New opportunities and challenges in nuclear physics with high power lasers

Monday, 1 July 2024 - Friday, 5 July 2024

ECT*

Book of Abstracts

Contents

1

Welcome talk

Authors: Chieh-Jen Yang[1]; Klaus Spohr[None]

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Jerry & Klaus will give the overall scope of the workshop from a nuclear theorist/experimentalist viewpoint.

2

10 PW Laser driven electron acceleration and neutron production at ELI-NP

Author: Septimiu Balascuta[1]

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We report the recent acceleration of multi GeV electrons with laser pulses of ultrashort and high power (1 - 10 PW) focused in gas jets with circular and rectangular profiles. The energy of the electrons was measured at each laser pulse with an electron spectrometer made of a 80 cm long dipole magnet and three scintillating screens. We measured the energy spectrum of the neutrons generated in the photonuclear reactions induced by high energy bremsstrahlung radiation in Iron nuclei of the dipole magnet and its yoke. The energy spectrum of the electrons and their electric charge was measured at each laser shot.

3

Flying focus beams as a tool to investigate strong-field physics

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In a flying focus beam (FFB) the velocity of the focus can be “programmed” and it is independent of the group and the phase velocity of the beam itself. Recent experiments have demonstrated a moving focus over centimeter lengths, i.e., much longer than the Rayleigh length [1]. Scaling this technology to higher power laser pulses would allow one to employ FFBs as a tool for fundamental high-field physics, especially to investigate effects that accumulate with the interaction length. Specifically, by considering an ultrarelativistic electron beam counterpropagating with respect to a FFB, whose focus copropagates with the electrons at the speed of light, we show that the effects of the so-called transverse formation length of radiation on the radiation itself can be enhanced as compared to the case of a conventional Gaussian beam [2]. Analogously, radiation-reaction effects can be rendered measurable at much lower intensities than conventionally required in a similar setup [3]. Finally, we

show how FF beams with angular momentum can be an efficient tool to transport ultrarelativistic electron beams over macroscopic distances without significantly spreading on the transverse plane [4].

[1] D. H. Froula, D. Turnbull, A. S. Davies, T. J. Kessler, D. Haberberger, J. P. Palastro, S.-W. Bahk, I. A. Begishev, R. Boni, S. Bucht, J. Katz, and J. L. Shaw, Nat. Photonics **12**, 262 (2018).
[2] A. Di Piazza, Phys. Rev. A **103**, 012215 (2021).
[3] M. Formanek, D. Ramsey, J. P. Palastro, D. Froula, and A. Di Piazza, Phys. Rev. A **105**, L020203 (2022).
[4] M. Formanek, J. P. Palastro, M. Vranic, D. Ramsey, and A. Di Piazza, Phys. Rev. E **107**, 055213 (2023).

4

Recent Progress on Heavy-Ion Acceleration: Towards the Fission-Fusion Nuclear Reaction Scheme

Author: Peter Thirolf[1]

Co-authors: Erin Grace Fitzpatrick [1]; Laura Desiree Geulig [1]; Masoud Afshari [1]; Veronika Kratzer [1]; Runjia Guo [1]; Florian H. Lindner [1]; Vitus Magin [1]; Maximilian Weiser [1]; Jörg Schreiber [1]

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The generation of heavy elements in the universe via the rapid neutron-capture process (r-process) lacks direct experimental probing, as the relevant nuclides lie far-off the last known isotopes near the 'Waiting Point'at N=126. The proposed 'fission-fusion'reaction mechanism aims at investigating this region by using laser-accelerated fissile ions in a two-stage (fission, fusion) scenario, exploiting their unprecedented high bunch density [1]. In a first development step, the acceleration of gold ions is investigated, as recently achieved in our measurement at the PHELIX laser with 500 fs long pulses [2]. In this experiment, the laser-based acceleration of Au ions to kinetic energies above 7 MeV/u was demonstrated. Additionally, individual Au charge states were resolved with unprecedent resolution. This allowed to investigate the role of collisional ionization using a developmental branch of the particle-in-cell simulation code EPOCH [3], showing a much better agreement of the simulated charge state distributions with the experimental ones than when only considering field ionization. This work is presently continued at the Centre for Advanced Laser Applications (CALA), using the ATLAS 3000 laser (800 nm central wavelength, 25 fs pulse length). The laser is focused with an f/2 parabola on Au foils with thicknesses from 200 nm to 500 nm. To analyze the accelerated ion bunch, a Thomson-Parabola Spectrometer was designed to resolve heavy ions in high charge states. Spectroscopically controlled radiative target heating is integrated into the setup in order to facilitate the acceleration of gold ions by removing carbo-hydrate surface contaminations. An integrated IR spectrometer allows for in-situ measurements of the heated foil temperature, while allowing for a simultaneous monitoring with a transmission screen camera to detect possible foil damage [4]. Recent results on Au ion acceleration at CALA will be presented together with preparations for the next stage of the fission-fusion process, i.e. laser-driven fission.
Ultimately, these exploratory experimental campaigns aim at preparing for studies at the 10 PW laser facility at ELI-NP with optimum pulse energy and focused intensity.

[1] D. Habs et al., "Introducing the fission–fusion reaction process: using a laser-accelerated Th beam to produce neutron-rich nuclei towards the N=126 waiting point of the r-process", Appl. Phys. B 103, 471-484 (2011)
[2] F.H. Lindner et al., "Charge-state resolved laser acceleration of gold ions to beyond 7 MeV/u", Sci. Rep. 12, 4784 (2022)
[3] M. Afshari et al., "The role of collisional ionization in heavy ion acceleration by high intensity laser pulses", Sci. Rep. 12, 18260 (2022)
[4] M. Weiser, "Development of a Spectroscopic Real Time Temperature Diagnostic for Laser Heated Thin Gold Foils", Master Thesis, LMU Munich, 2021

5

Nuclear isomers at the interface

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Nuclear isomers –excited states of atomic nuclei with half-lives ranging from less than a nanoseconds to many years [1] –have a variety of actual and potential applications beyond the domain of nuclear physics [2]. There are, for example, opportunities to study novel physics at the nuclear-atomic interface, including high-intensity, low-energy photon-nucleus interactions. One promising avenue is focused on the low-energy photo-deexcitation of isomers. By selecting a suitable isomer, the deexcitation is able to liberate at least one photon of much higher energy, which provides a unique signal of the interaction. Also, with the large span of possible isomer half-lives, a range of timing and physical-separation techniques can be used to enhance the experimental sensitivity to isomer interactions. Meanwhile, the underlying consideration is the need to understand the basic atomic and nuclear processes involved.

This presentation will discuss the different types of nuclear isomer, and consider a selection of isomer-inspired experiments aimed at shedding light on the interactions at the nuclear-atomic interface.

[1] P.M. Walker and G.D. Dracoulis, Energy traps in atomic nuclei, Nature 399 (1999) 35.
[2] P.M. Walker and Zs. Podolyák, Nuclear isomers, Chapter 12 in "Handbook of Nuclear Physics", Eds. I. Tanihata, H. Toki and T. Kajino (Springer Nature Singapore 2023) 487.

6

Two Laser-Driven Nuclear Physics (LDNP) flagship experiments have been identified for the NSF OPAL Laser Facility

Authors: Chad Forrest[1]; Ani Aprahamian[2]; Arnold Schwemmlein[1]; Udo Schroeder[1]; Michael Wiescher[2]

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Laser-ion acceleration mechanisms provide a unique opportunity for generating radioactive tritium beams, which are currently not available at accelerator facilities. Few datasets exist of tritium-induced reactions involving light, neutron rich nuclei like 6He, 8Li and 11Be. However, these nuclei are of high interest for nuclear science because influence the r-process as "seed nuclei"[Ter01] and are also predicted to exhibit exotic structure [Qua18, Coc12, For05]. A new platform at the OMEGA-EP laser system at the University of Rochester (UR) Laboratory for Laser Energetics (LLE) is now in a position to support nuclear science experimentation [Sch22]. In a pilot study, 10x^13 tritons were accelerated to several MeV and directed onto a deuterated target, producing 108 fusion neutrons. Follow-up experiments using lithium and beryllium targets to measure the cross sections of di-neutron transfer reactions on these light nuclei will be discussed. This material is based upon work supported by the Department of Energy [National Nuclear Security Administration] University of Rochester "National Inertial Confinement Fusion Program"under Award Number(s) DE-NA0004144.

[Coc12] Cockrell et al: "Lithium isotopes within the ab-initio no-core full configuration approach" Physical Review C 86 (2012)
[For05] Forssen et al: "Large basis ab initio shell model investigation of 9Be and 11Be", Physical

Review C 71 (2005)
[Qua18] Quaglioni et al: "Three cluster dynamics within the ab initio no-core shell model with continuum: How many-body correlations and a clustering shape 6He", Physical Review C 97 (2018)
[Sch22] A. Schwemmlein et al: "First Demonstration of a Triton Beam Using Target Normal Sheath Acceleration", Nuclear Inst. and Methods in Physics Research B 522 (2022)
[Ter01] M. Terasawa et al: "New nuclear reaction flow during r-process nucleosynthesis in supernovae: Critical role of light, neutron-rich nuclei', The Astrophysical Journal, 562 (2001)

7

Photon-induced interactions in relativistic heavy ion collisions

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Heavy ions provide strong electromagnetic fields that can be used to probe properties of interest in nuclear structure, nuclear astrophysics and particle physics. In this talk I will discuss new developments in understanding the role of the symmetry energy in the equation of state of nuclear matter, nuclear collective phenomena, QED and QCD processes, and other physics phenomena induced by photon-photon and photo-nuclear interactions in reactions with heavy ions.

8

Coherent radiation from nonlinear plasma wakefields in the blowout regime

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Coherent light sources, such as free electron lasers, provide bright beams for biology, chemistry, physics and advanced technological applications. As their brightness increases, these sources are also becoming progressively larger, with the longest being several km long (e.g. LCLS). Can we miniaturise these sources and bring them into university, hospital, and industrial-scale laboratories? Plasmas accelerator sources are an attractive solution to this question, but only if their brightness increases several orders of magnitude.

Here, we re-examine the fundamentals of superradiance and temporal coherence by exploring the radiation emitted by collective excitations, such as plasma waves. We show that the trajectory of a collective excitation defines the radiation as if it were a single, finite-sized super-charged particle. By applying this principle to nonlinear plasma waves in the nonlinear blowout regime, we identify new conditions leading to superradiance and temporal coherence in plasma-based accelerators [1]. We find that the plasma density can control the radiation frequency over a wide range, from THz to soft x-ray emission, and possibly beyond. We explore these concepts in theory and through particle-in-cell simulations complemented by the Radiation Diagnostic for Osiris (RaDiO) [2,3].

[1] B. Malaca et al, Nature Photonics 18 (1), 39-45 (2024)
[2] R.A. Fonseca et al, Plasma Physics and Controlled Fusion 55 (12), 124011 (2013)
[3] M. Pardal et al., Computer Physics Communications 285, 108634 (2023)

9

Nuclear astrophysics with gamma-ray/neutron provided from high peak power laser

Author: Takehito Hayakawa[1]

Co-authors: Masaki Kando [1]; Akifumi Yogo [2]; Yasunobu Arikawa [3]

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High peak power laser has been developed quickly, which leads to generation of radiations such as gamma-rays and neutrons with energies higher than 1 MeV. These laser-driven radiations have unique features of high flux, ultra-short pulse, and continues energy distribution. These features are suitable for study of nuclear reactions in the universe, such as nuclear photoreactions with high energy gamma-rays in supernova explosions (gamma-process) and nuclear reactions with high-energy neutrons generated by spallation reaction with high energy cosmic-rays. In general, the energy spectrum of particles in stars and cosmic-rays have continues energy distribution, which may be similar to that generated by high peak power laser, and its event may occur in short time scale from ms to s. Neutrons have also important roles for stellar nucleosynesis for production of elements heavier iron. Furthermore, gamma-rays and neutrons may contribute to isotopic abundance anomalies observed in some elements in primitive meteorites. They may be caused by irradiations in parent bodies of meteorites in the solar system. T. Hayakawa et al. have theoretically proposed the experiments using laser-driven gamma-rays to study the nuclear photoreactions in supernovae [1]. Recently, high flux neutron pulses have been generated by the secondary reactions with ion pulses from laser-plasma interactions [2]. Such neutrons can also play an important role for the study of decay acceleration of long-lived radioisotopes which may have been considered by cosmic-ray irradiation in the early solar system [3]. Nuclear isomers are one of key for such studies. We discuss the possibility of experiments in nuclear astrophysics using laser-driven gamma-rays and neutrons.

[1] T. Hayakawa, et al. Quantum Beam Science, 1(1), 3 (2017).
[2] T. Mori, et al. Phys. Rev. C 104, 015808 (2021).
[3] T. Hayakawa, et al. Comm. Phys. 6, 299 (2023).

10

Realizing isotopic temperature profiling by using laser-driven neutron source

Author: Zechen Lan[1]

Co-authors: Yasunobu Arikawa [1]; Alessio Morace [1]; Yuki Abe [2]; Takehito Hayakawa [3]; Reza Mirfayzi [4]; Mitsuo Koizumi [5]; Fumiaki Ito [5]; Jaehong Lee [5]; Takashi Kamiyama [6]; Kunioki Mima [1]; Hirotaka Sato [6]; Hiroaki Nishimura [7]; Satyabrata Kar [8]; Tianyun Wei [1]; Natsumi Iwata [1]; Yasuhiko Sentoku [1]; Masakatsu Murakami [1]; Shinsuke Fujioka [1]; Ryousuke Kodama [1]; Akifumi Yogo [9]

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Non-contact thermometry, including phase-contrast imaging thermography, is one of the key technologies for modern science and industry. However, it is challenging to instantaneously measure the temperature of a specific element inside an object. As a possible solution, we propose Neutron Resonance Absorption (NRA) analysis using a Laser-driven Neutron Source (LDNS). Here, fast neutrons generated from the LDNS are decelerated down to a few eV in energy and pass through a sample consisting of tantalum (Ta) and silver (Ag) plates as a simplified model of a composite object. We measured NRA signals distinctive for the Ta and Ag. We demonstrate that the temporal structure of the NRA signal for Ta is broadened by a Doppler effect when the plate of Ta is heated. We measured the NRA signal as a function of the temperature and found that the Doppler width increases according to the free gas model by Bethe. It should be emphasized that the NRA measurement was performed by a single pulse of neutrons, the temporal duration of which is in an order of 100 ns at the sample. In other words, the NRA signal allow us to obtain the temperature during the 100 ns. This fact indicates that our method enables element (isotope)-sensitive and non-destructive thermometry to monitor the instantaneous temperature rise in dynamical processes.

11

Fast neutron production with kHz repetition rate, few-cycle lasers

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Co-authors: Zoltan Elekes [2]; Andras Fenyvesi [2]; Zsolt Fulop [2]; Tibor Gilinger [1]; Zoltan Halasz [3]; Katalin Hideghethy [4]; Attila Kovacs [1]; Laszlo Stuhl [5]; Rita Szabo [4]; Parvin Varmazyar [1]

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Recent development of ultrashort, high repetition rate laser technology resulted in systems with reliable and stable performance (<1%) over day-long operation. In addition to the several TWs peak power, these systems can produce 100 W average power at industrial standards. Hence, in neutron production they offer an alternative to the PW peak power lasers for applications which need a quasi-continuous source of neutrons.
Here we show a laser-based neutron source developed by the National Laser-Initiated Transmutation Laboratory of the University of Szeged, with the few-cycle lasers available at ELI ALPS. The heart of the beamline is a flat heavy water jet with a thickness of a few hundreds of nanometres. The laser pulses accelerated deuterons up to 1 MeV energy, which then induced 2H+2H fusion reaction in a deuterated polyethylene disk. The resulting fast neutrons were measured with three independent detection systems. A time-of-flight (ToF) detector system, within which each detector consisted of a plastic scintillator and a photomultiplier; a liquid scintillator, the ToF signal of which was evaluated with the pulse shape discrimination method; and a bubble detector spectrometer calibrated against a conventional PuBe source.
The system worked with high stability (10%) for several hours, shooting with 21 mJ, 12 fs laser pulses at 10 Hz repetition rate. Most recently, stable operation has been also demonstrated at 1 kHz repetition rate with 35 mJ, sub-10 fs laser pulses. The highest neutron yield so far (over 10^8 neutron per second) was achieved at 1 kHz repetition rate with 80 mJ laser pulses on target. The paper outlines one of the first related applications, i.e. the irradiation of zebrafish embryos with such laser-generated neutrons and planned experiments in nuclear astrophysics.

12

Nuclear excitation by electron capture perspectives for laser-generated plasmas and electronic vortex beams

online

13

Nuclear excitation by electron capture in electron-ion collisions

online

14

Developments in laser-driven ion acceleration relevant to nuclear physics with lasers

15

New opportunities in nuclear physics with high-power lasers and multi-photon absorption

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I will present some new possibilities, which are very unique for high-power laser systems, to advance nuclear photonics. The main focus will be to show that the multi-photon mechanism could pave a way to circumvent the very challenging problem of isomer pumping/depletion and gamma-ray laser, provided that an intense gamma-flash for laser-plasma interaction is available. The same mechanism might be applied to other high-intensity beams (such as neutron/proton) in the future to gain crucial knowledge of the nuclear man-body forces. By all means, a synergy between nuclear and laser-plasma physics is highly demanded.

16

What is Modern Nuclear Theory, and What are some of the pressing questions?

17

Nuclear isomers at the interface

online

18

Discussion (nuclear excitation and isomers)

Host by: Jerry & Klaus

19

Coherent radiation from nonlinear plasma wakefields in the blowout regime

Coherent light sources, such as free electron lasers, provide bright beams for biology, chemistry, physics and advanced technological applications. As their brightness increases, these sources are also becoming progressively larger, with the longest being several km long (e.g. LCLS). Can we miniaturise these sources and bring them into university, hospital, and industrial-scale laboratories? Plasmas accelerator sources are an attractive solution to this question, but only if their brightness increases several orders of magnitude.

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[1] B. Malaca et al, Nature Photonics 18 (1), 39-45 (2024)
[2] R.A. Fonseca et al, Plasma Physics and Controlled Fusion 55 (12), 124011 (2013)
[3] M. Pardal et al., Computer Physics Communications 285, 108634 (2023)

20

On the possibility of a laser assisted nuclear fusion in micron-scale 14N clusters

21

Advances in Laser-driven Neutron Sources and Applications at Osaka University

22

High yield fast neutron generation with 1kHz repetition rate few cycle lasers

23

Positron and photo-neutron creation using a petawatt laser to irradiate high-Z solid targets

Over the past decade, using the Texas Petawatt Laser (TPW, 130 J, 130 fs) at Austin, Texas to irradiate high-Z thick targets(Au, Pt, Re…) at intensities up to 5x10^21 W/cm^2, we have created copious amounts of positrons and photo-neutrons, resulting in super-high densities of emergent positrons and neutrons. We are still in the early stages of exploring potential applications of such high-density positrons and neutrons. A unique feature of TPW-irradiated high-Z dense metal targets is the production of excess high-energy gamma-rays > 8 MeV with a yield many times that expected from hot electron bremsstrahlung. These high energy gamma-rays appear to be concentrated near the giant-dipole resonance (GDR) of high-Z elements (8-20 MeV). They are ideal for photo-neutron and photo-fission reactions. This talk will summarize the large volume of data we have obtained and discuss plans for future research.
Work supported by US DOE DE-SC0024874.

24

On feasibility of sequential neutron captures studies with intense lasers

25

Nuclear Isomers in Nucleosynthesis

26

Discussion (neutron source and astrophysics)

Host: Klaus Spohr & Vojtech Horny

27

TBA (review of where we're at with Apollon)

28

TBA

29

discussion (strong QED, fission-fusion, neutron application)

Host: Leo Gizzi and Yuji Fukuda

30

Path towards a high-flux neutron source at ELI-NP

31

Electron screening in nuclear reactions

32

Nuclear spallation by irradiating an atomic thin graphene target with an intense laser

33

Plasma-Induced Modification of Nuclear β-Decays and Application to Nucleosynthesis

The talk will be focused on the theory behind the interaction of a plasma with a nucleus, and the consequent modification of decay rates through leptonic and hadronic channels. The former will involve a description of the electron contribution to the decay rate, while the latter will focus on nuclear excited and isomeric states. The talk will include some slides on experimental measurement of the process in stable magnetoplasma, and as promised, the last slides will be left open to discuss possible extension of these studies to laser generated plasmas. These studies will improve current models used for r- and s-process nucleosynthesis.

34

Nuclear physics measurements with a laser-induced plasma: potential experimental issues and open questions

35

discussion (laser-driven sources, reaction, etc.)

host: Yuji Fukuda & Klaus Spohr

36

TBA

37

discussion (all topics, future collaborations, etc)

host: Jerry, Vojtech, Leo.

38

Short Excursion (TBA, mountain hike, etc.)

To be arranged.

39

Plasma-Induced Modification of Nuclear β-Decays and Application to Nucleosynthesis

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The abundance of elements in the cosmos is a topic of active investigation. Since the dawn of nuclear astrophysics, various processes have been identified to explain the synthesis of elements, both qualitatively and quantitatively. Among these, the slow (s-) and rapid (r-) neutron capture processes are responsible for the synthesis of roughly 99% of all elements beyond the iron peak.

Nucleosynthesis models are sensitive to a variety of inputs, such as neutron capture cross sections and β-decay rates. Among these, the latter is known to be strongly modified in the presence of hot and dense plasmas, such as those found in s- and r-process nucleosynthesis sites [1]. As such, there is a need to study the variation of nuclear decay rates as a function of plasma properties, to improve the accuracy in calculated elemental abundances.

In this talk, we will present the concept of plasma-induced modification of β-decay rates through the examples of electron capture in ^{7}Be and ^{140}Pr and bound-state β-decay in ^{163}Dy. We will begin from the model of Takahashi and Yokoi [1] to calculate the lepton phase volume of the radionuclides as a function of their ionisation state and excitation level, and consequently, the configuration-dependent decay rate. By combining this with the ion charge state distribution (CSD), the decay half-life can be mapped to the plasma density and temperature. Additionally, we will also discuss the enhancement of decay rates through excitation of isomeric levels in certain nuclei such as ^{176}Lu. The talk will include a short description of the upcoming PANDORA (Plasmas for Astrophysics, Nuclear Decay Observations and Radiation for Archaeometry) facility at INFN-LNS, Catania, which aims to measure decay rates and light element opacity in stable plasmas produced in an electron cyclotron resonance ion trap (ECRIT) [2]. The talk will conclude with perspectives on similar studies that may be performed in short-lived laser-generated plasmas, discussing the pros and cons compared to ECRITs.

[1] Takahashi K. and Yokoi K., Nuclear β-Decays of Highly Ionised Heavy Atoms in Stellar Interiors. Nucl. Phys. A 404, 578 (1983)

[2] Mascali D., Santonocito D. et al, A Novel Approach to β-Decay: PANDORA, a New Experimental Setup for Future In-Plasma Measurements. Univese 8, 80 (2022)

40

Advances in Laser-driven Neutron Sources and Applications at Osaka University

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The evolution of laser and accelerator technologies has taken a new turn, giving rise to a new trans-disciplinary field: Nuclear Photonics. Advances in high-intensity laser technologies have made it possible to accelerate electrons in the GeV class and protons close to 100 MeV from a distance of less than 1 mm. In particular, secondary beams such as laser-driven neutron sources (LDNS) are attracting much interest as a promising application of laser particle acceleration.
LDNS is attracting interest for several reasons, including (i) compactness of the source, (ii) short neutron pulses, and (iii) transportability of the laser beam. By reviewing recent activities at ILE, Osaka University, we discuss the characteristics of LDNS in comparison with accelerator-based neutron facilities. In particular, we discuss the potential and limitations of LDNS by showing that neutrons ranging from meV to MeV [1-10] in energy have been produced by LDNS and applied to neutron radiography [2,6,8], neutron spectroscopy [9,10], astrophysics [3,4], and medical science [7].

[1] S. R. Mirfayzi, A. Yogo, Z. Lan et al. Proof-of-Principle Experiment for Laser-Driven Cold Neutron Source, Scientific Reports 10, 20157 (2020).
[2] A. Yogo, S. R. Mirfayzi, Y. Arikawa, et al. Single Shot Radiography by a Bright Source of Laser-Driven Thermal Neutrons and X-rays, Appl. Phys. Express 14, 106001 (2021).
[3] T. Mori, A. Yogo, T. Hayakawa et al. Direct Evaluation of High Neutron Density Environment Using (n, 2n) Reaction Induced by Laser-Driven Neutron Source, Phys. Rev. C 104, 015808 (2021).
[4] T. Mori, A. Yogo, T. Hayakawa et al. Thermal neutron fluence measurement using a cadmium differential method at the laser-driven neutron source, J. Phys. G: Nucl. Part. Phys. 49 065103 (2022).
[5] Z. Lan and A. Yogo Exploring nuclear photonics with a laser driven neutron source, Plasma Phys. Control. Fusion 64 024001 (2022).
[6] T. Wei, A. Yogo, T. Hayakawa et al. Non-destructive inspection of water or high-pressure hydrogen gas in metal pipes by the flash of neutrons and x rays generated by laser, AIP Advances 12, 045220 (2022);
[7] T. Mori, A. Yogo, Y. Arikawa et al. Feasibility study of laser-driven neutron sources for pharmaceutical applications, High Power Laser Sci. Eng., 11, e20 (2023).
[8] Y. Arikawa, A. Morace, Y. Abe et al. Demonstration of efficient relativistic electron acceleration by surface plasmonics with sequential target processing using high repetition lasers, Phys. Rev. Research 5 013062 (2023).
[9] A. Yogo, Z. Lan, Y. Arikawa et al. Laser-Driven Neutron Generation Realizing Single-Shot Resonance Spectroscopy, Phys. Rev. X 13 011011 (2023).
[10] Z. Lan, Y. Arikawa, T. Hayakawa, A. Yogo et al. Single-Shot Laser-Driven Neutron Resonance Spectroscopy for Temperature Profiling, accepted for publication in Nature Communications.

41

Welcome talk from ECT* director: U. van Kolck

42

Nuclear Isomers in Nucleosynthesis

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In most astrophysical environments, the transitions among excited states of a nucleus occur more rapidly than those between the nucleus and other nuclei. In this case, the nucleus can be considered to be internally equilibrated. In certain interesting cases, however, the nucleus may possess a long-lived isomer that communicates inefficiently with the ground state. In the nucleosynthetic environment, the isomer equilibrates with the ground state via transitions to upper-lying levels and then cascading back to the ground state. In this talk, I will present the formalism one may use to include this effect in a nucleosynthetic environment and will use the example of s-process nucleosynthesis of the important geochronometer rubidium-87, whose nucleosynthesis is affected by the isomer at krypton-85, as an example.