News from ANPhA

- ANPhA (= DNP-AAPPS)
- China
- India
  - VECC
- Korea
  - RISP/RAON
- Japan
  - J-PARC
  - RIKEN
  - ELPH
  - Medical Application
ANPhA Activity

• The AAPPS extended council meeting was held in Xi’an in China from April 6 to April 8, where the first Division chair meeting was held.

• Chairs of Division of Plasma Physics (DPP), Division of Astrophysics, Cosmology, and Gravitation (DACG), and Division of Nuclear Physics (DNP) (=ANPhA) gathered together.

• AAPPS council proposed to select annually an “AAPPS‘s Distinguished Physicist (AAPPS-DP)” in each divisional conference in order to increase the visibility of AAPPS, and basically accepted by three Divisions. ANPhA will ask organizer to select one AAPPS-DP at each ANPhA supported conference.
• Next AAPPS Council meeting will be held in Kuala Lumpur, Malaysia on December 3rd in 2017 in conjunction with International Meeting for Frontier of Physics (IMFP2017) which will be held in December 3-7 at Kuala Lumpur.

• **ANPhA (=DNP-AAPPS) helps to organize Nuclear Physics session of IMFP2017.**

• ANPhA (=DNP-AAPPS) board meeting will be held at Halong City, Vietnam on Sept. 24th, 2017 and ISPUN17 will open the days after.

• **ANPhA is organizing ANPhA awards for young Scientists** for ANPhA supported meetings.
Meetings concerning DNP-AAPPS/ANPhA by the end of 2017

• 5th International Meeting on Frontiers of Physics (IMFP2017), Kuala Lumpur, Malaysia, Dec. 4-7, 2017
• 90th NuPECC Meeting, Saclay, Oct. 6-7, 2017
• 12th ANPhA/DNP-AAPPS Board Meeting, Halong City, Sept. 24, 2017
• IUPAP-WG9 Nuclear Science Symposium, Tokyo, Aug. 29-30, 2017
• 89th NuPECC Meeting, Lisbon, June 16-17, 2017
• 35th AAPPS Extended Council Meeting, Xi’an, April 7-8, 2017
• 88th NuPECC Meeting, CERN, March 10-11, 2017
• NuPECC Long Range Plan Town Meeting, Darmstadt, January 11-13, 2017
• 33rd and 34th AAPPS Council Meeting, Brisbane, Dec. 4, 2016
• 11th ANPhA Board Meeting, Sendai, Nov. 25, 2016
News from China
Some news update of Chinese nuclear physics community (current but not very complete progress in China)
From Weiping Liu, ANPhA Vice Chair.

- **Large scale facility plan**
  - Heavy ion facility **HIAF** granted with feasibility permit by national commission.
  - **Jinping deep underground lab** and **Beijing ISOL project** listed in national 5 years plan.

- **Ongoing project progress**
  - Jinping nuclear astrophysics experiment **JUNA**, ground test get proton beam of 260 keV and 3 mA on May 27.
  - **ADS R&D**: get proton beam of 26.1 MeV and 12.4 mA pulsed beam on June 5.
  - Large scale cosmic ray observatory **LHAASO**, is under construction in Daocheng, Sichuan.

- **Science project application**
  - Jinping Xe dark matter project **Pandex-II**, get 1st round evaluation in NSFC (science foundation).
  - Jinping Ge dark matter project **CDEX-II**, get another funding support from MOST (science ministry).
Roadmap of NP facilities

1986
北京串列加速器
HI-13

1988
兰州回旋加速器
SSC

2008
兰州储存环
CSR

2014
北京串列升级工程

2021?
重离子应用装置
HIAF

2028?
北京ISOL装置
JUNA: Jinping underground nuclear astrophysics

JUNA

CDEX

PandaX

JUNA II: 4MV accelerator
H\(^+\), 4He\(^+\): 400keV, 10mA
4He\(^{2+}\): 800keV, 2.5mA

JUNA I: 400kV accelerator

Heavy ions

CJPL-II, 300,000 m\(^3\)

JUNA实验室
14mX14mX50m
China Jinping Underground Laboratory (CJPL)

Sichuan Province
(home of Panda)

Jinping tunnels

Yalong River

Jinsha River

Yunnan Province
Layout and beam specification

The main components

HFRS
- L: 152m, Bp: 15 Tm
- RIBs, stable ion beams

SRing
- SRing: Spectrometer ring
- Circumference: 273.5m
- Rigidity: 15 Tm
- Electron/Stochastic cooling
- Two TOF detectors
- Four operation modes

BRing
- BRing: Booster ring
- Circumference: 530 m
- Rigidity: 34 Tm
- Beam accumulation
- Beam cooling
- Beam acceleration

iLinac
- iLinac: Superconducting linac
- Length: 100 m
- Energy: 17 MeV/u(U^{35+})

SECR
CIADS Project (2016-2023)

China Initiative Accelerator Driven System (CIADS)

- 2015年12月建议书获国家发改委批准
- 经费: ~(18+12)亿元 (中央财政+地方政府)
- 建设地点: 广东省惠州市
- 建设及合作单位: 广州分院、近物所、高能所、合肥物质院、401、中广核等

CIADS layout

Proton LINAC: 250~600 MeV
- 10 mA with CW mode

Spallation Target:
- Granular flow > 2.5 MW

Sub-critical core:
- LBE coolant
- <10 MWt

1. Ion source+LEBT+RFQ+MEBT
2. HWR009 section
3. Spoke042 section
4. SEE Elliptical062 section
5. Elliptical082 section
6. Coupling section
7. Reactor
IMP & Related Centers

- IMP main campus
- National Laboratory of Heavy Ion Accelerator in Lanzhou (NLHAL)
- Industrialization Pilot Base at Baiyin city
- Lab of Superconducting Technology at Baiyin city
- Lab of Spallation Target at Baiyin city
- Center of Nuclear Energy For ADANES
- Center of Heavy Ion Science Branch of IMP at Huizhou
- Research Center of Advanced Energy and materials at Huizhou
- Center of Heavy Ion Therapy at Lanzhou
- R&D Center of Heavy Ion Applications, New Campus in Lanzhou
- Center of Heavy Ion Therapy at Wuwei city
LHAASO is expected to be the most sensitive project to face the open problems in Galactic cosmic ray physics through a combined study of photon- and charged particle-induced extensive air showers in the energy range $10^{11}$ - $10^{17}$ eV.
News from India (VECC)

• Prepared by Dr. Amitava Roy, New Director of VECC.
Experimental facilities and Nuclear Physics Research Activities at VECC

Charge particle detector array

MWPC

Neutron Detectors

Segmented Clover

Penning Ion trap

Gamma Multiplicity Filter

VENUS and VENTURE array

LAMBDA Detector array
Recent studies:

Studies on GDR using LAMDA array
- Study of dependence of GDR width at high temperatures
- Probing clustering phenomena in atomic nuclei using GDR as a tool
- Jacobi shape transition
- Systematic study of isospin mixing

Studies on nuclear level density using neutron detector
- Effect of angular momenta
- Effect of collectivity
- Shell effect and its damping

Studies using Charged Particle detector
- Fragments emission mechanisms
  - Fusion-fission, DIO, DI, QE etc.
  - Deformation of nuclei using LCP as probe
- Cluster structure studies
  - Hoyle state,
  - Other cluster states of $^{12}$C
  - Hoyle analogue states and excited states of Hoyle analogue states in other nuclei
  - Effects of clustering in fragments emissions

Gamma ray spectroscopic studies using VENUS, INGA and other setup:
- Spectroscopy of heavy nuclei
- Complete spectroscopy of nuclei using lifetime and quadrupole moment measurement
  - In beam prompt spectroscopy to study nuclei in $A \sim 130$ region
  - Decay spectroscopy of radiochemically separated fission fragments around $^{132}$Sn

International Collaborations:
- FAIR NUSTAR (GSI, Germany)
- DST-RFBR project, JINR, DUBNA
- AGATA Expt., GANIL, FRANCE
- PARIS collaboration (FAIR)

Fission studies using MWPCs
- Fission dynamics
- Fusion-fission vs. Quasi fission
- Physics related to Super Heavy Elements (SHE)
Study of cluster formation in atomic nuclei via GDR decay:

\[ \frac{\eta}{s} \text{ for finite nuclear matter: Experiment at VECC} \]

- $\frac{\eta}{s}$ remains within (2.5-6.5) $\hbar/4\pi k_B$ for finite nuclear matter


Experiments with INGA

$^{198}$Pt($^7$Li, 5n)$^{200}$Tl

$^{169}$Tm($^{32}$S, $^{32}$S')$^{169}$Tm*

Return of backbending in $^{169}$Tm

Soumik Bhattacharya et al, PRC 95, 014301 (2017)

Md. A. Asgar et al., PRC 95,031304(R) (2017) T. Bhattacharee et al. NIM A 767, 10(2014).

Critical behavior in the evolution of GDR with at low $T$

- $^{63}$Cu
- $^{120}$Sn
- $^{208}$Pb


Long lived beta decaying isomer in $^{150}$Pm $\rightarrow$ ($\alpha + ^{150}$Nd)
Exploring fission valleys of pre-actinides

A. Chaudhuri et al; PRC 94, 024617 (2016)

A. Chaudhuri et al; PRC 92, 041601 (2015) (R)

A. Chaudhuri et al; PRC 91, 044620 (2015)

Evidence of fadeout of collective enhancement in nuclear level density

K. Banerjee et. al accepted in PLB

P. Roy et al., PRC 88, 031601 (2013) (R)

Direct vs. Sequential decay of the Hoyle state

T. K. Rana et al., PRC 88, 021601(R) (2013)

Survival of cluster structure at high excitation

S Manna et. al., PRC 94, 051601( 2016)(R)
Electron cloud trapped in VECC Penning Ion Trap and observed using indigenously developed resonant detection electronics setup

Penning Ion trap assembly

Indigenously developed 19 pin cryogenic feedthrough

Low noise amplifier

Helical resonator

Designed and developed at VECC

TWO RING MAGNETS ENCLOSING FIVE ELECTRODE TRAP ASSEMBLY

FEP: Field Emission Point for electron generation
Recent works on Nuclear Theory at
Variable Energy Cyclotron Centre, Kolkata
Multidimensional Potential energy surface calculated at T=0 using Density Functional Theory

Mass (left) and charge (right) distributions of the heavier fission-fragment of \(^{240}\text{Pu}\)
Shaded regions indicate model-dependent error

*a predictive framework to describe spontaneous fission yields of a heavy nucleus*

**Nuclear Liquid gas phase transition**: A new proposed signature

Canonical Thermodynamical Model

$dM/dT$ vs $T$ (Multiplicity Derivative)

Multiplicty and Specific Heat

$M$: total multiplicity from nuclear fragmentation at intermediate energies

$T$: temperature


$C_v$ & $dM/dT$ peaks at same $T$

$dM/dT$ much more accessible experimentally

To be continued in other models............
• For EoS of White Dwarfs, the pressure is provided by the relativistic degenerate electrons only while the
for energy density both electrons (with its kinetic energy) and atomic nuclei contribute.

• For magnetized White Dwarfs, electrons, being charged particles, occupy Landau quantized states. This
changes the EoS, which, in turn, changes the pressure and energy density.

• The mass-radius relations for non-magnetized & magnetized White Dwarfs are obtained by solving the
Tolman-Oppenheimer-Volkoff equations. Surface magnetic field is kept at $10^9$ Gauss estimated by
observations while central magnetic field goes up to maximum $10B_c = 4.414 \times 10^{14}$ Gauss (theoretical limit).

• The masses of non-magnetic White Dwarfs remain within Chandrasekhar’s limit of $1.4 M_\odot$ but for
magnetized White Dwarfs it increases with central magnetic field and goes far beyond Chandrasekhar’s
limit.

The high-density behavior of neutron star matter obtained from DDM3Y interaction satisfies constraints from the observed flow data of heavy-ion collisions.

The neutron star properties agree with the recent observations of the massive compact stars.

The density, pressure and proton fraction at the inner edge separating the liquid core from the solid crust of neutron stars are determined thermodynamic stability conditions:

\[ \rho_t = 0.0938 \text{ fm}^{-3}, \quad P_t = 0.5006 \text{ MeV fm}^{-3} \quad \text{and} \quad x_{p(t)} = 0.0308, \quad \text{respectively} \]

These results for pressure and density at core-crust transition together with the observed minimum crustal fraction (1.4% -1.6%) of the total moment of inertia provide a new limit for the radius of the Vela pulsar: \( R > 4.10 + 3.36 M/M_\odot \text{ kms} \). Present calculations suggest that this fraction can be at most 3.6% due to crustal entrainment because of Bragg reflection of unbound neutrons by lattice ions.

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Constant dark matter central density = 0.14 fm$^{-3}$

$M_{\text{max(rot)}}$ = 1.3640 $M_{\odot}$; $R_{\text{rot}}$ = 6.7523 kms

when $f_{\text{nucl}}$ = 700 Hz and $f_{\text{dark}}$ = 300 Hz

Constant nuclear matter central density = 0.38 fm$^{-3}$

$M_{\text{max(rot)}}$ = 1.9355 $M_{\odot}$; $R_{\text{rot}}$ = 10.3717 kms

when $f_{\text{nucl}}$ = 300 Hz and $f_{\text{dark}}$ = 700 Hz

The masses and radii of non-rotating and rotating configurations of pure hadronic stars mixed with self-interacting fermionic Asymmetric Dark Matter are calculated within the two-fluid formalism of stellar structure equations in general relativity. The Equation of State (EoS) of nuclear matter is obtained from the density dependent M3Y effective nucleon-nucleon interaction. We consider dark matter particle mass of 1 GeV. The EoS of self-interacting dark matter is taken from two-body repulsive interactions of the scale of strong interactions. We explore the conditions of equal and different rotational frequencies of nuclear matter and dark matter and find that the maximum mass of differentially rotating stars with self-interacting dark matter to be 1.94$M_{\odot}$ with radius 10.4 kms.

Ref: S. Mukhopadhyay, D. Atta, K. Imam, D.N. Basu, C. Samanta

arXiv: 1612.07093 Communicated
News from Korea

• Assembled by Prof. Byungsik Hong of Korea University, ANPhA Board member.
News from Korea

RAON Site: Sindong in Daejeon

A construction company was selected in September, 2016.

Area (Lot/Bldg): 952,066 m² / 130,846 m²
Test facilities for **Superconducting RF cavities** and modules

**Facility List**

1. **Cavity test pit**  
   (SRF Cavities performance test)
2. **Module test bunker***  
   (SRF Modules performance test)
3. **Clean Room**  
   (Clean assembly & Inspection)
4. **Cryogenic Plant**  
   (Liquid He, Liquid N)
5. **SC Linac Demonstration**  
   (ECRIS+LEBT+RFQ+MEBT+1 QWR)

*1st QWR Module has been tested successfully in May.*
### Performance test for QWR cryomodule

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<tr>
<td>Thermal heat load</td>
<td>$&lt; 25 \text{ W}$ @ 4.2 K, 6MV/m</td>
<td>$9.9 \text{ W}$ @ 4.2 K, 6MV/m</td>
<td>pass</td>
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</tbody>
</table>

Thermal heat load (9.9watt @ 6.1MV/m)

![QWR cryomodule test bunker](image)
News from Japan
Hadron Hall Extension

One of Two Top Priority projects of Japanese Nuclear Physics Community

• The hadron hall extension project of J-PARC was selected as one of the top 28 major projects by the Science Council of Japan this year. The selection was made in every three years.

• Selection process (Hearing) from these 28 big projects (+1, added by MEXT) has been started by MEXT (Funding agency in Japan) for MEXT’s "Road Map". Only 10~15 projects will survive to “Road Map”. The budget approval will be made only on these "Road Map“ projects.
J–PARC Upgrade for Nuclear & Particle Physics

Science Council of Japan selected this one of 27 Major Projects of Japan

COMET-II ($\mu$–e conversion) $46M$
Hadron Hall for Counter Experiments with 150kW SX
“Big projects” in NP, HE and Space

- Four New projects + 1 (added by MEXT)
  - Hadron Hall Extension + μe conversion exp. + g-2/μEDM
  - HyperKAMIOKANDE + Neutrino Beam Power Upgrade
  - HL-LHC
  - LiteBIRD (Light satellite for the studies of B-mode polarization and Inflation from cosmic background Radiation Detection)
  - SPICA (Space Infrared Telescope for Cosmology and Astrophysics)

- Four On-Going projects (financed!)
  - High Intensity J-PARC (750kW for ν, 100kW for SX)
  - Super KEK-B
  - KAGRA (Kamioka Gravitational wave detector, Large-scale Cryogenic Gravitational wave Telescope)
  - 30m Telescope (TMT)
Next generation LBL experiment

J-PARC $\rightarrow$ Hyper-Kamiokande

with realization of

• J-PARC MR at beam power of $\sim 1$MW ($\geq 750$kW)
• New 1Mt Water Ch det: Hyper-Kamiokande
Hadron Experimental hall of J-PARC
Spring 2017 RUN (Started on April 12)

JFY2017
~50kW

E31: Hyperon Resonance

E07 Ξ-hypernuclei with Emulsion

* COMETのための8GeV試験

Hi-p/COMET construction

K1.1 Installation Plan

Jan 2017

Hi-p/COMET construction

Jan 2017

Hi-p/COMET construction
E07 with 10 times statistics of E337

- $^4\Lambda\Lambda H$, $^5\Lambda\Lambda He$ and $^5\Lambda\Lambda H$
  - $\Lambda\Lambda-\Xi N$ coupling interaction affects mass since s-shell nucleons are not fully occupied. Thus, it can be determined.

- A=6—17 $\Lambda\Lambda$ hypernuclei
  - Confirmation of $\Lambda\Lambda$ interaction strength and nuclear structure effects such as shrinkage due to $\Lambda$, independent information of NAGARA event, $^6\Lambda\Lambda He$

- $^{10}\Lambda\Lambda Be^*$ (excited states)
  - Sensitive to $\Lambda\Lambda$ p-wave interaction, which might change max. n-star mass about 10%.

- $\Xi$-hypernuclei: $\Xi^{-16}O$, $\Xi^{-14}N$(KISO event), $\Xi^{-12}C$
  - From multiple events of $\Xi$-hypernucleus, we can determine the (natural) width of $\Xi$-hypernucleus, which is related to $\Lambda\Lambda-\Xi N$ coupling interaction.
Discovery of $\Xi$-hypernuclues, E373 / E07

K.Nakazawa et al, PTEP 2015, 033D02 (2015)

- found by applying a newly developed “overall scanning method” (for E07) to the E373 emulsion
- uniquely identified as $\Xi^- + ^{14}\text{N} \rightarrow ^{10}_\Lambda\text{Be}(\#1) + ^{5}_\Lambda\text{He}(\#2)$
- Binding energy of $\Xi^-$ should be $>1.03 \pm 0.18 \text{ MeV}$
  $\leftrightarrow 0.17 \text{ MeV}$ for 3D atomic orbit
- $\Xi$ hypernuclei and attractive $\Xi N$ interaction were established.
- won the 22nd JPS Outstanding Paper Award in 2017
ストレンジネス核物理グループ
E07実験 - エマルジョン解析状況

**Hybrid法**: K1.8BL & KURAMAで(K^-,K^+)反応でのΞ^-生成を選び、SSDで求めたΞ^- track情報を使ってエマルジョン中のΞ^-を自動追跡する。

KURAMAの解析

mass*charge [GeV/c^2]  

Ξ^- → Λ + π^- decay

エマルジョン中のΞ^-の事象を確認 ➡ E07実験でのHybrid法の確立
Future program on SNP at the present hadron hall

• Double-strangeness system
  • Emulsion exp. (E07) in progress
  • High resolution ($K^-,K^+$) spectroscopy on $\Xi$–hypernuclei (E05)
  • Search for H dibaryon (E42)
  • X-ray spectroscopy of $\Xi$-atom (E03)

• $\Sigma p$ scattering (E40)

• $K^-$pp and $K^{\text{bar}}N$ interaction
  • $\Lambda(1405)$ (E31) in progress
  • X-ray spectroscopy of $K$-d atom (E62) and $K^{-3/4}$He atoms (E57)

• $\gamma$-ray spectroscopy of $\Lambda$ hypernuclei (E63)
  • spin-dependent $\Lambda N$ interaction
  • effects of $\Lambda N-\Sigma N$ 3-body force
  • magnetic moment of $\Lambda$ in nuclear medium

K1.8
K1.8
K1.8BR
K1.1
Charge Symmetry Breaking in $\Lambda N$ interaction from $\gamma$-ray spectroscopy (E13)

- Large CSB of $1^+ - 0^+$ level spacing
- spin-dependent CSB
  - $1^+$: very small
  - $0^+$: large
- effect of $\Sigma N - \Lambda N$ mixing?

Editors’ suggestion
Construction of Radiation Shield in the Hall


Jan. 2017

South Floor of Hadron Exp. Hall
May 2017, Beam Dump (Iron Part) Completed
ELPH
1.3 GeV Booster Storage Ring, "Source of γ rays"
• Tagged bremsstrahlung γ-rays from internal target wires.
• Two γ-ray beam lines available.
• Maximum stored beam current ~ 40 mA.

[What’s new]
A spectrometer for “forwards scattered” charged particle was installed in the GeV-γ experimental hall.
${}^{113}\text{Nh (RIKEN)}$
2017 March 14th
Naming Celebration Party
@東京国立博物館平成館
Naming Ceremony, March 14, 2017 on the presence of Crown Prince of Japan
Cancer Treatment by Heavy-Ion/Proton Accelerators in Japan
One of big issues from NUMATRON

Heavy-Ion Medicine
## Particle Beam Cancer Treatment Center in Japan

http://www.antm.or.jp/05_treatment/04.html

<table>
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235MeV proton Cyclotron
(Diameter: 5m, Weight: 220t)
Cancer Treatment System with 235 MeV Proton Cyclotron

Sapporo Teishinkai Hospital

- Succeeded in reducing the installation area by arranging the accelerator, beam line, and rotating gantry vertically.
- 3km from Sapporo JR station and 5min walk from subway station.
Simple Proton Synchrotron (250MeV)
Medical Heavy-Ion Accelerator System
(Gunma Univ. Hospital)