

ExtreMe Matter Institute EMMI



www.gsi.de/emmi



EMMI

- founded in 2008 in framework of Helmholtz Alliance (2008 - 2015)
Cosmic Matter in the Laboratory



Alliance on Cosmic Matter
in the Laboratory

- since 2016 continued as part of GSI:
taking the momentum of the alliance into the future

EMMI Partner Institutions

- GSI Helmholtz Centre for Heavy Ion Research
- Forschungszentrum Jülich
- Technische Universität Darmstadt
- Goethe-Universität Frankfurt
- Ruprecht-Karls-Universität Heidelberg
- Universität Münster
- Max-Planck-Institut für Kernphysik (MPIK), Heidelberg
- FIAS Frankfurt Institute for Advanced Studies
- Université VI (Pierre et Marie Curie), Paris
- Lawrence Berkeley National Laboratory, Berkeley
- Joint Institute for Nuclear Astrophysics (JINA)
- University of Tokyo
- RIKEN, Saitama



... and its Partners



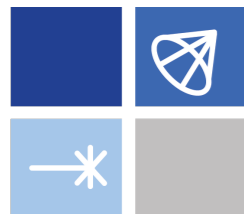
WESTFÄLISCHE
WILHELMS-UNIVERSITÄT
MÜNSTER



TECHNISCHE
UNIVERSITÄT
DARMSTADT



BERKELEY LAB
Lawrence Berkeley National Laboratory



JINA-CEE



東京大学
THE UNIVERSITY OF TOKYO



UPMC
SORBONNE UNIVERSITÉS



UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386



MAX-PLANCK-INSTITUT
FÜR KERNPHYSIK



FIAS Frankfurt Institute
for Advanced Studies



HGSFP



HGS-HIRe for FAIR
Helmholtz Graduate School for Hadron and Ion Research



Organisation

13 Partner Institutions

Management:

Scientific Director: Peter Braun-Munzinger

Scientific Coordinator: Carlo Ewerz

+ administrative support

31 further experts as **Associated Partners**

Steering Committee (representatives of Partners)

as main steering body

Scientific Advisory Committee (9 external experts)

Budget

During Alliance funding period:

18.745 MEuro for 6 years or

3.12 MEuro per year

matched by the partner institutions with

63.111 MEuro in 6 years

Since 2016 as department of GSI

(without partner institutions):

500 kEuro per year

Main Research Areas of EMMI

Matter under extreme conditions of temperature, density and pressure, in particular

- quark-gluon plasma, phase diagram of strongly interacting matter, and hadron physics
- structure and dynamics of neutron-rich systems from the laboratory to the stars
- plasma physics
- atomic physics and ultracold gases

... and related topics

Aim:

bringing together the best minds from these communities

Emergence of common concepts

Common underlying theoretical concepts for strongly coupled systems, and systems requiring combination of different theoretical methods

- BEC and BCS
- QGP and ultracold Fermi gases
- holographic duality relating QCD to black holes
- multi-messenger astronomy: neutron star mergers, kilonovas, ...
- hydrodynamics, turbulence, ...
- ...

Goals

central goal of EMMI:

act as think tank & provide intellectual environment
for extreme matter research (at GSI and beyond)

aiming at:

- interdisciplinary scientific events of highest quality
- strong promotion of early-career researchers
- network among two Helmholtz centres and eleven top national and international laboratories and universities

EMMI Scientists

- more than 100 senior researchers participating in EMMI, more than 400 scientists in total
- 14 new positions (professorships / tenured) created by partners:
 - 10 at TUD, F, MPI-K, MS, HD, LBNL
 - 4 EMMI Fellow positions at GSI
- EMMI PhD students associated with surrounding graduate schools (HGS-HIRe, HGSFP)

Decoding the phase structure of QCD via particle production at high energy

Anton Andronic^{1,2}, Peter Braun-Munzinger^{1,3,4*}, Krzysztof Redlich^{1,5} & Johanna Stachel³



Vol 466 | 8 July 2010 | doi:10.1038/nature09250

nature

LETTERS

The size of the proton

Randolf Pohl¹, Aldo Antognini¹, François Nez², Fernando D. Amaro³, François Biraben², João M. R. Cardoso³, Daniel S. Covita^{3,4}, Andreas Dax⁵, Satish Dhawan⁵, Luis M. P. Fernandes³, Adolf Giesen^{6†}, Thomas Graf⁶, Theodor W. Hänsch¹, Paul Indelicato², Lucile Julien², Cheng-Yang Kao⁷, Paul Knowles⁸, Eric-Olivier Le Bigot², Yi-Wei Liu⁷, José A. M. Lopes³, Livia Ludhova⁸, Cristina M. B. Monteiro³, Françoise Mulhauser^{8†}, Tobias Nebel¹, Paul Rabinowitz⁹, Joaquim M. F. dos Santos³, Lukas A. Schaller⁸, Karsten Schuhmann¹⁰, Catherine Schwob², David Taqq¹¹, João F. C. A. Veloso⁴ & Franz Kottmann¹²

LETTER

doi:10.1038/nature12226

Masses of exotic calcium isotopes pin down nuclear forces

F. Wienholtz¹, D. Beck², K. Blaum³, Ch. Borgmann³, M. Breitenfeldt⁴, R. B. Cakirli^{3,5}, S. George¹, F. Herfurth², J. D. Holt^{6,7}, M. Kowalska⁸, S. Kreim^{3,8}, D. Lunney⁹, V. Manea⁹, J. Menéndez^{6,7}, D. Neidherr², M. Rosenbusch¹, L. Schweikhard¹, A. Schwenk^{7,6}, J. Simonis^{6,7}, J. Stanja¹⁰, R. N. Wolf¹ & K. Zuber¹⁰

Radio-Frequency Association of Efimov Trimers

Thomas Lompe,^{1,2,3*} Timo B. Ottenstein,^{1,2,3} Friedhelm Serwane,^{1,2,3} Andre N. Wenz,^{1,2} Gerhard Zürn,^{1,2} Selim Jochim^{1,2,3}

The quantum mechanical three-body problem is one of the fundamental challenges of few-body physics. When the two-body interactions become resonant, an infinite series of universal three-body bound states is predicted to occur, whose properties are determined by the strength of the two-body interactions. We used radio-frequency fields to associate Efimov trimers consisting of three distinguishable fermions. The measurements of their binding energy are consistent with theoretical predictions that include nonuniversal corrections.

Under certain conditions, the long-range behavior of a physical system can be described without detailed knowledge of its short-range properties; few-body systems with resonant interactions are a prime example of this concept of universality (*1*). Ultracold gases, where

resonant scattering may be achieved by tuning the interactions with the use of Feshbach resonances (*2*), have been used extensively to test the predictions of universal theory.

If the parameter describing the interactions, the s-wave scattering length a , is much larger than the characteristic length scale r_0 of the interaction potential, the few-body physics in such ultracold gases is predicted to become universal. For two particles with a large positive scattering

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*To whom correspondence should be addressed. E-mail: thomas.lompe@mpi-hd.mpg.de

LETTER

High-precision measurement of the atomic mass of the electron

S. Sturm¹, F. Köhler^{1,2}, J. Zatorski¹, A. Wagner¹, Z. Harman^{1,3}, G. Werth⁴, W. Quint², C. H. Keitel¹ & K. Blaum¹

EMMI Programs

- EMMI Workshops
- EMMI Programs
- EMMI Rapid Reaction Task Force meetings (RRTFs)
- joint workshops with ECT* Trento



- Visiting Professor program
- Visiting Researcher program

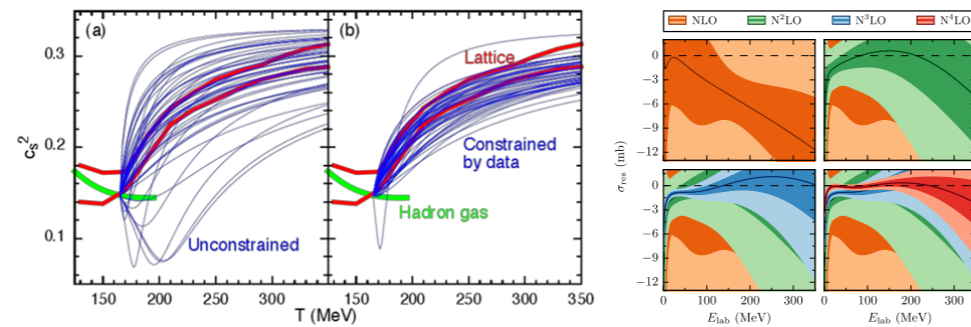
Interdisciplinary Events: examples

ExtreMe Matter Institute EMMI

EMMI Workshop

Uncertainty Quantification at the Extremes (ISNET-6)

GSI, Darmstadt, Germany
October 8-12, 2018



Goals

- Facilitate cross communication, fertilization, and collaboration on statistical applications among the nuclear sub-fields
- Provide the opportunity for nuclear physicists unfamiliar with Bayesian methods to start applying them to new problems
- Learn from experts about innovative and advanced uses of Bayesian statistics, and best practices in applying them
- Learn about advanced computational tools and methods
- Critically examine the application of Bayesian and frequentist methods to particular physics problems in the subfields

Information

www.gsi.de/emmi/workshops

Organizers

Dick Furnstahl, Ohio State U.
David Ireland, U. Glasgow
Daniel Phillips, Ohio U.
Ian Vernon, Durham U.

More about EMMI

www.gsi.de/emmi

ExtreMe Matter Institute EMMI

EMMI Workshop

Functional Methods in Strongly Correlated Systems

Darmstädter Haus, Hirschegg, Austria
March 31 - April 6, 2019



Speakers:

Laura Classen (Brookhaven National Lab & University of Minnesota)
Sebastian Diehl (University of Cologne)
Joaquin Drut (UNC Chapel Hill)
Nicolas Dupuis (Université Pierre et Marie Curie)
Stefan Flörchinger (Heidelberg University)
Kenji Fukushima (Tokyo University)
Daniel Litim (University of Sussex)
Hans-Werner Hammer (TU Darmstadt)
Urko Reinosa (CPHT, Ecole Polytechnique)
Fabian Rennecke (Brookhaven National Lab)
Michael Scherer (University of Cologne)
Malo Tarpin (Université Grenoble Alpes & Heidelberg University)
Ralf-Arno Tripolt (Goethe University Frankfurt)
Corbinian Wellenhofer (TU Darmstadt)
Nicolas Wink (Heidelberg University)

Information:

www.gsi.de/emmi/workshops

Organizers:

Jens Braun
Michael Buballa
Stefan Flörchinger
Jan M. Pawłowski
Dirk H. Rischke
Bernd-Jochen Schaefer
Lorenz von Smekal

Registration Deadline:

February 28th, 2019

More about EMMI:

www.gsi.de/emmi



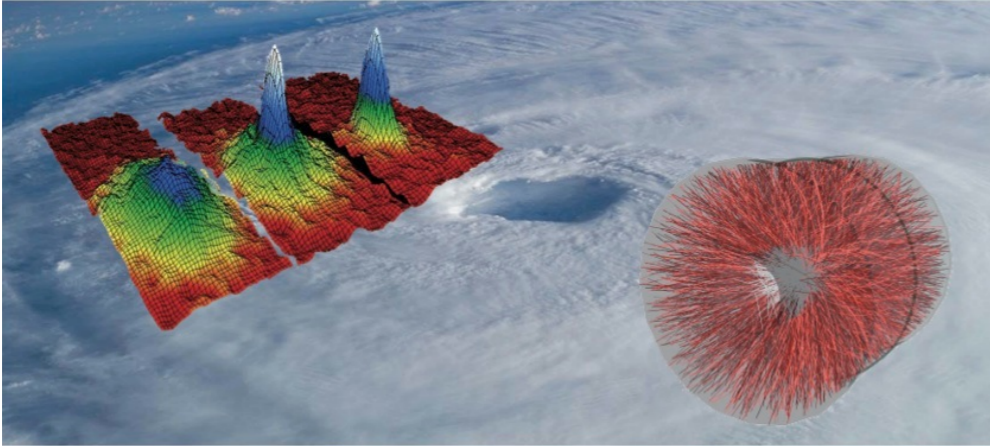
Interdisciplinary Events: examples

Helmholtz Alliance
Extremes of Density and Temperature: Cosmic Matter in the Laboratory

ExtreMe Matter Institute EMMI

Quark-Gluon Plasma meets Cold Atoms - Episode III

Workshop at Waldemar-Petersen-Haus
Hirschegg, Austria
August 25 - 31, 2012



Lecturers
Jens Braun, TU Darmstadt
Peter Braun-Munzinger, EMMI, GSI
Kenji Fukushima, Keio University
Thomas Gasenzer, Heidelberg University
Larry McLerran, Brookhaven National Lab
Thomas Schäfer, North Carolina State University
Florian Schreck, Innsbruck University & IQOQI
Achim Schwenk, EMMI, TU Darmstadt
Lorenz von Smekal, TU Darmstadt
Johanna Stachel, Heidelberg University
Michael Thies, Erlangen University
John Thomas, North Carolina State University

Organizers
Michael Buballa
Selim Jochim
Jan M. Pawłowski
Dirk Rischke

Registration deadline
July 15th, 2012

Registration and further information
<http://www-aix.gsi.de/conferences/emmi/QGPmCA2012>

More about EMMI
www.gsi.de/emmi

ExtreMe Matter Institute EMMI

EMMI Workshop

Interdisciplinary Workshop on Supersolidity

September 20-22, 2021

Aula Silvestri - Economics and Management Department of the University of Trento, via Antonio Rosmini 44

Scientific Organizers:
Francesca Ferlaino (University of Innsbruck; IQOQI Innsbruck)
Alessio Recati (INO-CNR, Trento)
Sandro Stringari (University of Trento)

Logistics and Local Organization:
Monica Cosi (University of Trento)
Silvia Bonazza (University of Innsbruck)
Communication and Event Office,
Polo Collina (University of Trento)

Following recent advances in the field, we are organizing an Interdisciplinary Workshop on Supersolidity. The workshop will explore, in an interdisciplinary fashion, various aspects of supersolidity, focusing on different mechanisms and experimental platforms. The latter include dipolar and spin-orbit-coupled quantum gases, Rydberg atoms, light-induced dipoles, as well as solid Helium and nuclear systems.

Speakers:
Blair Blakie (ONLINE)
Jordi Boronat
Fabio Cinti
Tilman Esslinger
Randy Hulet (ONLINE)
Massimo Mannarelli
Giovanni Modugno
Matthew Norcia
Christopher Pethick (ONLINE)
Tilman Pfau
Thomas Pohl
Nikolay Prokof'ev (ONLINE)
Guido Pupillo
Alessio Recati
Carlos Sa de Melo (ONLINE)
Luis Santos
Gora Shlyapnikov
Giancarlo Strinati
Sandro Stringari
Leticia Tarruell
Michael Urban
Martin Zwierlein




image: ©AG_Ferlaino_Group

Information:
www.gsi.de/emmi/workshop

www.erbium.at/workshopTN
supersolid.physics@unitn.it

More about EMMI:
www.gsi.de/emmi



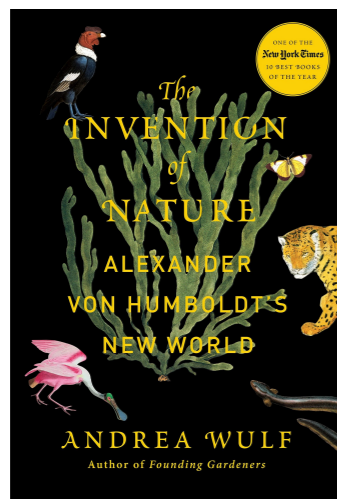
EMMI RRTFs

- concentrate on focussed problem in intense discussion
- 15 - 25 expert participants
- aim: summary of results, optimally with publication on arXiv and/or in journal

EMMI RRTFs

RRTF concept goes back to **Alexander von Humboldt**:

*Humboldt was revolutionizing the sciences. In September 1828 he invited hundreds of scientists from across Germany and Europe to attend a conference in Berlin. Unlike previous such meetings at which scientists had endlessly presented papers about their own work, Humboldt put together a very different program. **Rather than being talked at, he wanted the scientists to talk with each other.** [...] ‘Without a diversity of opinion, the discovery of truth is impossible’, he reminded them in his opening speech.*



in Andrea Wulf, *The Invention of Nature*, 2016

EMMI RRTFs: examples

- Thermalization in a Nonabelian Plasma (2011)
- Quark Matter in Compact Stars (2013)
- Direct-Photon Flow Puzzle (2014)
- Non-Exponential Two-Body Weak Decays (2014)
- Resonances in QCD (2015)
- Extraction of heavy-flavor transport coefficients in QCD Matter (2016)
- The physics of neutron star mergers (2018)
- Electromagnetic Structure of Strange Baryons (2018)
- Direct reactions and nuclear structure (2018)
- Space-time structure of jet quenching: theory and experiment (2019)
- Real and virtual photon production at ultra-low transverse momentum and low mass at LHC (2022)

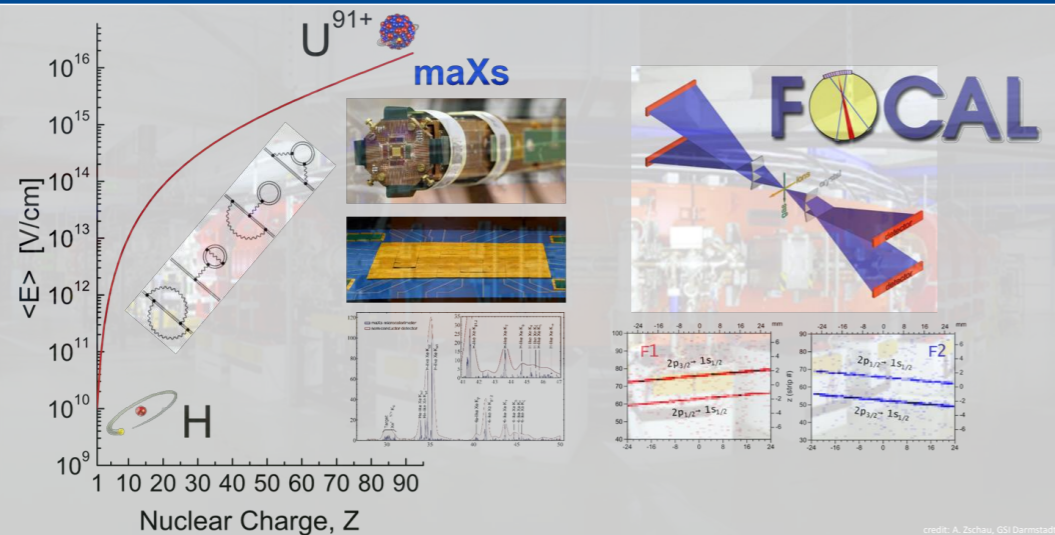
Recent RRTFs

ExtreMe Matter Institute EMMI

EMMI Rapid Reaction Task Force

1s Lamb shift in heavy H-like ions: towards an accuracy of <1 eV

Rosensäle, Jena, Germany
September 17-19, 2018



Topics

- High-resolution X-ray microcalorimeters and crystal spectrometers
- Precision X-ray spectroscopy of stored and cooled heavy highly-charged ions
- Bound-state QED

Information

www.gsi.de/emmi/rrtf

Organizers

Alexandre Gumberidze (GSI, U Frankfurt)
Yuri Litvinov (GSI, U Heidelberg)
Günter Weber (HI Jena)
Thomas Stöhlker (HI Jena, GSI, U Jena)

More about EMMI

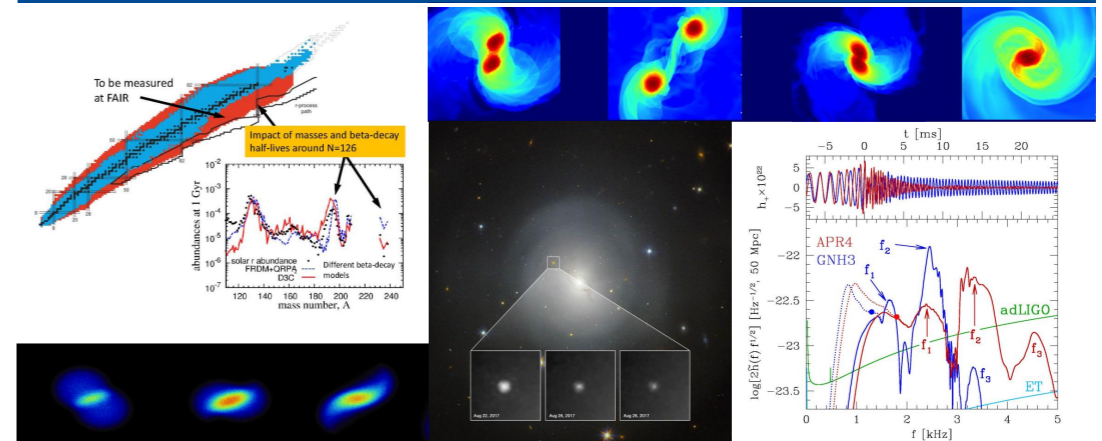
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ExtreMe Matter Institute EMMI

EMMI Rapid Reaction Task Force

The physics of neutron star mergers at GSI/FAIR

GSI, Darmstadt, Germany
June 3 -15, 2018



Topics

Dense matter equation of state
Gravitational wave observations
R-process nucleosynthesis
Astrophysical simulations of mergers
Electromagnetic signatures of the r-process

Information

www.gsi.de/emmi/rrtf

Organizers

Gabriel Martinez Pinedo (GSI & TU Darmstadt)
Tetyana Galatyuk (TU Darmstadt & GSI)
César Domingo Pardo (IFIC)
Brian Metzger (Columbia University)
Luciano Rezzolla (U Frankfurt)
Samaya Nissanke (Radboud University)

More about EMMI

www.gsi.de/emmi

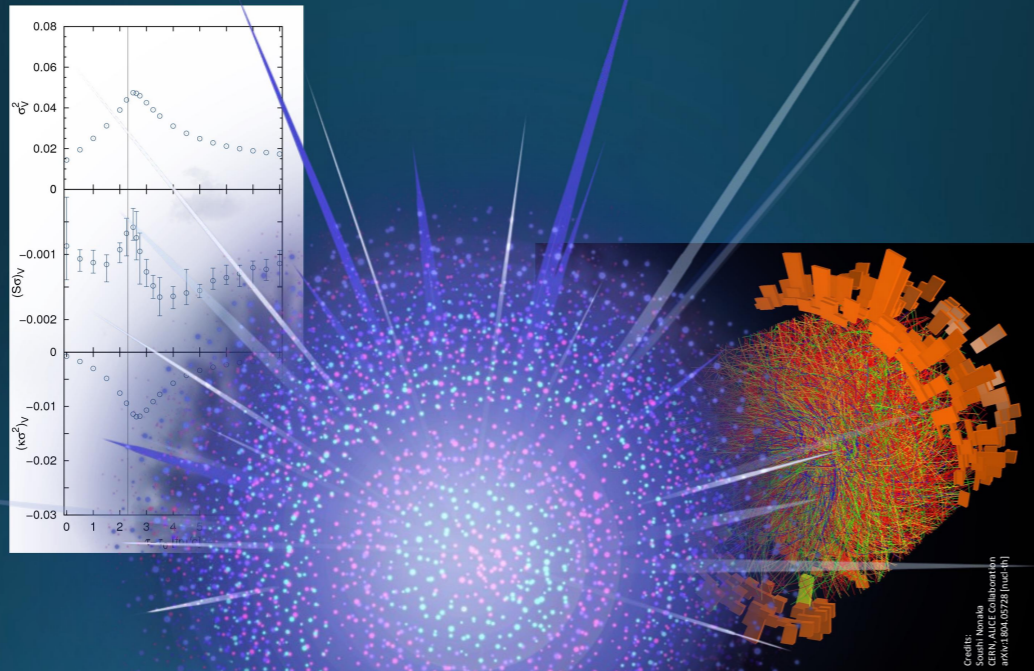
Recent RRTFs

ExtreMe Matter Institute EMMI

EMMI RRTF

Dynamics of critical fluctuations: theory – phenomenology – heavy-ion collisions

GSI, Darmstadt, Germany
April 8-12, 2019



Topics:

- dynamical modelling of critical fluctuations in QCD
- coupling of the critical dynamics to the bulk evolution in HIC
- proper treatment of the order parameter(s) in and out of the scaling region
- experimental observables and challenges
- connection with cold atomic gases at phase transitions

Organizers:

Marcus Bluhm, Subatech
Alexander Kalweit, CERN
Marlene Nahrgang, Subatech

Information:

www.gsi.de/emmi/workshops

More about EMMI:

www.gsi.de/emmi

ExtreMe Matter Institute EMMI

EMMI Rapid Reaction Task Force

Nuclear Physics Confronts Relativistic Collisions of Isobars

Heidelberg University, Germany, May 30 – June 3 & October 12 – 14, 2022

High-energy collisions of the A=96 isobars ^{96}Zr and ^{96}Ru have been performed in 2018 at the Relativistic Heavy Ion Collider (RHIC) as a means to probe effects of local parity violation in the strong sector, that would manifest as deviations from unity in the ratio of observables taken between $^{96}\text{Zr}+^{96}\text{Zr}$ and $^{96}\text{Ru}+^{96}\text{Ru}$ collisions. Recently released measurements of such ratios reveal deviations from unity. However, such observations are primarily caused by the two collided isobars having different radial profiles and intrinsic deformations. To make progress in understanding RHIC data, we will gather nuclear physicists across the energy spectrum to answer the following question: Does the combined effort of state-of-the-art low-energy nuclear structure physics and high-energy heavy-ion physics allow us to understand the observations made in isobar collisions at RHIC?

Heavy Ion Collisions:

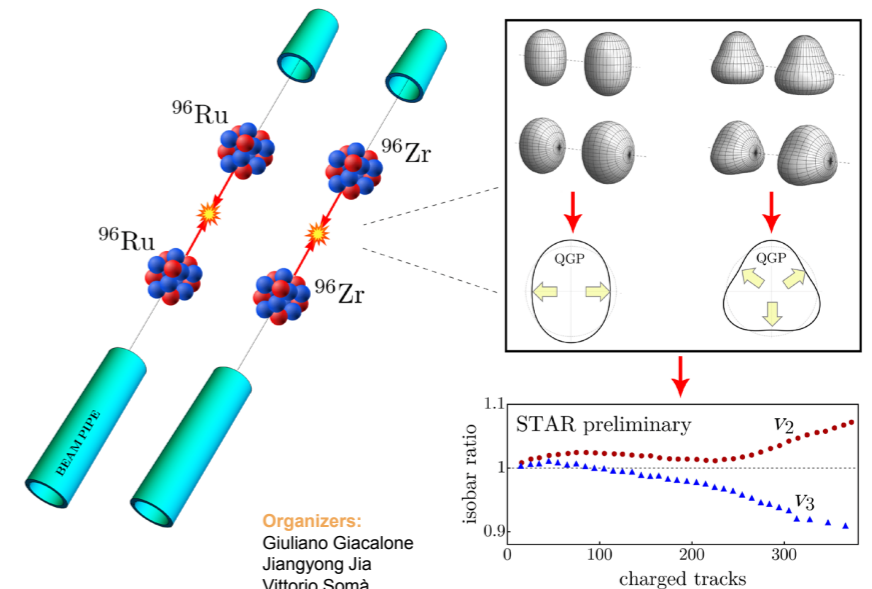
Federica Capellino
Hannah Elfner
Frédérique Grassi
Eduardo Grossi
Jan Hammelmann
Andreas Kirchner
Matthew Luzum
Jaki Noronha-Hostler
Jean-Yves Ollitrault
Niels Saß
Björn Schenke
Chun Shen
Huichao Song
Derek Teaney
Wilke van der Schee

Nuclear Structure:

Anatoli Afanasjev
Benjamin Bally
Jean-Paul Ebran
Dean Lee
Tamara Nikšić
Takaharu Otsuka
Luis Robledo
Tomas Rodriguez
Wouter Ryssens
Yusuke Tsunoda

Organizers:

Giuliano Giacalone
Jiangyong Jia
Vittorio Somà
You Zhou



Website:

<https://indico.gsi.de/event/14430/>

Information:

www.gsi.de/emmi/rtrf

More about EMMI:

www.gsi.de/emmi

Publication: from RRTF



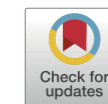
Contents lists available at [ScienceDirect](#)

Physics Letters B

www.elsevier.com/locate/physletb



New test of modulated electron capture decay of hydrogen-like ^{142}Pm ions: Precision measurement of purely exponential decay



F.C. Ozturk^{a,*}, B. Akkus^a, D. Atanasov^b, H. Beyer^c, F. Bosch¹, D. Boutin^{d,e}, C. Brandau^{c,f}, P. Bühler^g, R.B. Cakirli^a, R.J. Chen^{c,h}, W.D. Chen^{h,i}, X.C. Chen^{c,h}, I. Dillmann^j, C. Dimopoulou^c, W. Enders^c, H.G. Essel^c, T. Faestermann^k, O. Forstner^l, B.S. Gao^{c,h}, H. Geissel^c, R. Gernhäuser^k, R.E. Grisenti^{c,m}, A. Gumberidze^c, S. Hagmann^{c,m}, T. Heftrich^m, M. Heil^c, M.O. Herdrich^l, P.-M. Hillenbrand^c, T. Izumikawaⁿ, P. Kienle¹, C. Kraushofer^g, C. Kleffner^c, C. Kozhuharov^c, R.K. Knöbel^{c,d}, O. Kovalenko^c, S. Kreim^b, T. Kühl^c, C. Lederer-Woods^o, M. Lestinsky^c, S.A. Litvinov^c, Yu.A. Litvinov^{c,*}, Z. Liu^h, X.W. Ma^h, L. Maier^k, B. Mei^m, H. Miura^p, I. Mukha^c, A. Najafi^k, D. Nagae^q, T. Nishimura^p, C. Nociforo^c, F. Nolden^c, T. Ohtsubo^r, Y. Oktem^a, S. Omika^p, A. Ozawa^q, N. Petridis^c, J. Piotrowski^s, R. Reifarth^m, J. Rossbach^c, R. Sánchez^c, M.S. Sanjari^c, C. Scheidenberger^c, R.S. Sidhu^c, H. Simon^c, U. Spillmann^c, M. Steck^c, Th. Stöhlker^{c,l,t}, B.H. Sun^u, L.A. Susam^a, F. Suzuki^{p,v}, T. Suzuki^p, S.Yu. Torilov^w, C. Trageser^{c,f}, M. Trassinelli^x, S. Trotsenko^{c,l}, X.L. Tu^{c,h}, P.M. Walker^y, M. Wang^h, G. Weber^{c,l}, H. Weick^c, N. Winckler^c, D.F.A. Winters^c, P.J. Woods^o, T. Yamaguchi^p, X.D. Xu^h, X.L. Yan^h, J.C. Yang^h, Y.J. Yuan^h, Y.H. Zhang^{h,z}, X.H. Zhou^h and the FRS-ESR, ILIMA, SPARC, and TBWD Collaborations

ExtreMe Matter Institute EMMI

Call for Proposals

EMMI Workshops, Programs, Rapid Reaction Task Forces

The ExtreMe Matter Institute EMMI invites proposals for workshops, programs, and Rapid Reaction Task Forces in the research areas of EMMI:

- quark gluon plasma, phase diagram of strongly interacting matter, and hadron physics
- structure and dynamics of neutron-rich systems
- electromagnetic plasmas of high energy density
- ultracold quantum gases and extreme states in atomic physics

all understood in a broad sense.

Further information at www.gsi.de/emmi

