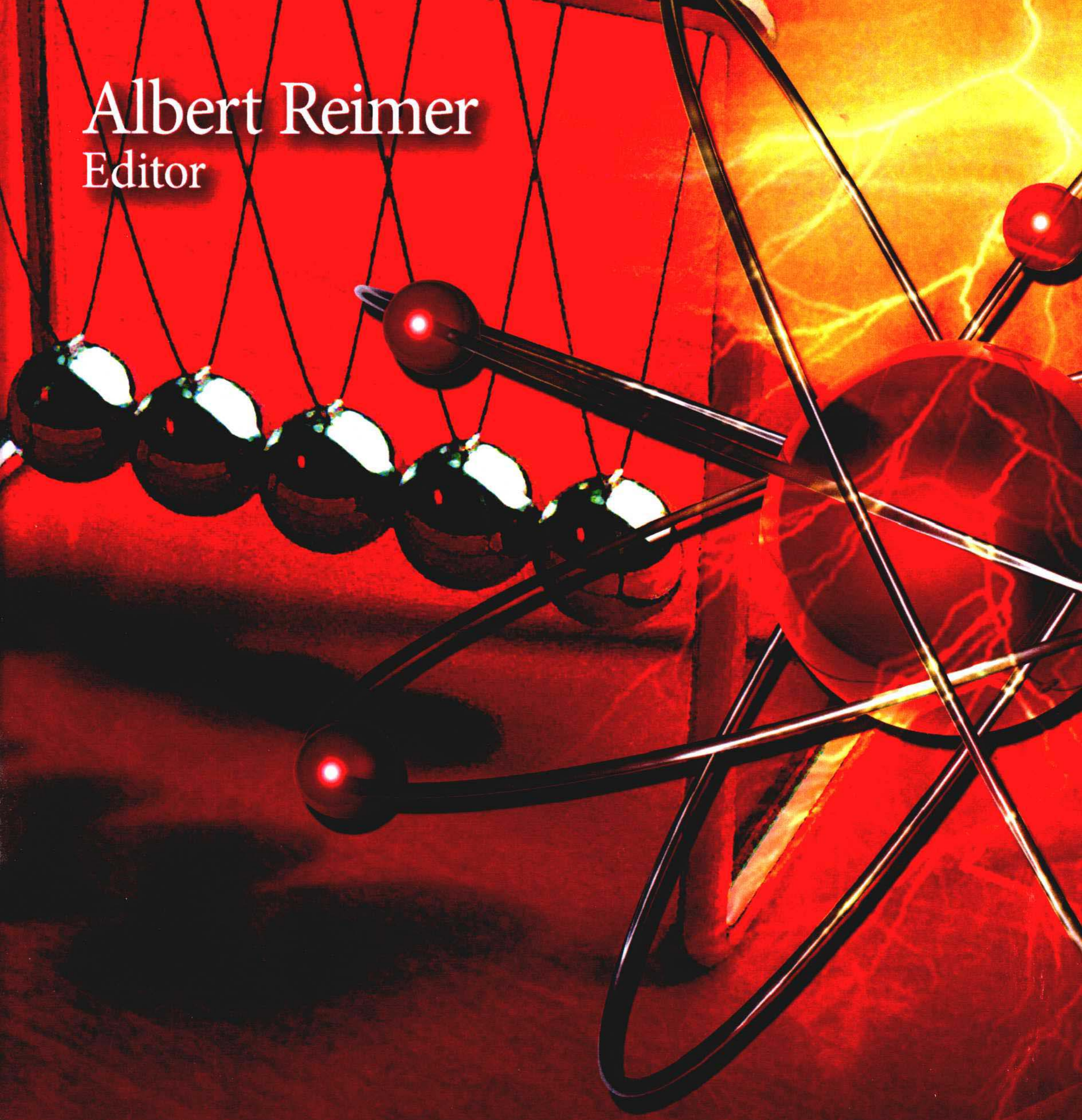

Albert Reimer
Editor

HORIZONS IN WORLD PHYSICS

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VOLUME 274

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PREFACE

This book presents original research results on the leading edge of physics. Each article has been carefully selected in an attempt to present substantial research results across a broad spectrum. Topics presented in this compilation include the production of isomers by spallation and the consequences for nuclear science; solar flare numerical magnetohydrodynamic simulation and solar flare models; X and Gamma ray interactions with soft contact lenses; visible light therapy research and the structure and development of barrier discharges at atmospheric pressure.

Chapter 1 - Spallation reactions induced by high and intermediate energy protons impinging on heavy targets experience nowadays a renewed interest due to their use in many modern applications. One such application is the production of exotic nuclei for nuclear physics research. The development of secondary beams of high–spin isomeric nuclei for use in fusion–evaporation and transfer reactions, Coulomb excitation or static nuclear moment measurements is of high interest and much effort is put into it. In this chapter, the results of a systematic study of spallation reactions with intermediate energy protons and moderately heavy targets are discussed to understand the mechanisms of populating long–lived high–spin isomers in the mass region A≈180. Several different target materials were considered for this purpose, such as ^{nat}Re, ^{nat}W, ^{186}W, ^{nat}Ta, ^{nat}Hf and ^{179}Hf. The irradiations were performed at several proton energies ranging from 100 to 660 MeV. A large number of radioactive nuclei were produced in the irradiated targets. Their identification and the estimation of their yields were done with the method of the gamma–ray activity measurements. The wealth of data obtained from this systematic study allowed for a detailed study of the mass distributions of the produced radioactive nuclei and of the isomer–to–ground state ratio as a function of the target material and the proton beam energy. The experimentally determined yields were compared to state–of–the–art calculations performed with the LAHET code. Data and calculations were analyzed to determine the optimal combination of target material and proton beam energy for achieving the highest possible absolute cross section and isomer–to–ground state ratio for selected long–lived high–spin nuclear isomers. A survey of the yields for radioactive nuclei and isomers is of significant interest for modern physics research and applications and, in particular, for those located at the frontier between nuclear and laser physics. On other hand, the observation of high–spin nuclear isomers gives important information on the transferred angular momentum to the residual nuclei in spallation reactions with intermediate energy protons. This information, usually omitted in the study of the spallation mechanism, is of high importance in understanding the mechanisms leading to the formation of the high–spin isomers. Among the reaction products, fission fragment nuclei could also be identified allowing for the investigation of the fission probability for medium–mass fissile nuclei. The experimental data discussed in this chapter reveal new facets of the spallation processes, related in particular to the angular momentum of the products, that lead to a better understanding of the underlying reaction mechanism

Chapter 2 - Accelerated energetic particles in solar flares produce nuclear γ-lines in the processes of interaction with ambient solar atmosphere. Gamma-ray emission from solar flares gives information about the nature of the accelerated particles and physical conditions in the area, in which the flare occurs, and in the surrounding media. Nuclear lines properties represent the abundance of elements, density and temperature of the ambient solar atmosphere and the parameters of the accelerated ions.

In this chapter the authors study the processes of the nuclear and neutron capture gamma lines formation during solar flares as well as the methods and the results of estimations of the abundance of the elements, parameters of surrounding media and other solar characteristics. Several types of γ-lines presented in the energy spectra of solar flares: narrow nuclear de-excitation lines with fractional FWHM around 2% which generated via de-excitation processes of excited nuclei produced in the interactions of flare-accelerated protons and α-particles with the ambient nuclei heavier than He (as the recoil velocity of a heavier nucleus is relatively low) and broad γ-lines with fractional FWHM around 20% caused due to the de-excitation processes of excited nuclei produced in the interactions of accelerated α-particles and heavier ions with ambient H and He (as the recoil velocity of a nucleus is relatively high). Also flare spectra contain lines caused by neutron capture on hydrogen and helium-3 and relatively narrow γ-lines via the de-excitation processes of excited nuclei produced in heavy-heavy interactions (for example, 1.634 MeV ^{20}Ne, 1.369 MeV ^{24}Mg and 0.937 MeV ^{18}F). Thus the time integrated spectra up to 10 MeV could be fitted with a model of multi-components, including the bremsstrahlung, the annihilation line, neutron–hydrogen capture line, several narrow nuclear lines as well as the broad lines. Based on the fitted data, the authors discuss the spectral index of accelerated ions, the abundance of ambient medium and so on. For example, it was shown that during some events the abundance of Ne/O tends to be of 0.15 rather than 0.25, and that accelerated α/p tends to be within the range of 0.01–0.1 but not bigger than 0.1.

The authors present the results of the analysis of some solar flares characteristics and surrounding medium (solar plasma) by means of 2.223 MeV line time profile of gamma-emission from neutron captures by hydrogen nuclei. This analysis is based on the comparison between the observations and profiles computed taking into account a number of parameters describing the generation and transport of the flare neutrons in the atmospheric layers of various densities. The composed code (SINP code) makes allowance for the main processes of neutron interactions and deceleration in the solar atmosphere, character of neutron source, losses of neutrons and density model of the solar atmosphere. Comparing of the simulated temporal profiles of 2.223 MeV gamma-line with observed ones allowed us to reveal the density enhancements in the sub-flare regions of the some extreme flares. Using the same analysis the values of spectral indices of charged particles were estimated and their evolution with the time during gamma-emission of the flares was obtained. The hardening of charged particles spectrum which was found using our methods is discussed.

Just as in this chapter the authors consider the flux ratio between two lines from excited states of ^{12}C ($f_{15.11}/f_{4.44}$) and our results of preliminary calculation of intensity ratio between two neutron capture lines at ^{3}He and ^{1}H ($f_{20.58}/f_{2.223}$). In particular, they consider the opportunity to obtain $n(^{3}He)/n(^{1}H)$ ratio during solar flares and using high energy gamma-emission studying based on the satellite data. The possible interpretation of the spectral features observed during some very intensive events is discussed.

Chapter 3 - Spallation study has broad civilian/military applications. In theory, spall crack formation is the direct consequence of the stress wave (tensile and compressive wave) interactions in solids. The area is highly stretched wherever the strong enough tensile and compressive waves meet, and a spall crack may occurs.

This paper presents a discrete dynamic fracture model, hybrid lattice particle modeling (HLPM), and its applications in the stress wave propagation and spallation of solids. The HLPM is established based on a combination of the first author's prior particle modeling (PM) technique together with the conventional lattice modeling (LM) theory. The HLPM can not only accurately predict the wave propagation in solids, but also has the robustness of simulating the dynamic fragmentation of solids under high strain rate loadings at macroscales with a varying Poisson's ratio. In this paper, first, the HLPM technique is introduced as well as compared with other existing discrete element methods (DEM), and second, a number of successful HLPM validations are mentioned, including the case of the comparison of wave propagation in 1D and 2D homogenous material with the analytical solutions; next, simulations of wave propagation in 1D heterogeneous structure accounting for different ratios of strength and density with the components are mentioned; finally, HLPM simulations of spall cracks due to hyper-velocity impact and blasting are completed. In the impact study, spall crack formation and multiple spalling is captured, and the HLPM results are in good agreement with the analogous molecular dynamics (MD) simulations by Krivtsov [36, 37]. Furthermore, a functionally designed infrastructure material coated with a high strength layer, but with different coating strengths at the interface, is also investigated to find out the protective effect of material from spallation. The modeling results demonstrate that prevention of a material from spallation under extreme loadings is difficult; it needs the coating material with a super strength. In the blasting study, spalling and also the fracturing effect associated with different spatial explosive setup is investigated. This will benefit the explosive fracturing applications.

Chapter 4 - This Chapter is devoted to computer simulation of target performance in particle beams for fusion or fission irradiation. Such simulation is realized by means of a set of Russian computer codes SHIELD, RADDAM, etc. The set can permit the full modeling of irradiation conditions of any possible installation in terms of such parameters as:

- point defect generation by irradiation;
- rate of accumulation of He atoms produced in nuclear reactions;
- rate of accumulation of H atoms;
- spectra of primary knock-on atoms in collision displacements and
- temperature of the sample under irradiation.

The evidence of possibilities for the modeling of different irradiation conditions (for example, fusion) at the RADEX facility of the INR RAS is presented. RADEX is the irradiation channel located inside the proton target of the beam stop of the INR RAS linear proton accelerator with energy up to 600 MeV. The proton target is situated in the bottom part of target's cylindrical container and is formed by tungsten plates, which are covered with a titanium coating and cooled by light water. The RADEX irradiation channel is located asymmetrically relatively to the vertical axis of the cylinder. The proton beam enters the irradiation channel through the aluminum alloy first wall, having passed through some of the tungsten plates, all of thickness ~4 cm. Besides the proton flux, the irradiation channel is subjected to a neutron flux of a spallation spectrum. The location of the irradiation channel of the RADEX facility can be changed by rotation of the proton target about the vertical axis. There are six possible different positions of the irradiation channel, with angles of 0°, 60°, 120°, 180°, 240°, 300°, and 360° relative to the proton beam direction. In the position 0, the proton and neutron fluxes are maximal in the irradiation channel, and the spectrum of primary knock-on atoms in the irradiated sample will be very hard due to the predominance of high-energy protons in the irradiation field. The spectrum can be significantly softened by means of rotation of the proton target around the vertical axis. Spectrum softening will also occur when the sample moves upwards in the irradiation channel away from the proton beam line. This gives us the possibility to change all five irradiation parameters pointed out above to model almost any possible irradiation installation. The example of computer modeling for the irradiation conditions of the ITER fusion device at the RADEX facility is presented.

Chapter 5 - Cadmium telluride (CdTe) and cadmium zinc telluride (CdZnTe) wide band gap semiconductors for x-ray detectors have experienced a rather rapid development in the last few years. Among the traditional x-ray detectors based on silicon (Si) and germanium (Ge), CdTe and CdZnTe detectors show higher detection efficiency at high energies and good room temperature performance and are well suited for the development of compact detection systems and pixel arrays for simultaneous measurements of photon interaction position and energy. This chapter is an introduction to the physics and the technology of CdTe and CdZnTe pixel detectors for x-ray spectroscopy and imaging. The physical properties of CdTe and CdZnTe and the device fabrication technology are presented. A detailed discussion on physical processes and signal formation in CdTe and CdZnTe pixel detectors follows the introduction. The authors describe the electrical, the spectroscopic and the spatial properties of different CdTe/CdZnTe pixel detector configurations. Finally, present the performance and the test results of recently developed pixel detector prototypes designed for astrophysical applications.

Chapter 6 - Tensor of dielectric permeability for the system of electron beam – interplanetary space plasma was derived in the ray-optics approximation. Based on the Maxwell equations closed by the derived material equation, frequency characteristics of perturbations of one-dimensionally heterogeneous system of electron bean - solar wind plasma were studied in the linear approximation.

The beam is generated by an active region during solar flare and is a source of radio burst of III-type in the interplanetary space. The appropriate dispersion equation has been solved. It appears that resonance interaction of a wave with an electron beam can occur only in two space points.

Such transient (point wise) mechanism of resonance may throw light on one of the basic problems of physics of electron beams generated by solar flares: their overwhelmingly greater time of existence than the time of existence determined by the former theoretical estimates of the rate of energy loss of beams due to radiation in the homogeneous medium.

Within the scope of quasilinear theory it turned out that when radio bursts of III type are generated by the inhomogeneous system of electron beam – solar wind plasma, only time of development of the primary stage of instability, i.e., hydrodynamic, is more than the total time of relaxation of an electron beam derived within the homogeneous model.

During the development of hydrodynamic instability the electron beam is spread from the Sun to the distance of 4 astonomical unities. The hydrodynamic stage is followed by the development of kinetic instability leading, ultimately, to the formation of horizontal plateau in the beam region at the tail of Maxwell distribution.

Parameters of the plateau, such as its length and height, have been calculated as characteristic parameters of an electronic beam generated by the active solar bursts. In the process of development of kinetic beam instability more than a half of kinetic energy of the beam is transmitted to plasma oscillations.

Chapter 7 - The capacity of lasers to cut, cauterize, evaporize and destroy tissues is well documented. These same or similar lasers at lower powers can nonthermally and nondestructively alter cellular function. This phenomenon, known as laser biostimulation, is the basis for the current use of lasers to treat a variety of articular, neural and soft tissue conditions. Low-level laser therapy (LLLT) is a form of phototherapy that involves the application of low power lasers or LEDs to injuries and lesions to stimulate healing. LLLT has been investigated and used clinically for over 40 years, mostly in Europe, Canada and Asia. In current practice, it uses low output levels (1-100 mW), short treatment times (10-300 seconds), and low energy levels (1-30 J/cm2). It should be noted that non-laser multiwave light sources in the visible range were found to have the same biostimulation effects as lasers. Low-level laser therapy has been expanded to a wide variety of uses, belonging to two main fields of medicine practice where LLLT has a major role. These are: (1) wound healing, tissue repair and prevention of tissue death; (2) relief of inflammation in chronic diseases and injuries with their associated pain and edema.

Thus, LLLT is applicable to wound healing (patients with bedsores, skin disorders, ulcerations, and diabetics with delayed wound healing) and musculoskeletal conditions such as osteoarthritis, rheumatoid arthritis, fibromyalgia, and carpal tunnel syndrome. LLLT may be administered by several different types of providers, including physicians, chiropractors, physical therapists, or occupational therapists. It is generally provided in a physician's office or other outpatient setting, with no anesthesia or sedation needed. The effectiveness of LLLT has been compared with ultrasound therapy, and should be considered as an extension to the accepted physiotherapy modalities that currently utilize parts of the electromagnetic spectrum, such as shortwaves, microwaves, infrared, and ultraviolet therapy. Although low level laser therapy is currently used worldwide and routinely for many medical morbid states, there is still controversy as regards the mechanism by which visible light interacts with the living tissue. It has been proposed that reactive oxygen species (ROS) production by illumination is a mechanism of photobiomodulation.

In this chapter the authors show how visible light can change the redox (short for reduction/oxidation reaction) state of the cell by producing ROS, thus modulating many biological processes. The purpose of this review is to stimulate further interest in light therapy.

Chapter 8 - In view of the extensive use of radioactive isotopes in medical fields such as nuclear diagnostics (computerized tomography), nuclear medicine, radiation dosimetry and radiation biophysics, the knowledge on X- and gamma ray interactions with different types of materials has become the subject of researches for nuclear engineers, radiologists and radiation physicists for different purposes i.e. shielding, dosimetry, X-ray imaging and radiotherapy. The photon mass attenuation and mass energy absorption coefficients, energy dependence, effective atomic number, effective electron density and buildup factor are the basic quantities required in determining the penetration of X-rays and gamma photons through the material. While the extensive studies based on radiation interaction in biological materials are available, there are almost no studies for soft contact lenses from the point of radiation interaction. At this point, the present study aimed at the investigation of X and/or gamma radiation interaction with different types of soft contact lenses in terms of the parameters mass attenuation and energy absorption coefficients, effective atomic number, effective electron density and energy dependence in the wide energy range of 1keV-20MeV as well as the energy absorption and exposure buildup factors from 0.015 to 15 MeV up to 40 mfp penetration depth. Influences of photon energy, chemical composition and penetration depth on these parameters were studied.

Chapter 9 - Three-dimensional MHD simulation of the plasma and magnetic field of the states preceding the flares shows that the energy released by the flare is accumulated in the magnetic field of a current sheet (CS) formed in the corona above the active region. The system of MHD equations for compressible plasma with all dissipative terms is solved using the finite-difference scheme. The scheme is conservative relative to magnetic flux and absolutely implicit. This scheme permits to stabilize numerical instability appearing especially on the photospheric boundary. Maps of the photospheric magnetic field in its preflare state are used in simulations to define the boundary and initial conditions. The CS is formed in the vicinity of a singular line as a result of magnetic field disturbances focusing appeared before the flare. Simple scenario for CS formation in the corona can be realized during the emergence of new magnetic flux in the neighborhood of existing flux, if the magnetic fields are opposite in these fluxes. The solar flare electrodynamical model is built on the base of observed data and results of numerical simulation. It is sown that magnetic energy order of 10^{32} erg is accumulated in the CS magnetic field. The source of thermal X-rays above a magnetic arch in the corona arises from the fast dissipation of the magnetic energy of the current sheet due to the reconnection of magnetic field lines. The hard X-rays power spectrum emitted from the footpoints of the magnetic arch by beams of electrons accelerated in field-aligned currents induced by the Hall electric field generated in CS. The Lorenz electric field accelerates protons along the singular magnetic X line. The prompt component of relativistic protons with exponential spectrum measured by neutron monitors moves along the interplanetary field line.

Chapter 10 - Barrier Discharges belong to the most important plasma sources in plasma technology. But the discharge development, plasma parameters and detailed knowledge on elementary processes can not be easy obtained. Barrier discharges are a challenge for plasma diagnostics due to their small discharge gaps (mm-range), its temporal behavior (transient with durations in the range of micro- to hundreds of picoseconds) and weak intensity of emitted light. In this chapter spectroscopic methods with high temporal resolution based on time-correlated single photon counting techniques are demonstrated to be powerful tools to study the structure, development and elementary processes of barrier discharges in different arrangements and discharge modes, namely the _lamentary and the diffuse mode. The most-common _lamentary mode is characterized by the presence of many erratic and transient microdischarges, which can be interpreted as transient glow discharges. Uniform or diffuse modes, which are generated at speci_c conditions only, can be interpreted as atmospheric pressure Townsend or glow discharges.

CONTENTS

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Chapter 1

PRODUCTION OF ISOMERS BY SPALLATION AND CONSEQUENCES FOR NUCLEAR SCIENCE AND APPLICATIONS

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ABSTRACT

Spallation reactions induced by high and intermediate energy protons impinging on heavy targets experience nowadays a renewed interest due to their use in many modern applications. One such application is the production of exotic nuclei for nuclear physics research. The development of secondary beams of high–spin isomeric nuclei for use in fusion–evaporation and transfer reactions, Coulomb excitation or static nuclear moment measurements is of high interest and much effort is put into it. In this chapter, the results of a systematic study of spallation reactions with intermediate energy protons and moderately heavy targets are discussed to understand the mechanisms of populating long–lived high–spin isomers in the mass region A≈180. Several different target materials were considered for this purpose, such as ^{nat}Re, ^{nat}W, ^{186}W, ^{nat}Ta, ^{nat}Hf and ^{179}Hf. The irradiations were performed at several proton energies ranging from 100 to 660 MeV. A large number of radioactive nuclei were produced in the irradiated targets. Their identification and the estimation of their yields were done with the method of the gamma–ray activity measurements. The wealth of data obtained from this systematic study allowed for a detailed study of the mass distributions of the produced radioactive nuclei and of the isomer–to–ground state ratio as a function of the target material and the proton beam energy. The experimentally determined yields were compared to state–of–the–art calculations performed with the LAHET code. Data and calculations were analyzed to determine the optimal combination of target material and proton beam energy for achieving the highest possible absolute cross section and isomer–to–ground state ratio for selected long–lived high–spin nuclear isomers. A survey of the yields for radioactive nuclei and isomers is of significant interest for modern physics research and applications and, in particular, for those located at the frontier between nuclear and laser physics. On other hand, the observation of high–spin nuclear isomers gives important information on the transferred angular momentum to the residual nuclei in spallation reactions with

intermediate energy protons. This information, usually omitted in the study of the spallation mechanism, is of high importance in understanding the mechanisms leading to the formation of the high–spin isomers. Among the reaction products, fission fragment nuclei could also be identified allowing for the investigation of the fission probability for medium–mass fissile nuclei. The experimental data discussed in this chapter reveal new facets of the spallation processes, related in particular to the angular momentum of the products, that lead to a better understanding of the underlying reaction mechanism.

1. General Remarks

Long–lived excited nuclear states – isomers – schematically similar to metastable atomic states, were discovered in 1935 [1, 2]. Around this time remarks related to isomers were published by F. Soddy, O. Hahn and C. F. von Weizsacker [3]. The first review of isomers' properties was published as early as 1949 [4]. Physics of isomers has since then been treated as a separate branch of nuclear physics and many studies were undertaken with the purpose to reveal their underlying structure and properties.

Along with fragmentation and fission reactions, spallation by intermediate and high energy protons has served over the decades as one of the most effective methods to produce radioactive nuclei in a wide range of masses and Z/A ratios. For the isolation and the study of these new exotic nuclei several facilities were built around the world, the premier ISOL facility being the ISOLDE laboratory at CERN. Two main methods for the separation of the exotic nuclei are used, depending on their production method: the in–flight separation where exotic nuclei produced in fragmentation reactions are selected with mass separators, and the Isotope Separation On Line (ISOL) method where the isotopes are produced at rest in a target exposed to an accelerator beam and subsequently extracted. The Ion Guide Isotope Separator On Line (IGISOL) method is based on the collection of the radioactive nuclei in gas and their transport by using the gas jet method under differential pumping. Significant improvements were recently obtained in the creation of a thermal flow of ionized atoms at charge state 1^+ for injection in an electromagnetic trap. Long–lived isomers can be produced as radioactive nuclei as well by using spallation reactions, then separated and delivered as isomeric beams.

Since 1990s the production of the ^{178m2}Hf long–lived high–spin isomer has gained much interest. This isomer is a singular case in the nuclear landscape; it is located at about 2.45 MeV excitation energy, it has spin and parity $I^{\pi}=16^{+}$ and a half–life of 31 years, and decays through gamma–ray emission. Such properties make it interesting both for nuclear structure studies and for possible applications. An important advantage of the ^{178m2}Hf isomer over other high–spin isomers is the possibility to accumulate the isomeric nuclei and produce isomeric targets that can be stored for long time before use. The process that produced the largest quantity of ^{178}Hf^{m2} isomer (10^{17} atoms) until now was the spallation by a 400 μA proton beam at 800 MeV energy of a ~1 kg Ta beam dump at the Los Alamos National Laboratory LAMPF meson factory. The main disadvantages of this method are the use of a huge accelerator to produce the high–energy proton beam and the extremely high activity of the irradiated samples. After *cooling* of the activated Ta beam dump over 20 years, it was possible to chemically process it and isolate the Hf fraction that contained mainly the ^{178m2}Hf and ^{172}Hf (1.87 y) long–lived nuclides and the stable Hf isotopes which could not be eliminated by chemical processing. The yield measurements of the spallation products and the methods for chemical processing were reported in Refs. [5-8].

There is currently an increased interest in developing beams of isomeric nuclei for the nuclear physics research as their use might open new research opportunities [9–11]. Yet, until now only few experiments were performed with isomeric beams [12–14]. On the contrary, several experiments with isomeric targets, such as ^{180m}Ta and ^{178m2}Hf, were performed and described in many publications (see for example Refs. [15–22]). The ^{180m}Ta isomer is unique in nature; it has a half–life of $T_{1/2} > 6 \times 10^{15}$ y [23], spin and parity $I^{\pi}=9^{-}$, and an excitation energy of 75.3 keV. The ^{180m}Ta abundance in natural Tantalum is only of 0.012% but still sufficient for getting enriched samples in amounts of grams as needed for typical nuclear reaction experiments. A similar case is the ground state of ^{176}Lu with $I^{\pi}=7^{-}$, half–life of $T_{1/2} = 3.78 \times 10^{10}$ y and a natural abundance of 2.59%. Nuclei such as ^{176}Lu, ^{178m2}Hf, and ^{180m}Ta provide the means to study nuclear reaction with nuclei in high–spin states. Production and use of the long–lived isomers for nuclear physics experiments were discussed in detail in a recent review [24].

At the beginning of the 1990s an international collaboration between nuclear research laboratories from France, Germany and Russia, called the *Hafnium Collaboration*, was established with the goal of producing sufficient ^{178m2}Hf isomers for nuclear physics experiments. For the production of ^{178m2}Hf isomers the ^{176}Yb(^{4}He,2n) reaction at 36 MeV was selected [25]. This method is, on an absolute scale, less productive than the spallation of Ta [5–8] but it has the great advantage of producing less contaminants and radioactivity. By using this method [25], it was possible to accumulate a total amount of about 1 μg of the ^{178m2}Hf isomer. This small quantity was already sufficient to perform many experiments. Since for some studies, such as Coulomb excitation and (d, d′) reactions with the isomeric targets, the purity of the material is of great importance it was even possible to mass separate the chemically purified Hf fraction to remove the stable Hf isotopes (others than ^{178}Hf). The microscopic amount of ^{178m2}Hf that remained in the tiny targets produced in this way made some of the experiments very difficult but, nevertheless, new results have been obtained and reported in Refs. [22, 26].

At the dawn of the third millennium, a new collaboration between laboratories from Russia, Romania and USA was established with the goal of optimizing the production of the high–spin isomers through spallation of heavy element targets with intermediate energy (from 100 to 660 MeV) protons at the 6m synchrocyclotron (phasotron) of LNP, JINR Dubna. The beam power of the Dubna synchrocyclotron is 3 orders of magnitude lower as compared to the LANL meson factory, thus one did not expect accumulation of large amounts of isomeric material but the main idea of the measurements was to investigate the behavior of the reaction cross sections for isomers as compared to other radioactive nuclei as a function of the proton beam energy and the target material in order to formulate the optimum and most economic conditions for isomers production. Several measurements with different target materials and proton beam energies were performed and a detailed description of the results is given in Refs. [27–30]. In the following an overview of these measurements will be given and the main conclusions will be discussed. The new results offered the opportunity to study in more detail the reaction mechanisms as spallation and fission and develop novel interpretations that are discussed in Sections 3 and 4. The last part of the chapter is devoted to the discussion of possible applications of isomers by taking advantage of the new results obtained from the experimental measurements. In the next Section the main physics motivations that triggered