PRAMANA
— journal of
physics

Vol. 57, Nos 2 & 3
Aug. & Sept. 2001
pp. 665–670

Summary of ISNP2K

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Abstract. This is a brief summary of the ISNP2K (International Symposium on Nuclear Physics, 2000). Many interesting works were presented on new developments and perspectives of nuclear physics in the plenary and poster sessions. Subjects discussed are 1) high temperature and high density nuclei, new QGP phases and relativistic HI collisions, 2) new degrees of freedoms studied by medium energy reactions, 3) exotic nuclei with large isospin, large A, high J and high E_x, 4) new dynamical properties of many body nucleon systems, 5) neutrino nuclear physics and neutrons for astroparticle physics, and 6) new accelerators and new applications. ISNP2K with extensive discussions on nuclear physics frontiers at the turning point from 2000 to 2001 provides a good bridge to the new century.

1. ISNP2K and nuclear physics frontiers

International Symposium on Nuclear Physics, 2000 (ISNP2K) was held during Dec. 2000, the end of the last year of the 20th century, discuss to the present status of nuclear physics, its frontiers and perspectives for future.

Nuclei are unique physics systems of strongly interacting nucleons/hadrons. They provide excellent opportunities for studying interesting properties of many body nucleon-hadron systems and strong QCD interactions. Nuclei are also used as micro-laboratories for studying fundamental properties of neutrinos and weak interactions and for investigating symmetries and conservation laws.

Interesting talks were given on present status and perspectives of nuclear physics frontiers in plenary sessions of ISNP2K. Many excellent contributions were presented in poster sessions. Hot discussions were made at all plenary and poster sessions.

The symposium started with an inauguration session. Impressive talks were made on how nuclear physics was developed in the 20th century in India and in the world. The speakers were all distinguished physicists, B K Jain (Chair of ISNP2K), V C Sahni (Director, Physics Group), R Chidambaram (Ex. Chairperson of AEC), Raja Ramanna (Member of Parliament), and S Kailas (Convener of ISNP2K).

ISNP2K covered most of the important current subjects of nuclear physics. The subjects discussed were 1) high temperature/density nuclei and possible QCD phases, 2) new degrees of freedoms of quarks, hyperons and mesons studied by medium energy probes, 3) exotic nuclei with high isospin (far from stability), high Z, high J, and high excitation energies, 4) new dynamics of many body nucleon systems and nuclear matters, 5) neutrino

nuclear physics for neutrinos and weak interactions, and neutrons for astroparticle physics, and 6) new accelerators and new applications.

2. High temperature and high density nuclei, new QGP phases and relativistic HI collisions

Extensive experimental and theoretical studies have been made to find possible phase transitions from the nucleon/hadron phase to the new QGP (quark gluon plasma) phase at high temperature and high density. Experimental studies of QGP have been carried out by using relativistic heavy ion beams.

Recent studies of production of photons and dileptons in relativistic heavy ion collisions at CERN SPS were presented by D K Srivastava, VECC. Single γ rays, lepton pairs of ll and hadrons were shown to suggest the possible QGP phase.

Heavy ion programs from SPS to RHIC were briefly reviewed by I Tserruya, Weizmann. The first results from RHIC PHENIX were presented by T K Ghosh, Vanderbilt. RHIC is very promising for further studies of QGP

Heavy ion physics with the ALICE detector at CERN LHC was discussed by J Schukraft, CERN. LHC was shown to give substantial improvements in the energy density, the volume and the time for the central collision. Thus the LHC with the ALICE detector provides opportunities for quantitative studies of strongly interacting matter at extreme energy density and the QGP phase.

Multiplicity distributions and fluctuations in high energy collisions were discussed by T K Nayak, VECC. They were shown to provide constraints on the initial conditions of the matter created at the reaction.

3. New degrees of freedoms studied by medium energy reactions

New degrees of freedoms in nuclei are interesting subjects of interacting hadron systems. Actually quark/QCD, meson and strangeness degrees of freedoms are well investigated by means of medium energy beams.

A W Thomas, Adelaide presented recent works on the role of the chiral symmetry in connecting hadron properties such as masses, charge radii, and magnetic moments on the lattice at large q-masses with those for real hadrons at small q-masses. Chiral unitary theory was shown by E Oset, Valencia to be used to extract more information from the chiral Lagrangian than chiral perturbation theory.

Parton distributions in nuclei were discussed by S Kumano, Saga, and the optimum valence quark, sea quark, and gluon distributions were proposed. Effect on the nuclear matter equation of state due to modification of partial restoration of chiral symmetry was discussed by A B Santra, BARC, and exclusive hadronic processes and color transparency were discussed by P Jain, Kanpur.

Extensive studies of meson production in $p + d$ reactions at COSY were reported by H Machner, Juelich. Mechanisms of the meson production are rather complex, and is hard to predict the absolute cross sections. Measurements of π^0 and π^+ were interesting for isospin symmetry studies.

Spin observables in medium energy hadronic reactions were shown to be successfully reproduced in terms of the microscopic quark recombination model by K I Kubo, TMU. A gluon process with $s_z = 1$ was suggested to play a role. Hyperon production in p-p collisions was studied by N G Kelkar and B K Jain, BARC in the meson exchange framework. It is sensitive to YN interaction models.

4. Exotic nuclei with large isospin, large A, high J and high E_x

Exotic nuclei are interesting for studying new properties of many body nucleon systems at extreme conditions. Actually nuclei at large T_z (far from stability), large A, high J, high excitation E_x and other extreme quantum numbers show interesting properties. They have been studied by modern nuclear spectroscopy with light and heavy ion beams and RI beams.

Super-heavy nuclei as cold systems were discussed by R K Gupta, Panjab, and it was shown that QMFT (quantum mechanical fragmentation theory) was a complete theory of decay and fusion of nuclei.

Exotic nuclei far from stability were studied extensively by means of RI beams. Y Blumenfeld, IN2P3 reported proton scatterings from unstable nuclei by using RI beams in inverse kinematics, and pointed out importance of the neutron distribution.

A Ozawa, RIKEN reported extensive works on new isotopes, nuclear diagonal and transition moments, reaction cross sections, shell structures and other interesting properties of unstable nuclei.

C Samanta, SINP/Virginia reported nice works of the consistent analyses of elastic and inelastic scatterings of protons from loosely bound light nuclei, and showed evidences for the SDR in ^{11}Li and $L = 3$ state in ^{8}He. The structures of light neutron-rich nuclei were studied by U Datta Pramanic, GSI *et al* by Coulomb dissociation measurements.

High spin states and nuclear structures were studied extensively by multi-detector γ spectroscopies. S B Patel, Mumbai presented detailed studies of high spin states by using GDA (gamma detector array) at NSC, New Delhi. H C Jain, TIFR reported extensive works on various nuclear properties of proton rich nuclei. They were studied by means of the 14 UD Pelletron at TIFR. A new possibility of rotational like bands, i.e. magnetic rotational bands, in weakly deformed nuclei was discussed by A K Jain, Roorkee.

5. New dynamic properties of many-body nucleon systems

Nuclei with $A = 10$–200 nucleons show interesting dynamic properties characteristic of strongly interacting nucleon systems. Giant resonances, nuclear compressions, fissions and fragmentations have been studied experimentally and theoretically.

V M Datar, BARC reported systematic studies of GDR's in excited nuclei by high energy γ measurements in coincidence with multiplicity detector signals. He presented interesting data on ^{28}Si + ^{58}Ni experiments at TIFR. G Viesti, Padova presented interesting data on entrance channel effects, emission barrier lowering effects and double GDR.

Theoretical studies of giant and pygmy dipole resonances in neutron-rich nuclei were made in terms of the phonon coupling model with phonon quasi-particle coupling by

N D Dang, RIKEN. Recent investigative results on hot GDR and the quadrapole shape were reported by A Ansari, Bhubaneswar.

Isoscalar giant monopole resonances (ISGMR) and isoscalar giant dipole resonances (ISGDR) are of great interest in view of nuclear matter incompressibility. Detailed studies of ISGMR and ISGDR were presented by S Shlomo, Texas AM, and the incompressibility coefficient of $K = 230$ MeV was derived.

S R Jain, BARC discussed quantum chaos, thermal equilibration and dissipation in nuclei as good testing systems for them. Current status and perspectives of the relativistic mean field (RMF) description were reported by Y K Gambhir, IIT, Powai. Annihilation of anti-protons at nuclear surface and parity-violating nuclear interactions were shown to be interesting.

A systematic study of the multi-fragmentation of 1 GeV heavy nuclei was reported by B K Srivastava, Purdue. Recent studies of fission reactions induced by heavy projectiles were reported by R K Choudhury, BARC, and those of neutron induced fissions by W I Furman, JINR.

As for a few body system, the Faddeev equation for the three body bound state was solved as three-dimensional integral equations without partial wave decomposition by C Elster, IKP.

6. Neutrino nuclear physics and neutrons for astroparticle physics

Neutrinos (ν) are of current interest for new physics beyond the standard electroweak theory. They are well studied in nuclei as micro-laboratories. Here nuclear responses for ν are crucial for ν studies in nuclei.

H Ejiri, Osaka/spring8/Washington studied nuclear responses for $\beta\beta - \nu$, solar-ν, and supernova-ν by means of charge-exchange spin-flip (^{3}He, t) reactions. ^{100}Mo is shown to have large responses for those ν's, and MOON (Mo Observatory Of Neutrinos) has been proposed for high sensitive ν-mass studies by $\beta\beta$ decays and for real-time studies of low energy solar-ν and supernova ν by inverse β decays.

A brief review of theoretical calculations was made by S K Singh, AMU, Aligarh on inclusive quasi-elastic and pion production processes in neutrino reactions at medium energies, which were relevant to atmospheric and accelerator ν oscillations. They were shown to be sensitive to nuclear medium effects.

Quark matter formation in dense stellar objects and large number of ν production in the equilibration process were discussed by S C Phatak, Bhubaneswar.

Intense low energy ν beams and large ν detectors are quite important for further progresses of ν nuclear physics. Actually ν plays vital roles for modern particle, nuclear and astrophysics.

Neutrons are very powerful probes for particle physics, astronuclear physics, condensed matter physics and for applied science. Recently solar and supernova ν's are shown to be studied by measuring neutrons induced by the ν interactions with nuclei. Ultra-cold neutrons are used for studying symmetries and conservation laws. Slowing down neutron spectroscopy methods (SDNS) on lead and graphite moderators were shown to be useful as modern neutron spectroscopy by Yu P Popov, JINR.

7. New accelerators and new applications

Accelerators are basic facilities for nuclear and particle physics. It is quite impressive to see how new accelerators are being built in India.

The super-conducting linac booster for the 15 UD Pelletron accelerator at NSC, New Delhi was reported by A Roy, NSC. Extensive studies of nuclear structures and reactions are expected to start in 2003 by using light and heavy ion beams from the new booster linac.

Status of the super-conducting cyclotron project at VECC, Calcutta was reported by R K Bhandari, VECC. It is a large super-conducting cyclotron with K value of 520 MeV for bending limit and 160 MeV for focusing limit. Thus it provides light-ion ($Q/A = 0.5$) beams up to 80 MeV/A and heavy-ion beams up to $520\,(Q/A)^{\,2}/A$. It will start operation in 2003.

Present status and future plans of the folded tandem ion accelerator (FOTIA) facility with a terminal voltage of 6 MeV at BARC was discussed by P Singh, BARC. The initial commissioning of the FOTIA has been done with carbon and oxygen ion beams. The accelerator is used for wide scopes of nuclear physics and applied science.

Exotic nuclei are interesting for extensive studies of nuclear and astrophysics. A Facco, LNL presented the project SPES (study and production of exotic nuclei). This is INFN's effort in view of the construction of the European next generation ISOL-type facility. SPES is a facility based on a 100 MeV, 30 mA CW proton linac and an ALPI-like super-conducting linac. The proton linac makes spallation neutrons, which are used for production of the fast neutron fission fragments from a uranium like target. Then neutron rich ion species are extracted, selected, and then accelerated through the super-conducting linac up to 20 MeV/A. It is expected to be operative by 2010.

Nuclear beams and detectors are used for various kinds of applied science. Medical use is one of important applications. J F Sharpey-Schafer, NAC, Cape Town presented proton therapy and other radiation cancer treatment modalities in Southern Africa. Current initiatives at NAC with emphasis on the dedicated 230 MeV proton accelerator were discussed.

8. Poster sessions

Many excellent works were presented as contributed papers in poster sessions. The number of the contributed papers were almost 250. Subjects covered were low and medium energy nuclear reactions, nuclear structures, physics with RI beams, intermediate energy reactions and sub/non-nucleonic degrees of freedom, hadronic structures and interactions, relativistic nuclear collisions and QGP, nuclear matter and equation of state, nuclear astrophysics, and accelerators and instruments. Many enjoyed their enthusiastic presentations and very hot discussions.

9. Concluding remarks

ISNP2K was indeed full of excellent talks on new developments of nuclear structures and phases, nuclear and hadronic reactions, nuclear astrophysics, nuclear particle (neutrino) physics, nuclear accelerators, nuclear instruments, and applications of nuclear beams and

many interesting discussions on perspectives of nuclear physics. Thus ISNP2K provides one with a wonderful summary of the present status of the nuclear physics frontiers at the end of this century and good prospects for the new century.

In short this symposium is very pleasant, productive, and successful due to all of you presenting nice works at the plenary and poster sessions and joining hot discussions. Among all, I would like to express our sincere gratitude to Prof. B K Jain, the chair of ISNP2K, Prof. S Kailas, the convener, Prof. A K Mohanty, the secretary, and all organization committee members for excellent organization.

We do hope to continue to enjoy nuclear physics with many new and exciting progresses in Mumbai, India and in all the world, just as a peacock (the bird of India) with its wonderful extended wing, in the 21st century.

Thank you for your attention. Dhannyawad.