) and phase space factors (PSF) by making use of the microscopic interacting boson model (IBM-2) for NMEs and of exact Dirac wave functions for the PSFs. The derived angular correlations of the emitted electrons show that distinction between different models of non-standard mechanisms, as well as standard mass mechanism, could be experimentally observable.

Primary author: KOTILA, Jenni (University of Jyvaskyla)

Presenter: KOTILA, Jenni (University of Jyvaskyla)

Session Classification: Contributed Talks

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

Update on the HOLMES experiment to directly measure the neutrino mass

Tuesday, 25 February 2020 15:40 (20 minutes)

The absolute neutrino mass is still a missing parameter in the modern landscape of particle physics. The HOLMES experiment aims at exploiting the calorimetric approach to directly measure the neutrino mass through the kinematic measurement of the decay products of the weakly-mediated decay of 163Ho. This low energy decaying isotope, in fact, undergoes electron capture emitting a neutrino and leaving its daughter nucleus, 163Dy*, in an atomic excited state. This, in turn, relaxes by emitting electrons and, to a considerably lesser extent, photons. The high energy portion of the calorimetric spectrum of this decay is affected by the non-vanishing neutrino mass value. Given the small fraction of events falling in the region of interest, to achieve a high experimental sensitivity on the neutrino mass it is important to have a high activity combined with a very small undetected pile-up contribution. To achieve these targets, the final configuration of HOLMES foresees the deployment of a large number of 163Ho ion-implanted TESs characterized by an ambitiously high activity of 300 Hz each. This contribution will provide an overview on the status of the major tasks that will bring HOLMES to achieve a statistical sensitivity on the neutrino mass as low as 2 eV: from the isotope production and embedding to the detector production and readout.

Primary author: FAVERZANI, Marco

Presenter: FAVERZANI, Marco

Session Classification: Contributed Talks

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

Sensitivity to the neutrinoless double beta decay of the DARWIN observatory

Tuesday, 25 February 2020 14:00 (20 minutes)

The DARWIN observatory is a proposed next-generation experiment whose primary goal is to search for particle dark matter. It will operate 50 tonnes of natural xenon in a dual-phase time projection chamber under ultra-low background conditions. These two characteristics make DARWIN sensitive to other rare interactions, like the neutrinoless double beta decay of the isotope Xe136. Without isotopic enrichment DARWIN will contain in total more than 4.5t of Xe136. We present here the expected half-life sensitivity for this rare decay. This sensitivity is based on a detailed study of attainable backgrounds, Monte Carlo predictions and event topologies in the homogeneous target. We show that DARWIN will be comparable in its science reach to dedicated double beta decay experiments using enriched Xe136.

Primary author: SANCHEZ-LUCAS, Patricia (University of Zurich)

Presenter: SANCHEZ-LUCAS, Patricia (University of Zurich)

Session Classification: Contributed Talks

Contribution ID: **40** Type: **Invited Talk**

First results from the neutrino mass experiment KATRIN

Tuesday, 25 February 2020 09:00 (30 minutes)

Since the discovery of neutrino oscillation we know that neutrinos have non-zero masses, but we still do not know the absolute neutrino mass scale, which is as important for cosmology as for particle physics. The direct search for a non-zero neutrino mass from endpoint spectra of weak decays is complementary to the search for neutrinoless double beta-decay and analyses of cosmological data.
Today the most stringent direct limits on the neutrino mass originate from investigations of the electron energy spectra of tritium beta-decay.

The next generation experiment KATRIN, the Karlsruhe Tritium Neutrino experiment, is improving the sensitivity from the tritium beta decay experiments at Mainz and Troitsk of 2 eV by one order of magnitude probing the region relevant for structure formation in the universe. KATRIN uses a strong windowless gaseous molecular tritium source combined with a huge MAC-E-Filter as electron spectrometer. To achieve the sensitivity, KATRIN has been putting many technologies at their limits. The full 70m long setup has been successfully commissioned. From early 2019 on KATRIN is taking high statistics tritium data hunting for the neutrino mass.

In this talk a detailed presentation of the KATRIN experiment and its results from the first KATRIN science run will be given. The new results are already bringing KATRIN into the lead position of the field. In the outlook the perspectives of KATRIN for the coming years and new technologies to potentially improve further the sensitivity on the neutino mass will be presented.

Primary author: WEINHEIMER, Christian (Institut für Kernphysik, University of Münster, Germany)

Co-author: FOR THE KATRIN COLLABORATION

Presenter: WEINHEIMER, Christian (Institut für Kernphysik, University of Münster, Germany)

Session Classification: Invited Talks

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

COSINUS, Dark Matter direct detection with NaI

Nowadays astronomical observations have provided solid proof for the existence of dark matter (DM), yet a direct measurement is lacking.
COSINUS (Cryogenic Observatory for SIgnatures seen in Next-generation Underground Searches) has the aim of detecting DM via elastic scattering off the nuclei of a target NaI crystal which is the core of the detector. The NaI crystal is kept at ~10 mK and it is operated as a low-temperature calorimeter. The deposited energy is precisely reconstructed from the phonon signal. By facing to the NaI crystal another cryogenic light detector particle discrimination is achieved using the scintillation signal. With this unique combined readout not only it is possible to eliminate the beta/gamma and alpha background, but also to study the material dependency of the DM interaction. Moreover, using the identical material as DAMA/LIBRA, COSINUS will finally shade a light on the long-standing controversy in the DM direct search community.
In this contribution I will outline the steps undertaken by the COSINUS collaboration towards establishing a final detector design and I will present the results of the first NaI prototypes.
The basic detector module is composed by a NaI crystal (up to 200 g mass) coupled to a Transition Edge Sensor (TES) via a carrier crystal (typically CdWO4) for practical purposes:being hygroscopic, NaI requires very special care in handling and does not cope well with the high temperature required to grow the thin superconducting W film of the TES. Except for the side where the NaI crystal is coupled to the carrier, all the other sides face a silicon beaker which encapsulates the NaI crystal and it is used as a light absorber. The emitted light is converted into a phonon signal which is read out using a second TES evaporated directly onto the silicon beaker external surface.
A prototype detector has been tested in a dilution refrigerator hosted in Hall C of the Laboratori Nazionali del Gran Sasso (LNGS), instrumented both with SQUIDs for the TES readout and conventional electronics for high impedance sensors, such as Neutron Transmutation Doped (NTD) Germanium thermistors.
I will present the first measurements perfomed with prototype detectors, the current status and further development of COSINUS concerning the experimental setup at LNGS and physics programme.

Primary author: PUIU, Andrei (INFN and University of Milano Bicocca)

Presenter: PUIU, Andrei (INFN and University of Milano Bicocca)

Session Classification: Contributed Talks

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

BBN, Underground Nuclear Astrophysics and Neutrinos

Tuesday, 25 February 2020 14:20 (20 minutes)

Nuclear astrophysics plays an important role in understanding open issues of neutrino physics. As an example, the two key reactions of the solar p-p chain $^3He(^3He, 2p)^4He$ and $^3He(^4He, \gamma)^7Be$ were studied at low energy with LUNA (Laboratory for Underground Nuclear Astrophysics), providing an accurate experimental footing for the Standard Solar Model and consequently to study the neutrino mixing parameters.
The LUNA collaboration has now completed the measurement of the $D(p, \gamma)^3He$ cross section with unprecedented precision at Big Bang Nucleosynthesis (BBN) energies. The accurate study of this deuterium-burning process provides a precise determination of the universal baryon density Ω_b, in agreement with the value derived from CMB data and with comparable accuracy.
Finally, our analysis severely constrains the possible existence of "dark radiation", i.e. the existence of relativistic particles not foreseen in the standard model, such as sterile neutrinos or hot axions 1. The LUNA result and consequences in cosmology and particle physics are discussed in this contribution.

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Primary author: GUSTAVINO, Carlo (INFN-Roma)

Presenter: GUSTAVINO, Carlo (INFN-Roma)

Session Classification: Contributed Talks

Contribution ID: **43** Type: **Invited Talk**

Status of the T2K experiment

Thursday, 27 February 2020 09:00 (30 minutes)

Current status of the T2K long-baseline neutrino-oscillation experiment is presented.
Future upgrades and prospects in coming ten years are also reported.

Primary author: OYAMA, Yuichi (KEK/J-PARC)

Presenter: OYAMA, Yuichi (KEK/J-PARC)

Session Classification: Invited Talks

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

Analysis of two-proton transfer in the 40Ca(18O,Ne)38Ar and 116Cd(20Ne,18O)118Sn reactions

We analysed the angular distribution of two-proton pickup transfer for the 40Ca(18O,20Ne)38Ar reaction at 270 MeV incident energy. The coupled reaction channel (CRC) and coupled channel Born approximations (CCBA) methods were considered in the theoretical calculations to obtain the two-proton transfer angular distributions, in which the results have reproduced very well the experimental data. In addition, we also analysed the two-proton stripping transfer reaction corresponding to the 116Cd(20Ne,18 O)118Sn, at 306 MeV bombarding energy, for which the integrated cross section for the final channels 18O gs(0+) +118 Sn gs(0+) and 18O gs(0+) +118 Sn 1.23(2+) were measured. The data were quite well described by the theoretical results. The one- and two-proton spectroscopic amplitudes were derived from the shell model calculations. In this work, we have discussed the role of the paring correlations during the transfer process to populate the final channels in the present reactions. Besides, once these reactions might strongly compete with the double charge exchange reaction, like 40Ca(18O,18Ne)40Ar 1 and 116Cd(20Ne,20O)116 Sn [2], is extremely important to be confident with respect to the prediction of transfer cross section mainly for many reactions for which there is no experimental information that might compete with double charge exchange reaction. This measurement of the double charge exchange cross sections for different systems is the main objective of the NUMEN project.

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Presenter: LUBIAN RIOS, Jesus (Federal Fluminense University)

Session Classification: Contributed Talks

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

The CROSS experiment: rejecting surface events with PSD

Tuesday, 25 February 2020 14:20 (20 minutes)

Neutrinoless double-beta decay is a hypothetical rare nuclear transition (T^1/2>1026 y). Its observation would provide an important insight about the nature of neutrinos (Dirac or Majorana particle) demonstrating that the lepton number is not conserved. This decay can be investigated with bolometers embedding the double beta decay isotope, the possibility to investigate this rare process is strongly influenced by the background level in the region of interest. A new R&D has recently begun within the CROSS project (Cryogenic Rare-event Observatory with Surface Sensitivity) aiming at the development of bolometric detectors, embedding the promising isotopes 100Mo and 130Te, capable of discriminating surface alpha and beta interactions by exploiting the properties of superconducting material (Al film) or normal metal (Pd film) deposited on the crystal faces (Li2MoO4 and TeO2). These films work as pulse-shape modifiers. The results of the tests on prototypes performed at CSNSM (Orsay, France) showed the capability of a few-μm (nm)-thick Al (Pd) film deposited on the crystal surface to discriminate surface from bulk events, with the required rejection level of the surface background. While Al film can only identify surface alpha particles, there are preliminary indications that normal-metal films can separate also the beta surface component. This is a breakthrough in bolometric technology for double beta decay that could lead to reach a background index in the range 10^-5 counts/(keV kg y). The CROSS cryostat has been recently installed underground (Canfranc, Spain). We plan to run the first CROSS demonstrator in 2021 with 32 enriched Li2100MoO4 crystals containing ~5 kg of 100Mo. A 5-year sensitivity to the effective Majorana neutrino mass mββ with a background of the order of 10^-3 counts /(keV kg y) would be in the range 68-122 meV (2.8 × 10^25 y), at the level of the best currently running experiments.

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Presenter: KHALIFE, Hawraa (CSNSM-cnrs (orsay, France))

Session Classification: Contributed Talks

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

Revealing the Effect of Individual Fission Products in the Antineutrino Spectra from Nuclear Reactors

The Inverse Beta Decay antineutrino spectrum generated by nuclear reactors is calculated using the summation methods with the highest fidelity nuclear databases to date to understand deviations from the smooth Huber-Mueller model due to the decay of individual fission products. Several numerical methods were explored, and concluded that plotting the ratio of two adjacent spectra points can effectively reveal these deviations. We obtain that for binning energies of 0.1 MeV or lower, abrupt changes in the spectra due to the jagged nature of the individual antineutrino spectra could be observed for highly precise experiments. Surprisingly, our calculations also reveal a peak-like feature in the adjacent points ratio plot at 4.5 MeV even with a 0.25 MeV binning interval, which we find is present in the IBD spectrum published by Daya Bay in 2016 as well as the RENO spectrum published in 2018. We show that this 4.5 MeV feature is caused by the contributions of just four fission products, 95Y, 98,101Nb and 102Tc. This would be the first evidence of the decay of a few fission products in the IBD antineutrino spectrum from a nuclear reactor. The same technique is applied to the electron spectra measured at ILL, which allows us to additionally identify 96Y and 92Rb. The significance of this finding for short baseline experiments will be discussed.

Primary authors: SONZOGNI, Alejandro (Brookhaven National Laboratory); MCCUTCHAN, Elizabeth (Brookhaven National Laboratory)

Presenter: SONZOGNI, Alejandro (Brookhaven National Laboratory)

Session Classification: Contributed Talks

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

The search for eV sterile neutrinos with the STEREO experiment

Friday, 28 February 2020 09:00 (20 minutes)

In the last decade, two unsolved anomalies have appeared from the study of reactor neutrinos: one related to the neutrino spectral shape, and another to the absolute neutrino flux. The second one, known as the Reactor Antineutrino Anomaly, presents a deficit in the observed flux compared to the expected one that could point to the existence of a light sterile neutrino in the eV range participating in the oscillation phenomena.
The STEREO experiment is a short baseline reactor antineutrino experiment trying to test the existence of those sterile neutrinos. This experiment, taking data since the end of 2016, measures the antineutrino energy spectrum from the compact core of the research reactor of the Institut Laue-Langevin (Grenoble, France) operated with highly enriched U-235 fuel. Covering baselines between 9 and 11m with a segmented neutrino target, STEREO can study the rate of neutrino interactions and compare it among cells to test oscillation hypotheses at different distances from the source. STEREO can also measure the absolute neutrino flux and spectral shape emitted from a pure U-235 core.
Neutrino data from 179 (235) days of reactor turned on (off) have been analyzed, showing compatibility with the null oscillation hypothesis and rejecting the best fit point of the Reactor Antineutrino Anomaly at 99.8% C.L. In this talk, these results together with the latest improvements in the description of the detector models and the background treatment are reported, providing a crucial input in the search for sterile neutrinos.

Primary author: ALMAZAN, Helena (Max-Planck-Institut fuer Kernphysik)

Presenter: ALMAZAN, Helena (Max-Planck-Institut fuer Kernphysik)

Session Classification: Contributed Talks

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

COHERENT's Neutrino-Induced Neutron Detectors

Tuesday, 25 February 2020 15:40 (20 minutes)

Neutrino-nucleus interactions can produce excited nuclear states that can de-excite by emitting particles, including neutrons. Neutrino-induced neutrons (NINs) produced in common gamma shielding material, such as lead or iron, can pose a background for neutrino and dark matter experiments. Additionally, NIN production in lead is the primary mechanism for the Helium and Lead Observatory (HALO) to detect supernova neutrinos, and iron-based supernova NIN detectors have been proposed. As part of the COHERENT experiment, two detectors seeking to study NIN production in lead and iron have been deployed to the Spallation Neutron Source (SNS). An overview of the detector design and current status will be presented.

Primary author: HEDGES, Samuel (Duke University)

Presenter: HEDGES, Samuel (Duke University)

Session Classification: Contributed Talks

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

EDELWEISS: searching for low-mass dark matter particles with germanium low-temperature detectors

Monday, 24 February 2020 14:20 (20 minutes)

EDELWEISS is a direct dark matter search experiment aiming at the detection of WIMPS and other candidates as the composition of the galactic dark matter halo. The EDELWEISS detection method is based on arrays of germanium mono-crystals operated at temperatures around or below 20 mK. Energy deposited in the crystals by particle interactions are read out simultaneously by thermal sensors, which collect the phonon component of the signal, and by surface electrodes, which collect the ionization component. This hybrid detection method is extremely powerful for background reduction. The EDELWEISS devices are operated in a low-radioactivity heavily-shielded dilution refrigerator installed in the deepest European underground laboratory in Modane (France). Recently, results have been achieved also with an extremely low-noise set up installed above ground. The versatile and highly performing technology adopted by EDELWEISS opens new possibilities to detect signals induced by either electrons or nuclear recoils. EDELWEISS has developed a rich program to look for DM candidates with masses below 1 GeV and down to the MeV range (EDELWEISS SubGeV program), in a region of the parameter space where low-temperature detectors are extremely competitive. There is an increasing interest in this mass range motivated by the lack of evidence of new physics at LHC (e.g. SUSY), which pushes to look beyond the standard WIMP dark matter scenario

Detectors are operated in two modes, according to the voltage magnitude applied to the ionization electrodes. In the low-voltage mode, discrimination between nuclear and electron recoils is maintained, with threshold down to 50 eV (electron equivalent) in prospects. In the high-voltage mode, detection of single electron-hole pair in massive detectors is possible.

We will report both on the promising technological advancements in these detection regimes and on recent results about low-mass candidates. In particular, we will present results on Axion-Like Particles in the keV range and will report the attainment of the first sub-GeV spin-independent dark matter limit based on a germanium target. The search has been extended to Strongly Interacting Particles (SIMP) down to masses of 45 MeV by exploiting the Migdal effect. Results on SIMPs with spin-dependent interactions will also be presented.

Primary authors: GIULIANI, Andrea (CNRS/CSNSM); (ON BEHALF OF THE EDELWEISS COLLABORATION)

Presenter: GIULIANI, Andrea (CNRS/CSNSM)

Session Classification: Contributed Talks

Contribution ID: **50** Type: **Oral**

Searching for neutrinoless double beta of 100Mo: the CUPID-Mo experiment

Monday, 24 February 2020 14:00 (20 minutes)

^{100}Mo deployed in the form of enriched Li_2 MoO_4 crystals can be used as a promising scintillating bolometer to search for $0\nu\beta\beta$ in a tonne-scale experiment. In this talk we will review the properties of this target crystal and achieved bolometric detector performances that make it the baseline choice for CUPID (CUORE Upgrade with Particle ID).
CUPID-Mo, installed in the underground laboratory of Modane, consists of an array of 20 enriched ~0.2 kg Li2MoO4 crystals equipped with 20 cryogenic Ge bolometers to discriminate alpha from beta/gamma events by the detection of both heat and scintillation light signals. The commissioning has started in december 2018 and we have switched to routine data taking in spring 2019. In this talk, we will present results confirming an excellent bolometric performance of ∼5-6 keV energy resolution (FWHM) at 2615 keV, full alpha to beta gamma separation and improved estimates on the radiopurity of the crystals. We will also report on the background level observed in the region of interest and give a competitive limit on the neutrinoless double-beta decay half-life of Mo-100 as well the most precise measurement of the 2-neutrino decay mode. We will conclude with an expectation of the sensitivity of CUPID-Mo and prospects for CUPID.

Primary authors: NONES, Claudia; ON BEHALF OF THE CUPID-MO COLLABORATION

Presenter: NONES, Claudia

Session Classification: Contributed Talks

Contribution ID: **51** Type: **Invited Talk**

Neutrinos in DUNE: long-baseline oscillations and non-beam physics

Thursday, 27 February 2020 08:30 (30 minutes)

The Deep Underground Neutrino Experiment (DUNE) is one of the most ambitious particle physics experiments of the next generation. DUNE consists of two detectors: the Near Detector (ND) - just downstream of the neutrino beam at FERMILAB (IL - USA), and the Far Detector (FD) - 1300 km away and 1500 m deep in the underground SURF laboratory (SD - USA). The ND is a multi-technology apparatus aiming to constrain the uncertainties related to the unoscillated neutrino flux and also to explore neutrino interactions physics. The FD is a modular 40 kton fiducial mass Liquid Argon Time Projection Chamber, dedicated to studying long-baseline neutrino oscillations, which includes precise measurements of neutrino mixing parameters, the CP violation phase as well as the determination of neutrino mass hierarchy. The physics list of DUNE extends to non-beam physics like supernova neutrinos and search for nucleon decay. In this contribution, we describe the main features of DUNE and its sensitivity for measurements on the primary physics goals.

Primary authors: KEMP, Ernesto (University of Campinas - UNICAMP); COLLABORATION, for the DUNE

Presenter: KEMP, Ernesto (University of Campinas - UNICAMP)

Session Classification: Invited Talks

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

Limits on the spectral parameters of core-collapse neutrinos extracted from the Diffuse Supernovae Neutrino Flux (DSNvF).

Thursday, 27 February 2020 13:30 (20 minutes)

In February 1987 neutrinos from the SN1987 traveled a distance of about 50 kpc from the Large Magellanic Cloud and were detected on Earth by two of the largest neutrino telescopes of that time, Kamiokande-II and IMB, thus confirming the vast amount of energy (~10^53 ergs) predicted to be emitted in neutrinos and setting allowed intervals for the emission parameters like the neutrinosphere temperature. The confirmation of the main features of neutrino emission for a single supernova also supports the prediction that all the past supernovae in the universe should originate a ubiquitous and isotropic neutrino flux, the so-called Diffuse Supernova Neutrino Flux (DSNvF). Up to now, no evidence of events from DSNvF was found by different neutrino telescopes. In this work, we use the upper limit on the DSNvF obtained from the null results of the Super-Kamiokande collaboration to estimate limits on average energy, spectral pinching, and neutrinosphere temperature for electron antineutrinos from a core-collapse neutrino burst. Finally, we check our results with those obtained from the solely SN1987a data concluding that the DSNvF may lead to comparable - or even better - upper limits on the neutrino emission parameters.

Primary authors: Mr RAISER, Rafael (University of Campinas - UNICAMP); KEMP, Ernesto (University of Campinas - UNICAMP)

Presenter: KEMP, Ernesto (University of Campinas - UNICAMP)

Session Classification: Contributed Talks

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

Borexino solar neutrino data as a probe of non-standard neutrino properties

Tuesday, 25 February 2020 14:00 (20 minutes)

Neutrinos produced in the Sun can be used as a probe of neutrino physics beyond the Standard Model (BSM). In this study, two BSM processes are considered, namely, non-standard neutrino-electron interactions, and electromagnetic neutrino interaction caused by an anomalous magnetic moment. These processes may occur during both neutrino propagation through the solar matter and detection, causing distortions in solar neutrino fluxes, survival probability, interaction cross sections and other properties. In the Borexino experiment, possible impacts of the non-standard interactions of solar neutrinos to the data have been estimated using both interaction rate and spectral information. For the anomalous neutrino magnetic moment study, both neutrino and anti-neutrino datasets have been considered.

Primary author: VISHNEVA, Alina (JINR)

Presenter: VISHNEVA, Alina (JINR)

Session Classification: Contributed Talks

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

Detection of supernova neutrino signal with NOvA detectors

Thursday, 27 February 2020 14:10 (20 minutes)

The NOvA experiment has two segmented liquid scintillation detectors, which are sensitive to the neutrino signal from a core-collapse supernova in our galaxy. Each of these detectors performs an online reconstruction and analysis of the neutrino interaction candidates, comparing their time distribution to that of the signals expected from a core-collapse supernova. The statistical significance calculated in this comparison is used to decide if a detector is currently observing a supernova signal.

The combination of these significance values from both detectors provides a more efficient metric for detecting the supernova signal, increasing the maximum distance at which NOvA can detect a core-collapse supernova.

NOvA's approach for its combination of two detectors for supernova detection can be generalized to a network of various detectors with different background levels and sensitivities.

Primary author: SHESHUKOV, Andrey (Joint Institute for Nuclear Research)

Presenter: SHESHUKOV, Andrey (Joint Institute for Nuclear Research)

Session Classification: Contributed Talks

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

Nuclear Structure Decay Studies for Reactor Antineutrino Physics

There have been two intriguing and unresolved puzzles surrounding recent measurements of reactor antineutrino spectrum in comparison with various calculated spectra, namely a deficient in the total number of measured antineutrinos and an excess of antineutrinos for energies from 5-7 MeV. While these observations could point to new physics, the beta-decay properties of fission fragments used as inputs to calculate the spectrum need to be fully understood before any solid conclusion could be reached. Particularly, with currently available data, the contribution of the decay of a few out of more than 800 total fission fragments is expected to be much more significant than the others to the energy region where the excess of antineutrinos is presented. These key isotopes include Rb-92, Cs-142, La-142 and Cs-141, which could be isotopically purified by the CARIBU facility at Argonne National Laboratory. Using the modern state-of-art gamma-ray spectrometers such as Gammasphere, we were able to study the decay properties of these purified isotopes in great detail, and to expand their decay schemes extensively. The results of these new measurements will be presented and their impact on reactor antineutrino calculations will be discussed.

Primary authors: ZHU, Shaofei (Brookhaven National Laboratory); MCCUTCHAN, Elizabeth (Brookhaven National Laboratory); SONZOGNI, Alejandro

Presenter: ZHU, Shaofei (Brookhaven National Laboratory)

Session Classification: Contributed Talks

Contribution ID: **57** Type: **Oral**

Total absorption measurements of the beta decay of relevant contributors to the antineutrino spectrum from reactors

Total absorption spectroscopy is presently the most reliable technique that provides beta decay transition probabilities free from the Pandemonium systematic error [1-3]. In this contribution we will present recent results from the work performed by our collaboration employing this technique, which is relevant for reactor applications and in particular for the prediction of the antineutrino spectrum in reactors. The measurements have been performed at the University of Jyväskylä IGISOL IV Facility [4] using trapassisted spectroscopy that provided radioactive beams of very high isotopic purity [5] and in certain cases has allowed us to disentangle beta decaying isomers.
These measurements have provided beta decay data that are a key ingredient in an updated antineutrino summation model [6] that presently provides the best description of the measured spectra by the Daya Bay collaboration. In this contribution results coming from our latest experiments will be presented [7-10].
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Primary author: ALGORA, Alejandro (IFIC (CSIC-Univ. of Valencia), Valencia, Spain)

Presenter: ALGORA, Alejandro (IFIC (CSIC-Univ. of Valencia), Valencia, Spain)

Session Classification: Contributed Talks

Contribution ID: **58** Type: **Oral**

Updated Summation Method Model and New Prediction for the Reactor Antineutrino Flux and Energy Spectrum

The accurate determination of reactor antineutrino spectra is still a challenge. In 2017 the Daya Bay collaboration has released a measurement of the evolution of the antineutrino flux with the fuel content of the reactor 1. The observed deficit of the flux compared with the predictions of the conversion model was quasi totally explained by the data arising from the fissions of 235U while the part dominated by the fissions of 239Pu was in good agreement with the model. The distortion of the measured antineutrino energy spectrum at reactors in the 5 to 7 MeV range in comparison with the conversion model (shape anomaly) is not yet understood as well. The understanding of the underlying components of the antineutrino spectrum is possible using the nuclear beta decay data and the fission yields. This computation method, called the summation method [2], was re-developed in 2011 in order to predict reactor antineutrino spectra from any fuel under any irradiation condition without restriction of the antineutrino energy range. It was shown that the Pandemonium effect [3] affects the evaluated nuclear databases containing the required beta decay data. In [4] new Total Absorption Gamma-ray Spectroscopy (TAGS) results revealed to have a major impact on the antineutrino spectral shape. Since then the Nantes-Valencia collaboration has carried out two experimental campaigns during the last decade at the University of Jyväskylä, Finland, measuring a large set of data in order to improve the quality of the predictions of the summation method [5]. The summation model of [3] has been updated using the most recent evaluated beta decay databases and the TAGS measurements performed by our collaboration during the last decade [5] have been included in a new summation calculation. The impact of the TAGS results for these 15 nuclei on the detected antineutrino flux and on the energy spectrum will be shown [6]. These studies give an indication of the improvement of the quality of the nuclear data since 2011 and some hints about the effort that still needs to be done. The resulting detected antineutrino spectrum and flux has been compared without any renormalization with that obtained by the Daya Bay experiment showing a remaining difference in flux of only 1.9%, that should be further reduced with the inclusion of more Pandemonium free data in the calculation.
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[6] M. Estienne et al., Phys. Rev. Lett. 123, 022502 (2019).

Primary authors: FALLOT, Muriel (Subatech); Dr ESTIENNE, Magali (Subatech); Dr ALGORA, Alejandro (IFIC Valencia); Dr BRIZ-MONAGO, Jose (Subatech); Dr BUI, Van Minh (Subatech); Dr CORMON, Sandrine (Subatech); Prof. GELLETLY, William (Surrey UK); Dr GIOT, Lydie (Subatech); Dr GUADILLA, Victor (Subatech); Dr JORDAN, M. D. (IFIC Valencia); Dr LE MEUR, Loïc (Subatech); Dr PORTA, Amanda (Subatech); Dr RICE, Simon (Surrey UK); Prof. RUBIO, Berta (IFIC Valencia); Dr

TAÌN, Jose-Luis (IFIC Valencia); Dr VALENCIA, Ebbhelixes (IFIC Valencia); Dr ZAKARI-ISSOUFOU, Abdul-Aziz (Subatech)

Presenter: FALLOT, Muriel (Subatech)

Session Classification: Contributed Talks

Contribution ID: **59** Type: **Invited Talk**

Experimental studies and perspectives for neutrino nuclear responses and isotopes production using negative muons

Neutrino nuclear responses associated with astro-neutrinos and double beta decays are crucial to extract neutrino properties of astro-particle physics interests. The present report
reviews briefly recent experimental studies and perspectives for neutrino nuclear responses and isotopes production using negative muons. Gamma rays following ordinary muon capture reactions are used for studies of nuclear responses for anti-neutrinos associated with double beta decays and astro-neutrinos, and for high-sensitivity nuclear-isotope detection and production. Recently, we have started a new research project for these subjects in collaboration with Universiti Teknologi Malaysia (UTM) Johor Bahru, RCNP Osaka and the Joint Institute for Nuclear Research (JINR) Dubna. The present work was started at the Research Center for Nuclear Physics (RCNP), Osaka University, and now it is continuing at RCNP, J-PARC and the Paul Scherrer Institute (PSI).

Primary author: Dr HASHIM, Izyan Hazwani (Universiti Teknologi Malaysia)

Presenter: Dr HASHIM, Izyan Hazwani (Universiti Teknologi Malaysia)

Contribution ID: **60** Type: **Oral**

Status and prospects of the KM3NeT/ORCA

Thursday, 27 February 2020 14:30 (20 minutes)

KM3NeT is the next-generation neutrino Cherenkov telescope currently under construction in the Mediterranean Sea. Its low energy configuration ORCA (Oscillations Research with Cosmics in the Abyss) is optimised for the detection of atmospheric neutrinos with energies above ~1 GeV. The main research target of the ORCA detector is the measurement of the neutrino mass ordering (NMO) and atmospheric neutrino oscillation parameters. This contribution will present the first results on atmospheric neutrinos detected with the already deployed ORCA detection units. The projected sensitivity of the detector to the NMO will be shown, alongside prospects for early analyses of data collected with a small sub-array of the detector during construction phase. The ORCA potential for other physics topics, including dark matter, non-standard interactions, sterile neutrinos, and supernovae neutrino detection will also be presented.

Primary author: MIRANDA PALACIOS, Salvador (University of Johannesburg)

Presenter: MIRANDA PALACIOS, Salvador (University of Johannesburg)

Session Classification: Contributed Talks

Contribution ID: **61** Type: **Oral**

Tests of three-neutrino paradigm by MINOS and MINOS+ Experiments

Thursday, 27 February 2020 13:30 (20 minutes)

MINOS and MINOS+ experiments collected unprecedented amount of data using two long baseline detectors that operated on axis of the NuMI neutrino beam at Fermilab. This has allowed to conduct some of the best measurements of neutrino oscillations that provide stringent constraints on neutrino mixing and transitions involving sterile neutrinos. We will present the latest results from these studies.

Primary author: LANG, Karol (University of Texas at Austin)

Presenter: LANG, Karol (University of Texas at Austin)

Session Classification: Contributed Talks

Contribution ID: **62** Type: **Oral**

EARTH, a meeting of neutrino- and nuclear- physics.

Tuesday, 25 February 2020 15:00 (20 minutes)

Over the past 15 years, in the consortium EARTH (Earth AntineutRino TomograpHy), low energy experiments have been carried out with the detection of antineutrinos as a theme. The ultimate goal was to learn more about the role of nuclear decay in the interior of the Earth [1-3]. This required developing direction sensitive antineutrino detection to detect geoneutrinos. Here searching for remnants of possible nuclear reactions may also provide clues [4]. Other experiments were done into whether neutrinos from the Sun have a greater influence on radioactive decay than is commonly accepted by using antineutrinos from reactors as a surrogate to investigate these claims [5]. The work done on these unfinished projects will be reviewed and some ideas for future work will be given.

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[4] R.J. de Meijer et al., Radiation Physics and Chemistry 71 (2004) 769
[5] R.J. de Meijer et al., Applied Radiation and Isotopes 69 (2011) 320

Primary authors: Prof. DE MEIJER, Rob (Stichting EARTH, 9321 XS2, Peize, the Netherlands and Dept. of Physics, University of the Western Cape, Belleville, South Africa.); SMIT, Frederick (NRF iThemba LABS, Somerset West, South Africa)

Presenter: SMIT, Frederick (NRF iThemba LABS, Somerset West, South Africa)

Session Classification: Contributed Talks

Contribution ID: **63** Type: **Invited Talk**

COSINE experiment - A WIMP dark matter search experiment with NaI(Tl) detectors

Tuesday, 25 February 2020 12:30 (30 minutes)

The COSINE experiment searches for interactions of Weakly Interacting Massive Particles (WIMPs) using an array of NaI(Tl) crystal detectors in the 700-m-deep Yangyang underground laboratory, Korea. The main goal is to check the annual modulation signal observed by DAMA/LIBRA with the same target material. The first phase of the experiment, COSINE-100 with 106 kg of NaI(Tl) crystals, has been running stably for more than 3 years. Several analyses in addition to the annual modulation have been actively ongoing, based on the 1 keV energy threshold and about 3 counts/day/kg/keV background rate in an energy region between 1 and 6 keV. In this talk, the detector performance, recent analysis results, and future prospects of the COSINE experiment will be presented.

Primary author: Dr LEE, Hyunsu (Institute for Basic Science)

Presenter: KIM, Yeongduk (Institute for Basic Science)

Session Classification: Invited Talks

Contribution ID: **64** Type: **Oral**

NEON - Neutrino Elastic-scattering Observation with NaI(Tl)

Tuesday, 25 February 2020 15:20 (20 minutes)

NEON is a proposed experiment to detect coherent elastic neutrino-nucleus scattering (CENNS) with high light yield NaI(Tl) detectors and a reactor as antinuetrino source. Due to extremely low energy signal predicted from the CENNS process, one needs to develop extremely low threshold detectors. We have optimized size of the crystals and developed new optical coupling design for high light collection efficiency. With current best crystal of approximately 23 photoelectrons per keV, a sub-keV scintillation signal is accessible with the NaI(Tl) crystals. We consider to install approximately 10~kg target mass at Hanbit reactor power plant, which is same place of the NEOS short baseline neutrino experiment, in early 2020. The site is 24 m far from reactor core with measured antineutrino flux of $7\times10^{-12}/\mathrm{cm}^2/\mathrm{s}$. We will present current status of detector developments as well as our strategy for an observation of CENNS process with the reactor antineutrino.

Primary author: LEE, Hyun Su (Institute for Basic Science)

Presenter: LEE, Hyun Su (Institute for Basic Science)

Session Classification: Contributed Talks

Contribution ID: **65** Type: **Invited Talk**

Status of the Mo-100 based AMoRE neutrinoless double beta decay experiment

Thursday, 27 February 2020 12:00 (30 minutes)

The AMoRE (Advanced Mo-based Rare process Experiment) intends to find an evidence for neutrinoless double beta decay of Mo-100 by using a cryogenic technique with molybdate based crystal scintillators. The crystals, which are cooled down to 10~20 mK temperatures, are equipped with MMC-type phonon and photon sensors to detect both thermal and scintillation signals produced by a particle interaction in the crystal to achieve high energy resolution and efficient particle discrimination. The AMoRE-pilot experiment with an array of six 48deplCa100MoO4 crystals with a total mass of about 1.9 kg was performed at the 700-m-deep YangYang underground laboratory and AMoRE-I preparation is in progress with ab ~ 6.1 kg of crystals, mostly 48deplCa100MoO4 and several R&D crystals such as Li2100MoO4 crystals. Significant improvement of effective Majorana neutrino mass sensitivity at the level of inverted hierarchy of neutrino mass, 20-50 meV, could be achieved by the AMoRE-II with 200 kg of molybdate crystals at the new 1,000 m deep underground laboratory excavated by the end of 2021 in the Yemi. Results of the AMoRE-pilot and status of the AMoRE-I and AMoRE-II preparation will be presented.

Primary authors: KIM, Hong Joo (Kyungpook National University); AMORE COLLABORTION

Presenter: KIM, Hong Joo (Kyungpook National University)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **66** Type: **Invited Talk**

Majorana neutrino mass generation, $0\nu\beta\beta$-decay and nuclear matrix elements

Wednesday, 26 February 2020 11:00 (30 minutes)

: A Quark Condensate See-Saw (QCSS) mechanism of generation of Majorana neutrino mass due to spontaneous breaking of chiral symmetry accompanied with the formation of a quark condensate is presented. Consequencies of this scenario of neutrino mass generation for the neutrinoless double beta decay ($0\nu\beta\beta$-decay), tritium beta decay and cosmological measurements are drawn. The attention is paid also to the problem of reliable calculation of the $0\nu\beta\beta$-decay nuclear matrix elements and the evaluation of quenching of the axial-vector coupling constant g_A.
For solving of these nuclear physics problems an importance of experimental study of the two-neutrino double-beta decay, muon capture in nuclei and nuclear charge-exchange reactions is stressed.

Primary author: SIMKOVIC, Fedor (Comenius University)

Presenter: SIMKOVIC, Fedor (Comenius University)

Session Classification: Invited Talks

Contribution ID: **67** Type: **Oral**

Decay Characteristics of the Scissors Mode of 0νββ-Decay Partner Isotopes*

Friday, 28 February 2020 09:00 (20 minutes)

The search for neutrinoless double beta (0νββ) decay, a process only allowed if the neutrino were a Majorana particle, recently gained much attention with numerous experiments being dedicated to its observation. It would demonstrate lepto-genesis in the universe and allow the determination of the neutrino mass from its decay rate. However, to quantitatively extract the neutrino mass or estimate decay rates a nuclear matrix element (NME) is required, which has to be calculated using nuclear structure models. One of them is the Interacting Boson Model 2 (IBM-2), which will be discussed below. Those calculations can be difficult because many of the 0νββ-decay candidate nuclei lie in regions of the nuclear chart that feature shape coexistence, with the hypothesized 0νββ-decay mother nucleus ^{150}Nd and its daughter ^{150}Sm even being located in the region of a shape phase transition along their respective isotopic chains. In particular, the occurrence of shape coexistence may lead to a significant population of an excited 0^+ state in 0νββ decay. To improve 0νββ-NME calculations for ^{150}Nd and ^{150}Sm within the IBM-2 information on its so-called Majorana interaction is needed. Therefore, new data on the decay characteristics of the scissors mode of these nuclei was recently taken in nuclear resonance fluorescence experiments performed at the High Intensity γ-ray Source. The decay characteristics of the scissors mode are sensitive to the nuclear deformation and allow inducing constraints on model parameters, especially the Majorana parameters of the IBM-2, in turn resulting in a more reliable prediction of the 0νββ-NME. Similar information has also been obtained for the 0νββ-partner nuclides ^{82}Se and ^{82}Kr. The experimental results and updated IBM-2 calculations will be presented and discussed.
*Supported by the DFG through the research grant SFB 1245 and by the State of Hesse under the grant “Nuclear Photonics” within the LOEWE program.

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Presenter: KLEEMANN, Jörn (AG Pietralla Institut für Kernphysik Technische Universität Darmstadt)

Session Classification: Contributed Talks

Contribution ID: **68** Type: **Invited Talk**

Solar Models and Neutrino: where do we stand?

Thursday, 27 February 2020 15:10 (30 minutes)

In this talk, I will present the status of solar models, review the main limitations imposed by uncertain input physics in the models and by external constraints (aka solar abudances), and discuss the current constraints imposed from helioseismic and solar neutrino measurements. Also, I will discuss the implications that our current limitations in modeling the Sun have for stellar physics. Finally, some discussion will be devoted to the importance of a prospective measurement of solar neutrinos from the CN-cycle would have for solar models and other fields.

Primary author: SERENELLI, Aldo (Institute of Space Sciences (ICE-CSIC))

Presenter: SERENELLI, Aldo (Institute of Space Sciences (ICE-CSIC))

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **69** Type: **Invited Talk**

What we can learn from CEvNS? (CEvNS - Coherent Elastic Neutrino Nucleus Scattering)

Wednesday, 26 February 2020 10:00 (30 minutes)

CEvNS process has been predicted in 1974 right after discovery of the neutral current of the week interactions. It took more than 40 years to confirm this prediction experimentally. In 2017 COHERENT collaboration reported of the first observation of CEvNS using 14 kg CsI detector and SNS neutrino source at the ORNL. In my talk I will review first observation of CEvNS and present experimental status to study CEvNS. The focus of my talk will be how we can use accurate CEvNS measurements to test S-M of the particle physics, and make contribution into nuclei physics and astrophysics.

Primary author: EFREMENKO, Yuri (University of Tennessee, USA)

Presenter: EFREMENKO, Yuri (University of Tennessee, USA)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **70** Type: **Invited Talk**

The nEXO double-beta decay experiment

Monday, 24 February 2020 12:00 (30 minutes)

The search for neutrinoless double-beta decay represents one of the most exciting opportunities to explore physics beyond the Standard Model. The knowledge that neutrinos are massive particles, yet, with masses that are many orders of magnitude smaller than those of charged fermions, provides encouragement to further push the sensitivity of these experiments.

nEXO is a 5-tonne detector based on the isotope 136Xe in a single phase, liquid time projection chamber. Its design is based on EXO-200, the first 100kg-class experiment to take data, demonstrating the power of a monolithic detector with good energy resolution and superior topological event reconstruction. nEXO is expected to reach a half-life sensitivity of about 10^28 years, covering substantial discovery space. The detector includes several state-of-the-art components but, at the same time, offers a conservative approach in which the background estimate is solidly grounded on existing materials and reliable simulation tools. In this talk the nEXO design and sensitivity reach will be discussed.

Primary authors: GRATTA, Giorgio (Stanford University); NEXO COLLABORATION

Presenter: GRATTA, Giorgio (Stanford University)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **71** Type: **Invited Talk**

Probing Dark Energy with the SKA in Africa

Tuesday, 25 February 2020 11:00 (30 minutes)

I will survey the progress towards the SKA radio telescope array, including the successful building and operation of South Africa's MeerKAT array. Then I will focus on how these instruments can deliver new measurements and insights about the Dark Energy that is driving the accelerated expansion of the Universe.

Primary author: MAARTENS, Roy (University of the Western Cape)

Presenter: MAARTENS, Roy (University of the Western Cape)

Session Classification: Invited Talks

Contribution ID: **72** Type: **Invited Talk**

Theory of Double-Beta Decay from First Principles

Wednesday, 26 February 2020 12:30 (30 minutes)

I discuss recent work to calculate the nuclear matrix elements that govern neutrinoless double beta decay in an ab-initio way, that is, without the adjustment of parameters except those in chiral effective field theory. A method based on the use of techniques from energy-density functional theory in combination with ab-initio Hamiltonians has proved particularly powerful. I describe its application to the double-beta matrix elements of 48Ca and 76Ge.

Primary author: ENGEL, Jonathan

Presenter: ENGEL, Jonathan

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **73** Type: **Invited Talk**

First-forbidden transitions in the reactor antineutrino ux and spectral anomalies

Wednesday, 26 February 2020 09:00 (30 minutes)

It has been almost a decade since the reactor antineutrino anomaly entered the stage, where the number of experimentally detected antineutrinos emerging from a nuclear power reactor interior was signicantly less than theoretically predicted from nuclear decay. This has, in turn, motivated the search for an eV-scale sterile neutrino in several very short baseline experiments, none of which have so far confirmed its existence. From the theory point of view, initial analyses introduced a signicant number of approximations, in particular for the treatment of so-called forbidden transitions. We report on the first large-scale calculation of the influence of first-forbidden transitions using state-of-the-art nuclear shell model calculations for a select number of highly-contributing branches. We use these results to propose a probability distribution for first-forbidden spectral shapes and employ Monte Carlo techniques to translate this into a detailed construction of theoretical uncertainties for the remaining forbidden transitions. We observed signicant changes in both the integrated
ux and spectral shape of the cumulative antineutrino spectra spectra for all ssion actinides [1, 2], and discuss both a mitigation of the so-called reactor shoulder and changes in the reactor antineutrino anomaly. Finally, we will comment how an improved treatment of allowed transitions [2, 3] can further signicantly change both ux and spectral shape.
1 L. Hayen, J. Kostensalo, N. Severijns, and J. Suhonen, Physical Review C 99, 031301(R) (2019).
[2] L. Hayen, J. Kostensalo, N. Severijns, and J. Suhonen, Physical Review C 100, 054323 (2019), arXiv:1805.12259.
[3] L. Hayen, N. Severijns, K. Bodek, D. Rozpedzik, and X. Mougeot, Reviews of Modern Physics 90, 015008 (2018),
arXiv:1709.07530.

Primary author: HAYEN, Leendert (North Carolina State University & Triangle Universities Nuclear Laboratory)

Presenter: HAYEN, Leendert (North Carolina State University & Triangle Universities Nuclear Laboratory)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **74** Type: **Invited Talk**

Dark Matter Direct Detection with Noble Liquids

Tuesday, 25 February 2020 11:30 (30 minutes)

What is the Dark Matter which makes 85% of the matter in the Universe? We have been asking this question for many decades and used a variety of experimental approaches to address it, with detectors on Earth and in space. Yet, the nature of Dark Matter remains a mystery. An answer to this fundamental question will likely come from ongoing and future searches with accelerators, indirect and direct detection. Detection of a Dark Matter signal in an ultra-low background terrestrial detector will provide the most direct evidence of its existence and will represent a ground-breaking discovery in physics and cosmology. I will review direct detection experiments using noble liquids which have shown the highest sensitivity to-date.

Primary author: APRILE, Elena (Columbia University)

Presenter: APRILE, Elena (Columbia University)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **75** Type: **Oral**

Axial Vector Form Factors of the Nucleon using lattice QCD

Friday, 28 February 2020 10:00 (20 minutes)

The success of experiments such as DUNE require the determination of neutrino flux and cross-section with nuclear targets with unprecedented accuracy. A crucial input in the calculations of these is the axial form factor. Starting from the standard model that defines the interaction of the axial current with quarks, one needs to include both QCD corrections that bind quarks into nucleons and nuclear effects that arise in heavy nuclear targets such as argon. Experimental access to the first, QCD corrections for nucleons, is prevented by safety concerns posed by liquid hydrogen targets. Axial and electromagnetic form factors of the nucleon can be calculated from first principals using lattice QCD. This talk will show that we now have control over all sources of systematic errors that arise in lattice QCD calculations and the axial form factors satisfy the PCAC relation, an essential and non-trivial check [see arXiv:1905.06470]. Finally, I will present state-of-the-art results at the physical pion mass and in the continuum limit and compare them with phenomenology. Prospects for reaching 1–2% accuracy will be discussed.

Primary author: GUPTA, Rajan (Los Alamos National Laboratory)

Presenter: GUPTA, Rajan (Los Alamos National Laboratory)

Session Classification: Contributed Talks

Track Classification: Nuclear structure in connection with neutrino physics

Contribution ID: **76** Type: **Invited Talk**

The role of neutrino-nucleus reactions in supernova nucleosynthesis

Monday, 24 February 2020 10:00 (30 minutes)

Neutrinos play an important role for the supernova dynamics and the associated nucleosynthesis. During collapse, electron neutrinos, produced by electron capture on nuclei, dominate, while all neutrino families are being produced during the cooling phase of the protoneutron star.

Neutrinos are crucial for the explosive nucleosynthesis. At first, by interaction with free nucleons they determine the proton-to-neutron ratio of the ejected matter which is crucial for the subsequent nucleosynthesis. Modern supernova simulations indicate that the ejected matter is not sufficiently neutron rich to support an r-process which also produces the solar abundances in the third r-process peak.

Neutrino-induced spallation reactions on abundant nuclei in the outer stellar shells are responsible for the production of selected nuclides (neutrino nucleosynthesis). Recently the first study of neutrino nucleosynthesis has been presented which considers the time-dependence of the neutrino emission including the neutrino burst, the accretion phase and the cooling phase as well as changes in the spectral forms of the neutrinos.

Primary author: LANGANKE, Karlheinz (GSI Darmstadt)

Presenter: LANGANKE, Karlheinz (GSI Darmstadt)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **77** Type: **Invited Talk**

Roles of Neutrinos in Explosive Nucleosynthesis of Supernovae and Neutron-Star Mergers and Cosmic Evolution

Wednesday, 26 February 2020 08:30 (30 minutes)

The big-bang universe, supernovae (SNe), collapsars and binary neutron-star mergers (NSMs) are the viable celestial sources of "multi-messengers". These messengers are neutrinos for weak force, gravitational waves for gravity, photons for electromagnetism, and atomic nuclei for strong nuclear force 1. Their detection takes the keys to solve still unanswered questions such as mass hierarchy of neutrinos [2], overproduction of big-bang lithium [3], the origin of p-nuclei [4], and the origin of r-process elements [1,5]. We will discuss the roles of neutrinos and radioactive nuclei for solving these problems.

Still unknown neutrino mass and oscillations are particularly important to answer the fundamental question why we need to go beyond the standard theory of elementary particles and fields. We will, first, discuss cosmological background neutrinos and fluctuations of primordial magnetic fields in order to solve overproduction problem of primordial big-bang lithium [3]. The relic SN neutrinos also are the energetic component of cosmic background neutrinos. We will propose a method how to constrain the neutrino mass hierarchy and EOS of proto-neutron stars in the proposed HK project of detecting these energetic neutrinos [6].

A huge flux of neutrinos is emitted from proto-neutron stars or accretion disks formed in SNe, collapsars and binary NSMs. The collective flavor oscillation due to the neutrino self-interactions is presumed to occur in the deepest region inside the iron-core, while the MSW high-density resonance occurs near the bottom of He/C-layer. The light mass nuclei, 7Li and 11B, and the intermediate-to-heavy mass nuclei, 19F, 50V, 53Mn, 92Nb, 98Tc, 138La and 180Ta, are respectively produced in outer He/C-layer and inner O-Ne-Mg-layer exposed to the intense neutrino flux (□-process) [2]. The intermediate mass p-nuclei, 74Se, 78Kr, 84Sr, 74Se, 92,94Mo and 96,98Ru (□p-process) [4], and r-process nuclei 1 are produced in the iron-core. Therefore, nucleosynthesis of 7Li and 11B is affected by both collective and MSW effects, however all the other intermediate-to-heavy mass nuclei are affected by the collective oscillation alone, being almost free from MSW effect. We will, secondly, discuss how differently these nucleosynthetic products depend on each of collective or MSW neutrino oscillation effect, and will propose how to distinguish these two effects from each other [2].

Finally, we will discuss the origin of r-process nucleosynthesis to understand the cosmic evolutionary history of each contribution from SN, collapsar and binary NSM [5]. We here discuss the roles of GW detection and spectroscopic astronomical observation of atomic nuclei as well as nuclear experiments of radioactive nuclei 1.

Primary author: KAJINO, Taka (Being University/NAOJ/University of Tokyo)

Presenter: KAJINO, Taka (Being University/NAOJ/University of Tokyo)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **78** Type: **Invited Talk**

Dark Matter Direct Detection with Noble Liquids

What is the Dark Matter which makes 85% of the matter in the Universe? We have been asking this question for many decades and used a variety of experimental approaches to address it, with detectors on Earth and in space. Yet, the nature of Dark Matter remains a mystery. An answer to this fundamental question will likely come from ongoing and future searches with accelerators, indirect and direct detection. Detection of a Dark Matter signal in an ultra-low background terrestrial detector will provide the most direct evidence of its existence and will represent a ground-breaking discovery in physics and cosmology. I will review direct detection experiments using noble liquids which have shown the highest sensitivity to-date.

Primary author: APRILE, ELENA (Columbia University)

Presenter: APRILE, ELENA (Columbia University)

Track Classification: Invited Talk

Contribution ID: **79** Type: **Oral**

Enlightening the dark with XENON1T and looking forward to XENONnT

Monday, 24 February 2020 15:00 (20 minutes)

The most recent results of the XENON1T direct dark matter detector will be presented. XENON1T was a two-phase xenon TPC using 248 low radioactivity PMTs to detect scintillation signals in a 2-ton active liquid xenon target. The detector was operational between 2016 and 2018 at the Laboratori Nazionale del Gran Sasso with continuously improving xenon purity and reduction of the internal Kr-85 background source. In addition to WIMP searches, XENON1T also produced important results on nuclear processes, such as the double electron capture of 124Xe, and is sensitive to flavour independent measurements of solar and supernova neutrinos. The status of the successor experiment, XENONnT will be discussed, as well as projections for WIMP and neutrinoless double beta decay searches.

Primary author: PIENAAR, Jacques (University of Chicago)

Presenter: WITTWEG, Christian

Session Classification: Contributed Talks

Track Classification: New related detection technologies

Contribution ID: **80** Type: **Invited Talk**

Recent results and perspectives on beta decay, double beta decay and lepton flavour violation

Monday, 24 February 2020 09:00 (30 minutes)

The lepton sector of the Standard Model is a very important and interesting field to search for new physics beyond the standard model. As we know that quarks and neutrinos are mixing it is an open question why the charged leptons are now. This stimulates the search for charge lepton violation (CLFV). In addition, neutrino-less double beta decay would violate total lepton number by 2 and prove that neutrinos are their own antiparticle. The obtained half-life can be linked to a potential Majorana neutrino mass. This is providing a complementary measurement to normal beta decay where new interesting results are obtained.
This talk will shortly review the current situation in this area of research, required support from theory and an outlook into the future.

Primary author: ZUBER, Kai (Technical University Dresden)

Presenter: ZUBER, Kai (Technical University Dresden)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **81** Type: **Invited Talk**

Hunting Down Solar Neutrinos; an Extraordinary South African Particle Physics Safari.

Tuesday, 25 February 2020 08:30 (30 minutes)

The detection of the neutrino and subsequently the solar neutrino had stood for over 25 years as a major challenge for nuclear physicists. The presentation is a narrative of the ground-breaking experiment of the joint South African and American teams of JPF Sellschop and F. Reines for the search of cosmic ray neutrino in the early sixties. The Case Western-Wits team operated a gigantic for its time liquid scintillator detector at an unbelievable depth of almost 3,5 Km undergound in the East Rand Proprietary Gold Mine (EPRM) in Johannesburg. After six years of preparations and operation the first evidence of high-energy cosmic ray neutrino interactions was published in 1965 in Physical Review Letters. This achievement was the determining factor for the career of JPF Sellschop and in certain respects for the development of Nuclear Physics in South Africa.

Primary author: SIDERAS-HADDAD, Elias (WITS UNIVERSITY)

Presenter: SIDERAS-HADDAD, Elias (WITS UNIVERSITY)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **86** Type: **not specified**

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Monday, 24 February 2020 15:00 (20 minutes)

Session Classification: Contributed Talks

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

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Thursday, 27 February 2020 14:30 (20 minutes)

Session Classification: Contributed Talks

Contribution ID: **102** Type: **Invited Talk**

Benchmarking aspects of weak interaction physics via precision beta decay spectroscopy and two-nucleon transfer reactions

Thursday, 27 February 2020 10:30 (30 minutes)

In this talk I shall present results from recent high-precision half-life and branching ratio measurements for 19Ne beta decay and the detailed spectroscopic analyses of states in 136Ba and 136Cs via two-nucleon transfer reactions. I will briefly discuss the connection between these experiments in the context of Standard Model tests, highlighting the importance of reconciling the experimental results with state-of-the-art theory calculations. Particular emphasis will be placed on implications pertaining to neutrinoless double beta decays.

Primary author: TRIAMBAK, Smarajit (University of Western Cape)

Presenter: TRIAMBAK, Smarajit (University of Western Cape)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **103** Type: **Invited Talk**

LiquidO detector development

Tuesday, 25 February 2020 17:00 (30 minutes)

In this talk I will present a potentially game-changing new particle detector technology called LiquidO. This idea turns the concept behind the widespread scintillator detectors on its head: for 50 years research has focussed on making more and more transparent scintillator materials, whereas LiquidO actually requires an opaque scintillator. In LiquidO, scintillation light is confined near its creation point due to a short scattering length and collected by a dense grid of wavelength shifting fibres. The resulting topological information, normally lost in transparent LS detectors, allows for powerful event-by-event particle identification including MeV-scale positrons, electrons and gammas, enabling strong background suppression. Another advantage over classical liquid scintillator detectors is the possibility of loading to unprecedented levels, since high transparency is no longer required. I will give an overview of the LiquidO idea in this talk as well as show the first results from the 'micro-LiquidO' prototype detector, which provided the proof of principle of light confinement.

Primary author: HARTNELL, Jeff

Presenter: HARTNELL, Jeff

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **104** Type: **Invited Talk**

The CONUS Experiment and future potential of coherent neutrino scattering

Wednesday, 26 February 2020 09:30 (30 minutes)

Coherent elastic neutrino nucleus scattering (CEvNS) was first observed 2018 with neutrinos from pion decay at rest. CONUS aims at detecting CEvNS with low energy anti-neutrinos. It uses novel Germanium detector technology and a virtual depth shield for operation at shallow depth only 17 meters away from the core of a multi GW power reactor. The talk will cover the status of CONUS, latest results and an outlook of the potential of future CEvNS experiments.

Primary author: LINDNER, Manfred (Max-Planck-Institut für Kernphysik)

Presenter: LINDNER, Manfred (Max-Planck-Institut für Kernphysik)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **105** Type: **Invited Talk**

Ab initio nuclear theory for beyond standard model physics

Wednesday, 26 February 2020 12:00 (30 minutes)

Long considered a phenomenological field, breakthroughs in many-body methods together with our treatment of nuclear and electroweak forces are rapidly transforming modern nuclear theory into a true first- principles, or ab initio, discipline. In this talk I will discuss recent advances, which expand the scope of ab initio theory to global calculations of nuclei, potentially as heavy as 208Pb, including first predictions of the limits of nuclear existence into the medium-mass region.
I will then focus on recent extensions to fundamental problems in nuclear-weak physics, including a proposed solution of the long-standing gA quenching puzzle, calculations of neutrinoless double-beta decay for determining neutrino masses, and WIMP-nucleus scattering cross sections relevant for dark matter direct detection searches.

Primary author: HOLT, Jason (TRIUMF)

Presenter: HOLT, Jason (TRIUMF)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **106** Type: **Invited Talk**

Recent results on nuclear reactions of interest for neutrinoless double beta decay at INFN-LNS within the NUMEN project

Thursday, 27 February 2020 11:00 (30 minutes)

Researches on neutrinoless double beta decay have crucial implications on particle physics, cosmology and fundamental physics. It is likely the most promising process to access the absolute neutrino mass scale. To determine quantitative information from the possible measurement of the 0νββ decay half-lives, the knowledge of the Nuclear Matrix Elements (NME) involved in such transitions is mandatory. The use heavy-ion induced double charge exchange (DCE) reactions as tools towards the determination of information on the NME is one of the goals of the NUMEN and the NURE projects. The basic point is that there are a number of similarities between the two processes, mainly that the initial and final state wave functions are the same and the transition operators are similar, including in both cases a superposition of Fermi, Gamow-Teller and rank-two tensor components.
The availability of the MAGNEX magnetic spectrometer for the measurements of the very suppressed DCE reaction channels is essential to obtain high resolution energy spectra and accurate cross sections at forward angles including zero degree. The measurement of the competing multi-nucleon transfer processes allows to study their contribution and to constrain the theoretical calculations.
An experimental campaign is ongoing at INFN-Laboratori Nazionali del Sud (Italy) to explore medium-heavy ion induced reactions on target of interest for 0νββ decay.
Recent results obtained by the (20Ne,20O) and (18O,18Ne) DCE reactions and competing channels, measured for the first time using a 20Ne(10+) and 18O(8+) cyclotron beams at 15 AMeV will be presented at the conference. A preliminary analysis of the double charge exchange channel in comparison with the competitive multi-nucleon transfer channels will also be shown and commented.

Primary author: CAVALLARO, Manuela (INFN - LNS)

Presenter: CAVALLARO, Manuela (INFN - LNS)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **107** Type: **Invited Talk**

Nuclear structure observables to shed light on neutrinoless double-beta decay

Friday, 28 February 2020 11:20 (30 minutes)

Neutrinoless double-beta decay (0nbb) is notoriously difficult to observe. Moreover, expected decay rates depend on the value of the nuclear matrix elements (NMEs) which are poorly known. In order to obtain insights on the NMEs, and therefore on expected decay rates, one can study other processes connected to 0nbb decay. In this talk I confront predictions and measurements of the half-life and beta spectrum of the two-neutrino double-beta decays to test nuclear models used to calculate 0nbb NMEs. In addition, I discuss the relation between 0nbb NMEs (mediated by the weak interaction) and other nuclear observables such as double Gamow-Teller (strong) and double-gamma
(electromagnetic) transitions.

Primary author: MENENDEZ, Javier (University of Barcelona)

Presenter: MENENDEZ, Javier (University of Barcelona)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **108** Type: **Invited Talk**

Nuclear Matrix Elements of neutrinoless double beta decay calculated by Monte Carlo Shell Model for 76Ge and 136Xe

Wednesday, 26 February 2020 11:30 (30 minutes)

The neutrinoless double beta decay is of special importance in determining the fundamental properties of neutrinos. The nuclear matrix element of this decay must be evaluated in a sufficient accuracy, and the shell-model calculation can make contributions to this end. This is because the shell-model calculations incorporate basically all correlations into the wave functions of the initial and final states of the decay, and the accuracy of the calculation can be investigated by referring to other observables. I will report results obtained by recent large-scale shell-model calculations on 76Ge and 136Xe as well as their daughter nuclei 76Se and 136Ba. Here the large-scale shell-model calculations mean those by Monte Carlo Shell Model at its most advanced edition. The results are not away from the ranges of earlier studies, but are rather on the edges of smaller values. I will also discuss why such smaller values arise as natural consequences of basic features of the wave functions.

Primary author: OTSUKA, Takaharu (Department of Physics, University of Tokyo)

Presenter: OTSUKA, Takaharu (Department of Physics, University of Tokyo)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **109** Type: **Invited Talk**

A high precision narrow-band neutrino beam: the ENUBET project

Tuesday, 25 February 2020 16:30 (30 minutes)

The knowledge of initial flux, energy and flavor of current neutrino beams is currently the main limitation for a precise measurement of neutrino cross sections. The ENUBET ERC project (2016-2021) is studying a facility based on a narrow band neutrino beam capable of constraining the neutrino fluxes normalization through the monitoring of the associated charged leptons in an instrumented decay tunnel. Since March 2019, ENUBET is also a CERN Neutrino Platform project (NP06/ENUBET) developed in collaboration with CERN A&T and CERN-EN. In ENUBET, the identification of large-angle positrons from K_{e3} decays at single particle level can potentially reduce the ν_e flux uncertainty at the level of 1%. This setup would allow for an unprecedented measurement of the ν_e cross section at the GeV scale. Such an experimental input would be highly beneficial to reduce the budget of systematic uncertainties in the next long baseline oscillation projects (i.e HyperK-DUNE). Furthermore, in narrow-band beams, the transverse position of the neutrino interaction at the detector can be exploited to determine a priori with significant precision the neutrino energy spectrum without relying on the final state reconstruction.

This contribution will present the final design of the ENUBET demonstrator, which has been selected on April 2019 on the basis of the results of the 2016-2018 testbeams. It will also discuss advances in the design and simulation of the hadronic beam line. Special emphasis will be given to a static focusing system of secondary mesons that, unlike the other studied horn-based solution, can be coupled to a slow extraction proton scheme. The consequent reduction of particle rates and pile-up effects makes the determination of the ν_μ flux through a direct monitoring of muons after the hadron dump viable, and paves the way to a time-tagged neutrino beam. Time-coincidences among the lepton at the source and the neutrino at the detector would enable an unprecedented purity and the possibility to reconstruct the neutrino kinematics at source on an event by event basis. We will also present the performance of positron tagger prototypes tested at CERN beamlines, a full simulation of the positron reconstruction chain and the expected physics reach of ENUBET.

Primary author: LONGHIN, Andrea

Presenter: LONGHIN, Andrea

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **110** Type: **Invited Talk**

Beta-delayed proton emission in neutron-rich nuclei: The quest for dark decay of the neutron.

Nuclei with more neutrons than protons tend to get rid of excess neutrons to reach the valley of stable nuclei through beta-minus (β-) decays. On the other side of the valley of stability, proton-rich nuclei follow the analogous process through beta-plus (β+) decays. Beta-delayed proton emission, observed more than 40 years ago, typically occurs in very proton-rich nuclei and not on the neutron-rich side of the stable nuclei. However, the emission of protons following β- decay is energetically allowed for neutron-rich nuclei with neutrons bound by less than 782 keV. This condition may be fulfilled in so-called halo nuclei where one or several neutrons are loosely bound and orbit far from the core. 11Be is one of the most promising candidates, resulting in 10Be following the beta decay to 11B and the subsequent proton emission. A team of NSCL (National Superconducting Cyclotron Laboratory, Michigan State University, USA) and TRIUMF (Canada) researchers carried out the first direct observation of the beta-delayed proton decay of a neutron-rich nucleus by directly measuring the very low-energy protons emitted following the beta decay of 11Be. This experiment was performed with the Active Target Time Projection Chamber (AT-TPC), a gas-filled detector capable of providing high efficiency and resolution for low-energy charged particles such as the emitted protons. In this talk, I will discuss the technique and the results of such experiment, as well as different aspects of this decay, including a speculative dark matter decay.

Primary author: AYYAD, Yassid

Presenter: AYYAD, Yassid

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **111** Type: **not specified**

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Friday, 28 February 2020 10:00 (20 minutes)

Session Classification: Contributed Talks

Contribution ID: **112** Type: **Oral**

GT Nuclear resonances for 71Ga(nu,e)71Ge reaction investigation

Friday, 28 February 2020 09:20 (20 minutes)

Neutrino-matter interaction has great importance for neutrino physics and astrophysics. Neutrino capture cross-section depends on the structure of the target nucleus strength function. 71Ga(v,e)71Ge process could be analysed using the charge-exchange strength functions of 71Ga(p,n)71Ge and 71Ga(3He,t)71Ge reactions. Nuclear phenomenology of charge-exchange reactions describes not only discrete excited levels, but also collective resonant states such as GTR and pygmy-resonances. It is shown that accounting of GT-resonances increase neutrino capture rate and that capture rate is very sensitive to the exact behavior of the Fermi function at low energies. We will discuss the quenching effect estimation and the accuracy of B(GT) extraction from experimental data as a function of resonance width. The talk proposes a comparison of the experimental data processing and calculations obtained in the framework of the self-consistent theory of finite Fermi systems.

Primary author: KOROTEEV, Grigory (Moscow Institute of Physics and Technology)

Presenter: KOROTEEV, Grigory (Moscow Institute of Physics and Technology)

Session Classification: Contributed Talks

Track Classification: Solar models and detection of solar neutrinos

Contribution ID: **113** Type: **Oral**

127I(nu,e)127Xe reaction for solar neutrino spectrum clarification

Tuesday, 25 February 2020 14:40 (20 minutes)

Solar neutrino spectrum measurement plays a crucial role for solar metallicity determination. 127I(nu,e)127Xe reaction is sensitive to CNO and boron components of the solar neutrino spectrum due to the relatively high threshold (662 KeV).
For neutrinos with energies upper S_n = 7.246 MeV 127I(nu,e) capture produces 126Xe + n. The concentration ratio of 127Xe and 126Xe could clarify parameters of high energy solar neutrino spectrum and neutrino oscillations. We present production rate estimation for of 127Xe and 126Xe based on experimental strength function from 127I(p,n)Xe reaction.

Primary author: FAZLIAKHMETOV, Almaz (MIPT)

Presenter: FAZLIAKHMETOV, Almaz (MIPT)

Session Classification: Contributed Talks

Track Classification: Solar models and detection of solar neutrinos

Contribution ID: **114** Type: **Invited Talk**

Neutrino masses, mixings and electroweak nuclear physics

Thursday, 27 February 2020 09:30 (30 minutes)

The current status of the mass-mixing parameters in the three-neutrino framework will be reviewed. The increasing connections between neutrino and nuclear physics will be highlighted. A case will be made for establishing an interdisciplinary field, that might be named as “electroweak nuclear physics”.

Primary author: LISI, Eligio (INFN, Bari, Italy)

Presenter: LISI, Eligio (INFN, Bari, Italy)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **115** Type: **Invited Talk**

Quenching of the spin-isospin response in nuclei

Friday, 28 February 2020 10:50 (30 minutes)

Quenching of the Gamow-Teller strength in in weak processes is a well-established phenomenon. I will briefly review our knowledge of quenching of the isospin-analog spin-M1 resonance. The interest is driven by recent developments of ab initio calculations based on interactions derived from χEFT, which allow a unified description of electromagnetic and weak processes populating isospin-analog states. This provides a unique testing ground for the role of two-body currents for the quenching phenomenon. I will also discuss the (very limited) data on quenching of higher multipoles and their implications for astrophysical scenarios and 0νββ decay and present some ideas for future experimental work using transverse electron scattering.

Primary author: VON NEUMANN-COSEL, Peter (Institut fuer Kernphysik, Technische Universitaet Darmstadt)

Presenter: VON NEUMANN-COSEL, Peter (Institut fuer Kernphysik, Technische Universitaet Darmstadt)

Session Classification: Invited Talks

Track Classification: Invited Talk

Contribution ID: **116** Type: **Oral**

Calculation of the neutrino-nuclear reaction cross-sections for ⬚⬚⬚⬚ nuclei and estimation of the solar neutrino background in the GERDA/LEGEND experiments.

Friday, 28 February 2020 09:40 (20 minutes)

The work presents calculations of the neutrino-nuclear reaction cross-sections using the example of the nucleus ⬚⬚'((⬚⬚'(⬚, ⬚ ⬚⬚'( ). *In the structure of the nucleus, not only discrete, but also continuous states formed due to the collective interaction of nucleons were distinguished. In particular, the contribution of the Giant Gamow-Teller resonance and so-called pygmy resonances in the capture rate of solar neutrinos was estimated (an increase of 25% to 50%, depending on the quenching parameter used).*
Based on the obtained capture rate, a Monte Carlo simulation of the subsequent beta decay of the nucleus ⬚⬚'((⬚⬚'(⟶ ⬚⬚'(+ ⬚2 + ⬚ + ⬚⬚) was carried out for germanium detectors in the GERDA experiment. Thus, the contribution of the background component due to solar neutrinos was estimated, which, due to the small cross-sections of neutrino-nuclear reactions, is practically unremovable, imposing confines on the sensitivity limit of the setup. A similar assessment can be made for the upcoming LEGEND experiment taking into account its geometry. Preliminary results suggest that BI of solar neutrinos are 1-2 orders of magnitude lower than the predicted accuracy of the LEGEND experiment.

Primary author: VYBOROV, Andrei (Moscow Institute of Physics and Technology)

Presenter: VYBOROV, Andrei (Moscow Institute of Physics and Technology)

Session Classification: Contributed Talks

Track Classification: Solar models and detection of solar neutrinos

Contribution ID: **117** Type: **not specified**

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Monday, 24 February 2020 15:20 (20 minutes)

Session Classification: Contributed Talks