The 5th International Conference on
"COLLECTIVE MOTION IN NUCLEI
UNDER EXTREME CONDITIONS"
September 14-18, 2015  Kraków, Poland

Organized by
RJ Tomaszewski and co-organized by
Input: [Text from the image]

International Advisory Committee
[Names and affiliations]

Invited Speakers
[Names and affiliations]

Local Organizing Committee
[Names and affiliations]

Honorary Organizing Committee
[Names and affiliations]
The COMEX conferences are a continuation of the long series of topical conferences on giant resonances started in 1979. The scope of COMEX5 will be similar to that of the previous ones:

COMEX1, held in Paris (France) in 2003,
COMEX2, held in Sankt Goar (Germany) in 2006,
COMEX3, held at Mission Point Resort on Mackinac Island, Michigan (US) in 2009
and COMEX4, held at Shonan Village Center, in Kanagawa (Japan) in 2012

The main topics of COMEX5 conference are:
• Giant resonances in cold and hot nuclei,
• Collective and new excitation modes in nuclei,
• Spin and isospin modes,
• Multi-phonon excitations, clustering and pairing effects in excitations,
• Studies of the decay of highly excited states,
• Applications in astrophysics,
• Novel instrumentation and novel methods,
• New facilities.
Giant Resonances, PDR, Multiphonons
Huge added value of High resolution and Polarized beams

A.Tamii et al (RCNP Osaka) PRL (2011)107,062502

**El Response of $^{208}$Pb and $\alpha_D$**

- **Isotope dependence on Sn and Zr have been measured precisely by proton inelastic scattering.**
Constraints on $J$ and $L$ by the $^{208}$Pb Dipole Polarizability

A. Tamii et al., PRL 107 (2011) 062502

A. Tamii et al., EPJA50, 28 (2014)
The splitting of the PDR region becomes even more evident with integration of the strength into two regions, 5–7 and 7–9 MeV.

IS nature of the PDR due to outermost nucleons, neutron skin. The $r_{np}$ is correlated with J and L. Interesting to study the properties of the neutron skin.

More experimental information's on Transitions densities, Decay pattern, branching ratio with NRF.

Transition region from bound to unbound ELI-NP!!
CAGRA+GR Campaign Exp. in 2016

- Study on PDRs by \((p, p'\gamma)\) and \((\alpha,\alpha'\gamma)\)*1 isospin/surface property, transition density ang. dep.
- \((^6\text{Li}, ^6\text{Li}'\gamma)\) for IV spin-flip inelastic ex.*2

CAGRA (Clover Ge Array)
for \(\gamma\)-coincidence measurements
also plans for \(\text{LaBr}_3\) detectors

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*1 A. Bracco, F. Crespi, V. Derya, M.N. Harakeh, T. Hashimoto, C. Iwamoto, P. von Neumann-Cosel, N. Pietralla, D. Savran, A. Tamii, and A. Zilges et al.
*2 S. Noji, R.G.T. Zegers et al.,
Relativistic Virtual photon scattering (GSI-RIKEN)

Extension to unstable “exotic” n-rich nuclei

high selectivity for dipole E1 excitation

 LAND-R3B -AGATA at GSI

BIG RIPS-DALI2 @ RIKEN

Inverse Energy-Weighted Dipole Strength and Dipole Polarizability in $^{68}$Ni

AGATA+LaBr3:Ce

GSI

400 MeV/u $^{64}$Fe + $^{208}$Pb (October 2012)

430 MeV/u $^{62,64}$Fe + $^{197}$Au (April 2014)

Riken

DALI2+LaBr3:Ce

280 MeV/u $^{70}$Ni + $^{197}$Au (October 2014)

280 MeV/u $^{72}$Ni + $^{197}$Au (future)

...
Low momentum collective modes: hadronic scattering
Experiments in storage rings and with active targets -

Experimental storage ring at GSI
Luminosity: $10^{26} - 10^{27}$ cm$^{-2}$s$^{-1}$

**INES Kinematics**
Stable and unstable beams

MAYA active target
And
New generation ACTAR
Monopole mode in $^{58}\text{Ni}$ and $^{56}\text{Ni}$: ring vs. active target

Innovative experimental methods and tools
Gamow-Teller Giant Resonance

GT operator: \( \sigma t^\pm (\sigma \tau^\pm) \)

Spin: up \( \leftrightarrow \) down
Isospin: p \( \leftrightarrow \) n

Purely quantum mechanical oscillation.

\[ \omega = \sqrt{\frac{k}{m}} \]

Isovector charge-exchange modes
Comparison of $(p, n)$ and $(^3\text{He}, t)$ $0^\circ$ spectra

**$^{58}\text{Ni}(p, n)^{58}\text{Cu}$**

$E_p = 160 \text{ MeV}$  

J. Rapaport et al.  
NPA (‘83)

**$^{58}\text{Ni}(^3\text{He}, t)^{58}\text{Cu}$**

$E = 140 \text{ MeV/u}$  

Y. Fujita et al.,  
EPJ A 13 (‘02) 411.  
H. Fujita et al.,  
PRC 75 (‘07) 034310

Key: Resolution!
GT states in $A=42-54$, $T_z=0$ nuclei

Collective excitation formed by the attractive IS residual interaction

Y. Fujita et al.
PRL 2014
PRC 2015

T. Adachi et al.
PRC 2006

Y. Fujita et al.
PRL 2005

T. Adachi et al.
PRC 2012

Collective excitation formed by the repulsive residual interaction

Peak heights are proportional to B(GT) values
Spin-isospin responses in unstable nuclei via the $(p,n)$ reaction

$^{132}\text{Sn}$ performed @RIBF SAMURAI, April 2014

Rapidly expanding the spin isospin giant resonance studies

$^{12}\text{Be}, ^{8}\text{He}$ (SHARAQ), $^{11}\text{Li}, ^{14}\text{Be}$ (SAMURAI), $^{16}\text{C}(p,n)$ (S800)

N=Z=28

S800@NSCL
The position of GR described form first principles for the first time

V. Nazarewicz, S. Bacca

Challenge: develop new ab-initio methods that can extend the frontiers to heavier nuclei

S.B. et al., PRL 111, 122502 (2013)
S.B. et al., PRC 90, 064619 (2014)
Nuclear Theory from evolution to revolution

Fusion cross sections from TDDFT
R. Keser et al., PRC 85, 044606 (2012)

Nuclear states and Clusters

\[ \alpha = \frac{b}{r_0} \]

\[ 48^{\text{Ca}} + 48^{\text{Ca}} \]

Experiment
\[ E_{\text{c.m.}} = 55 \text{ MeV}, \text{TDDFT} \]

\[ E_{\text{c.m.}} = 55 \text{ MeV}, \text{TDDFT} \]

\[ \text{Fusion cross sections from TDDFT} \]

\[ \text{R. Keser et al., PRC 85, 044606 (2012)} \]
Fully microscopic calculations beyond mean field studies are now available – No free parameters!!

Skyrme RPA+PVC
Y. Niu et al., PRL 114, 142501 (2015).
Y. Niu et al., PRC 90, 054328 (2014).

Skyrme TBA
N. Lyutorovich et al., PLB 749, 292 (2015)

Covariant TBA
E. Litvinova et al.

Fig. 1. Total dipole photoabsorption cross section in stable medium-mass nuclei

IV Dipole (above)
GTR, SDR, β-decay (below)
The origin of elements

Possible sites for the r-process

Balantekin et al., arXiv:1401.6435 [nucl-th]
<table>
<thead>
<tr>
<th>Source</th>
<th>Percentage Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diffusion coefficient of SSM</td>
<td>2.7%</td>
</tr>
<tr>
<td>Nuclear rates [mainly $^7\text{Be}(p,\gamma)^8\text{B}$ and $^{14}\text{N}(p,\gamma)^{15}\text{O}$]</td>
<td>9.9%</td>
</tr>
<tr>
<td>Neutrinos and weak interaction (mainly $\theta_{12}$)</td>
<td>3.2%</td>
</tr>
<tr>
<td>Other SSM input parameters</td>
<td>0.6%</td>
</tr>
</tbody>
</table>

Nuclear reactions and astrophysics

![Graphs and formulas](image)
Constraining \((n,\gamma)\) reaction cross sections for astrophysical applications

A. Spyrou, MSU

- New technique for constraining \((n,\gamma)\) reaction rates on unstable nuclei.
- Current neutron-capture rate uncertainty in many cases is more than a factor of 100.
- Technique uses \(\beta\) decay to populate the same nucleus as an \((n,\gamma)\) reaction and determine its level density and \(\gamma\)-strength function. \((n,\gamma)\) cross section is calculated using these measured quantities.
- Uncertainty of extracted \((n,\gamma)\) reaction rates is ~ factor of 2-3. Makes measurements on relevant short-lived nuclei possible.

The Summing NaI (SuN) detector at NSCL.

A. Spyrou et al., PRL 113, 232502 (2014)
Special properties of ELI-NP photon beam for NRF:

- very high intensity
  - \(10^4\) photons/(s·eV)
- narrow bandwidth
  - (down to 0.5%)
- high degree of polarization (> 99%)
- small beam diameter
  - (mm range)
- low duty factor (100 Hz)
Physics case:

- **Nuclear structure** – clustering in light nuclei: $^{12}\text{C}$, $^{16}\text{O}$;
- **Nuclear astrophysics**: $^{16}\text{O}(\gamma,\alpha)^{12}\text{C}$, $^{22}\text{Ne}(\gamma,\alpha)^{18}\text{O}$, $^{19}\text{F}(\gamma,p)^{18}\text{O}$, $^{24}\text{Mg}(\gamma,\alpha)^{20}\text{Ne}$, the $p$-process (with the high energy $\gamma$ beam in E8 experimental hall);
- **International collaboration**: Italy (INFN-LNS), Poland (Univ. Warsaw), USA (U. Chicago, U. Yale, U. Conn), Romania
Amazing Development of innovative instruments!!

Sydney Gales, Comex5, Sept 13-18, Krakow
Liquid hydrogen target vs 1-cm Be target: luminosity $\times 5$
The ISOLDE facility

Jyvaskyla

KVI

GSI

GANIL-SP1

Ensar

ALTO

Ganil

INFN LNS & LNL and SPES RIB

+ HE – ISOLDE is starting

TNA EU Facilities

+ ESFRI Facilities

National Laboratory of Cyclotrons in Poland

Heavy Ion Laboratory University of Warsaw

Cyclotron Center Bronowice at the Institute of Nuclear Physics

Isochronous cyclotron K=160

Cyclotron PROTEUS C-235
The frontiers of nuclear science today require new tools, technologies, and accelerators. The quest is to understand the origin, evolution, and structure of the visible matter in the universe. Photons, Stable and Radioactive Ion Beams are central to this quest worldwide.

(associated to impressive innovation in instrumentation)

Backed by a strong development in nuclear theory
Thanks to all contributors to this outlook talk

Dziękujemy za cierpliwość

See you in 2018 at COMEX6 - Capetown

Sydney Gales, Comex5, Sept 14-18, Krakow
END