UNIVERSITÄT BONN

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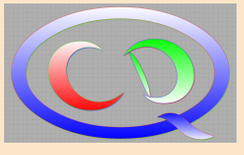
CENTER FOR SCIENCE & THOUGHT

JÜLICH Forschungszentrum

– The Sino-German CRC 110 –
Symmetries and the Emergence of Structure in QCD
–Genesis, Developments & Perspectives –



Ulf-G. Meißner, Univ. Bonn & FZ Jülich

Deutsche Forschungsgemeinschaft DFG

国家自然科学基金委员会
National Natural Science Foundation of China

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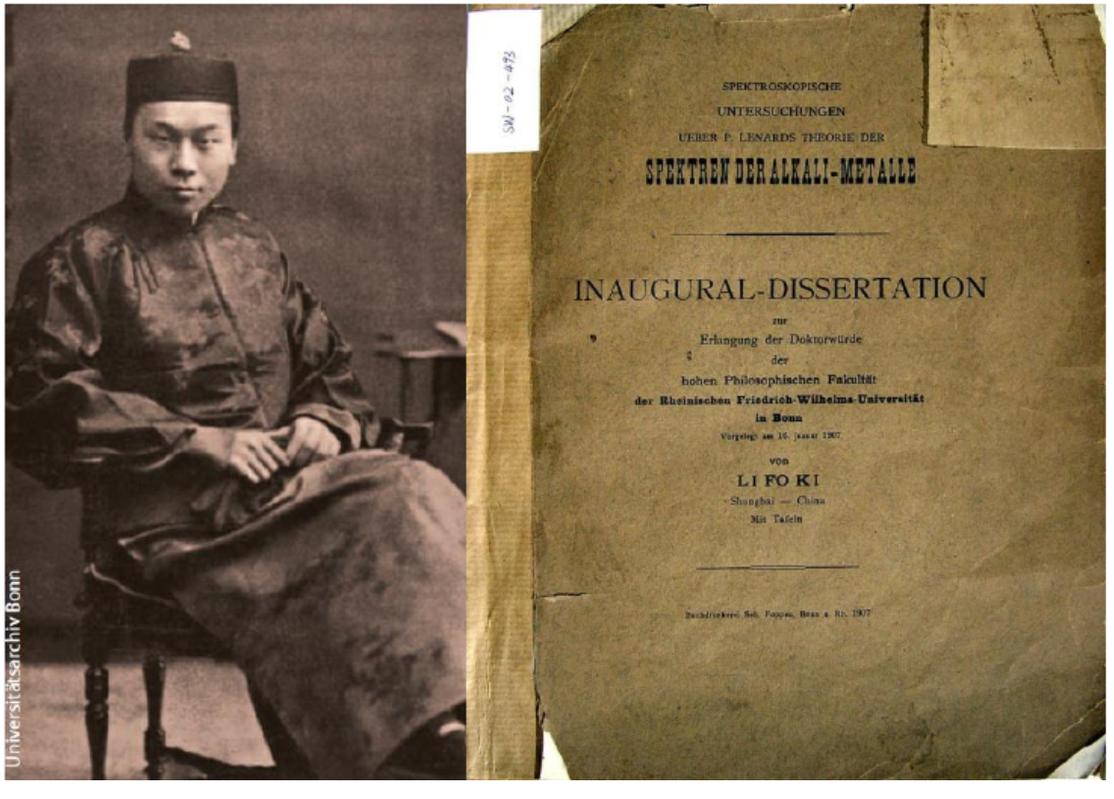
- Topics in the CRC 110
- Structural developments
- Status and achievements
- Perspectives

Genesis of the CRC 110

A bit of history

- Germany - an historically excellent place for fostering Chinese physicists

⋆ The first Chinese PhD in physics
Li Fo Ki, Univ. Bonn, 1907



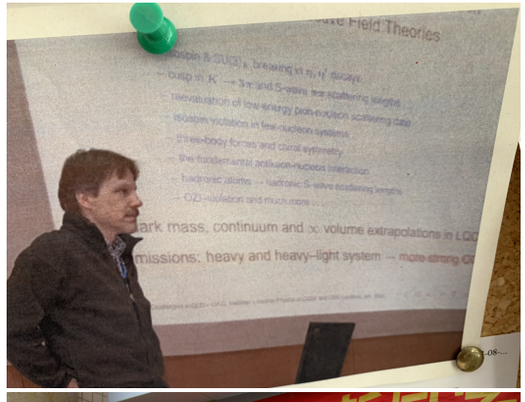
The first female Chinese Academician of physics
He Zehui, PhD TUB, 1940

First contacts with Chinese colleagues

- Sino-German Symposium “Hadron Physics at COSY & CSR”
  Institute of Modern Physics / CAS, Lanzhou, June 2006
  Summary talk (theory)

- Lectures on “Theory of Nuclear Forces”
  Guangxi Normal University, Guilin, September 2009

- 4th Internat’l Workshop on Charm Physics “CHARM2010”,
  Institute of High-Energy Physics, Beijing, October 2010
  plenary talk



$\Rightarrow$ China emerges as main player in basic sciences

$\Rightarrow$ tremendous talent pool (mostly US-oriented)

$\Rightarrow$ try to collaborate on a bigger scale

$\Rightarrow$ a golden window of opportunity opens

What is a Colloborative Research Center?

Collaborative Research Centres (CRCs) are institutions established at universities for a period of up to 12 years that enable researchers to pursue an outstanding research programme, crossing the boundaries of disciplines, institutes, departments and faculties. They facilitate scientifically ambitious, complex, long-term research by concentrating and coordinating the resources available at a/up to three university/ties. Universities submitting a proposal are expected to provide appropriate core support. The CRC programme should, thus, contribute towards defining the profiles of participating universities. Gender equality and early career support are additional goals of a Collaborative Research Centre.
Collaborative Research Centres may also incorporate projects at neighbouring universities or non-university research institutions and collaboration with industry and business within the research programme, provided they serve to further strengthen the core research area. In addition, CRCs maintain scientific relations with universities and other research institutions outside of Germany. **Co-funding for international CRCs is also possible.**

http://www.dfg.de/en/research_funding/programmes/coordinated_programmes/collaborative_research_centres/index.html [DFG website 2014]

The partners

- Setup simply driven by scientific excellence and complementarity
- requires one driver on both sides

Institute of High Energy Physics, CAS, Beijing

Peking University

Institute for Theoretical Physics, CAS [from 2nd FP]

Rheinische-Friedrich-Wilhelms-Universität Bonn

Technische Universität München

Forschungszentrum Jülich

Ruhr-Universität Bochum [from 2nd FP]

Institute of High-Energy Physics (IHEP)

- **Top institution in China for high-energy and hadron physics**

- hosts 3 big international experimental facilities
  - → **BEPC2 w/ BESIII collaboration**
  - → Daya Bay neutrino experiment
  - → Tibet cosmic ray observatory

- 7 research divisions with about 1200 researchers and about 600 postdocs & graduate students

  Accelerator Center, Experimental Physics Center, Theory Division, Particle-Astroparticle Center, Computing Center, Technology R&D Center, Multi-disciplinary Center

- Host of the 3 big international experimental facilities
  - → CSNS, HXMT, HEPS

Peking University

- **The first and top comprehensive university for humanities, natural & social sciences in China**

- 18 disciplines of PKU rank in the world top 1%
  $\rightarrow$ Mathematics, Physics, Chemistry, Materials Science, ...

- 39 schools & departments, $\sim$30000 students

- School of Physics: 200 faculty and staff, $\sim$1400 students
  Inst. of Theoretical Physics (ITP),
  Inst. of Condensed Matter & Material Physics,
  Inst. of Heavy Ion Physics, ...,
  + Dept. of Astronomy, ...

- the largest number of alumi elected as CAS Academicians

- the most Chinese high-school IPhO Gold medalists

Institute of Theoretical Physics (ITP)

- **Top institution in China for theoretical physics**

- established in 1978, approved by Deng Xiao-Ping
  $\rightarrow$ Peng Huanwu (PhD of Max Born) as founding director

- About 40 faculty researchers
  with 40% stayed a few years in Germany
  and about 25 postdocs & 140 graduate students

- First institution in China to award PhD
  and to start a postdoctoral program

- Largest number of national awards
  in theoretical physics

Starting point

- Very challenging endeavour, requires complementary and overlapping expertise

$\Rightarrow$ this is available at the various institutions forming this CRC

- Large investment in facilities requires concentrated theory effort

$\Rightarrow$ strong focus on data from BEPC-II (now) and FAIR (future) $\rightarrow$ slide

- Improving the bilateral scientific relations

$\Rightarrow$ best use of the science brain pool in both countries

- Builds on earlier and on-going collaborations by some of the PIs

$\Rightarrow$ [Brambilla, Vairo, Jia], [Guo, Hanhart, Meißner, Zhao], [Hanhart, Guo, Zou] [Kaiser, Meißner, Weise], [Rusetsky, Weise], [Dreiner, Hanhart], ...

$\Rightarrow$ Potential for a long-term synergy and innovation very much desired by the partners

Hadron Physics Complexes

- present and future HPC = Hadron Physics Complexes $\rightarrow$ BEPC-II, FAIR

  (the contenders: B-factories and colliders)

Thoughts from the Chinese side

- Long-standing problems:
  - Lack of up-to-date knowledge / modern perspective
  - Lack of creativity (central system)
  - Qian Xuesen's question:
    "Why do our universities always fail
    to nurture outstanding talents?"

©Wikipedia

- The situation was changing at that time
  - 100 Talents Program of CAS (from 1994), more than 2200 recruitements
  - 1000 Talents Plan (from 2008), more than 2000 recruitements (univ., CAS, industry)
  - later: 10000 Talents Plan (not to be talked about officially)
  - later: Young Talents Plan (not to be talked about officially)
  - Seeking international collaborations with top institutions, such as in this CRC

Principal Investigators (PIs)

- Principal investigators:

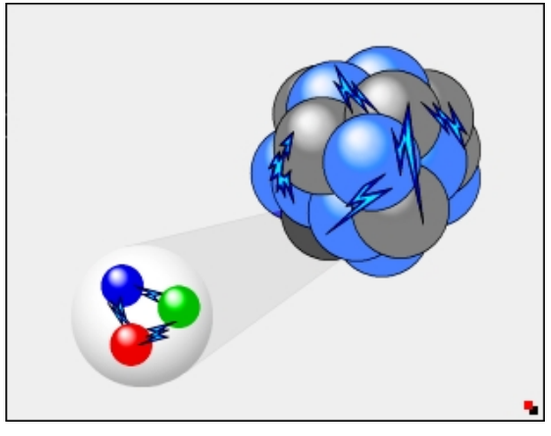
IHEP	Prof. Y. Chen, Prof. Y. Dong, Prof. M. Huang, Prof. Y. Jia, Prof. J.-X. Wang, Prof. P. Wang, Prof. Q. Zhao, Prof. B.-S. Zou [→ ITP/CAS]
PKU	Prof. C. Liu, Prof. S.-L. Zhu
UB	Prof. H. Dreiner, Dr. F.-K. Guo, [Prof. H.-W. Hammer,] Prof. B. Kubis, Prof. U.-G. Meißner, PD A. Rusetsky, Prof. C. Urbach
FZJ	PD J. Haidenbauer, Prof. C. Hanhart, [Prof. U.-G. Meißner], Dr. A. Nogga, [Prof. T. Luu [from 09/2013]]
TUM	Prof. N. Brambilla, Prof. N. Kaiser, PD A. Vairo, Prof. W. Weise

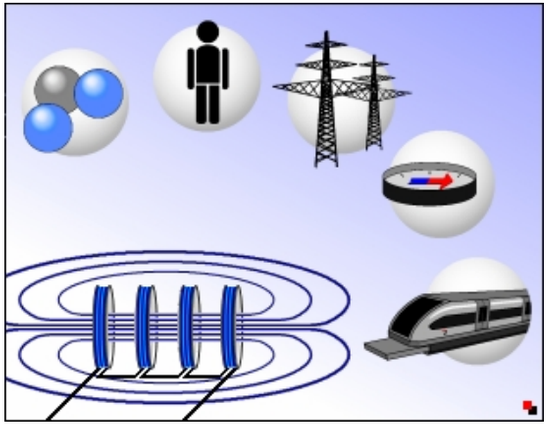
Topics in Strong QCD

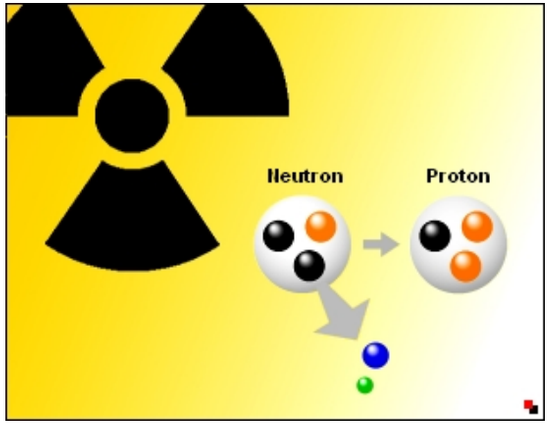
Forces in Nature

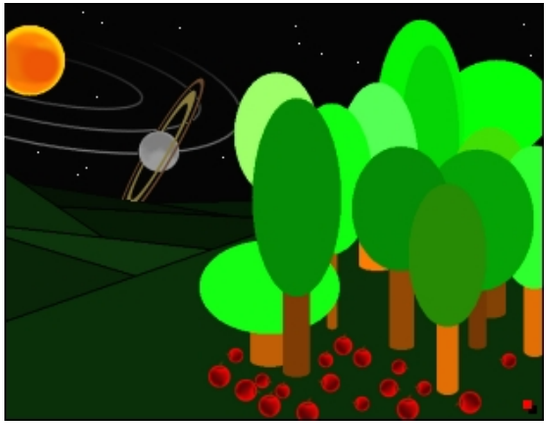
- 4 different forces: **strong**, electromagnetic, weak, gravitation

  Standard Model





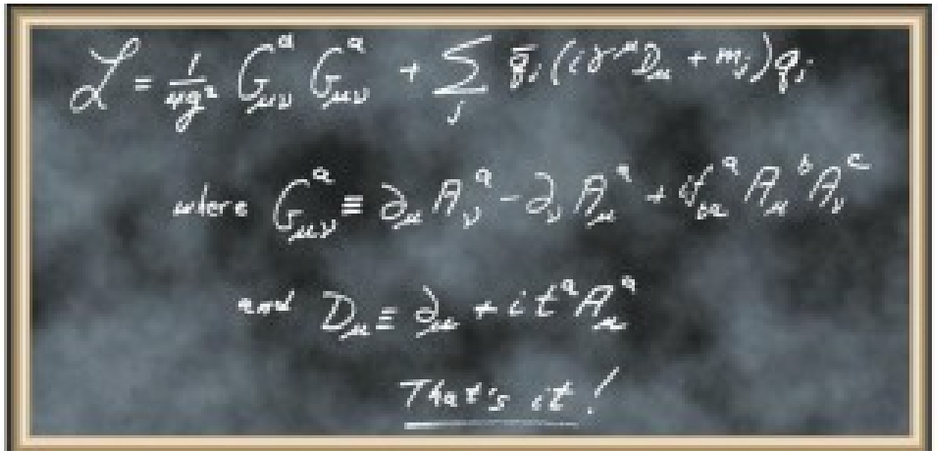




- three forces unified (Standard model of particle physics)
- Gravity plays no role on (sub)atomic scales
- The strong force is still not understood despite the underlying theory called Quantum Chromodynamics being known

Facets of Quantum Chromodynamics

- perturbative QCD: quarks, gluons, . . .
- strong QCD: hadrons, nuclei, . . .
- a plethora of *structures* and *(broken) symmetries*



- Aspects of QCD in the **CRC 110**:
  - decays and interactions of hadrons (esp. charm sector)
  - how QCD generates structures: hadrons, nuclei, . . .
  - precision calculations to test physics beyond the SM

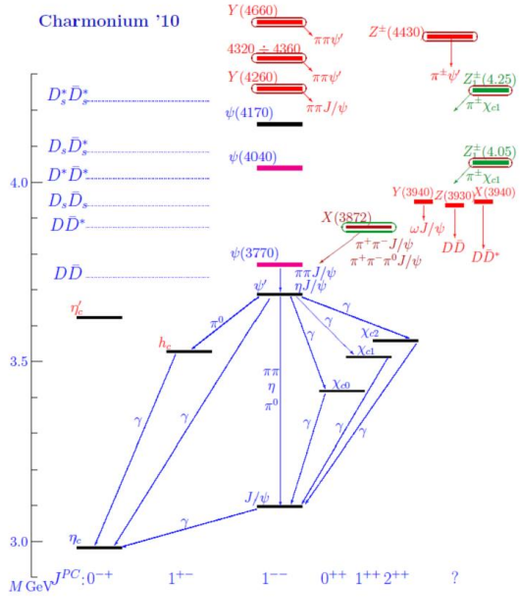
$\longrightarrow$ *interplay of lattice QCD, EFTs and models*

Facets of strong QCD

- quarks and gluons form hadrons

  ⇒ **lattice QCD + EFT + models**

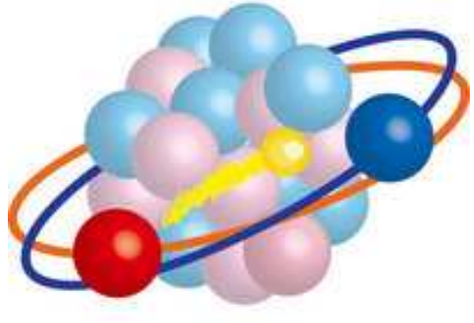
  ⇒ exploring the strong color force



- nucleons and mesons form nuclei

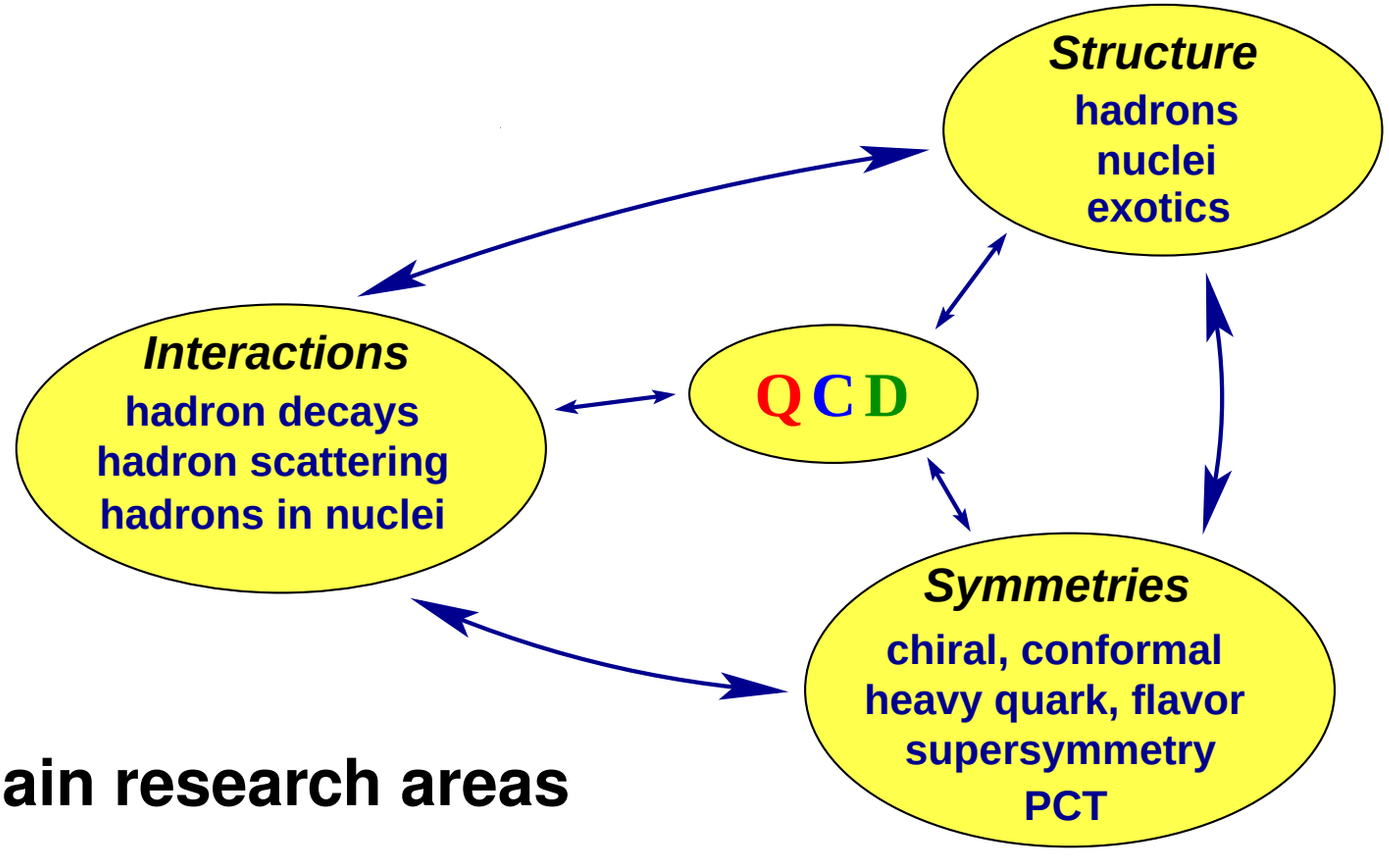
  ⇒ **nuclear physics (EFT, lattice, . . .)**

  ⇒ exploring the residual color force



Joint investigations of hadrons and nuclei:
world-wide unique approach

QCD research in CRC 110



- **CRC 110: two main research areas**

  A – symmetries

  B – emergence of structure

- **strongly intertwined**

Project areas FP1

- Project area A: **Symmetries**

A.1	Flavor symmetries and FSI in heavy hadron decays	Haidenbauer, Kubis, Zou
A.2	Hadron-hadron scattering in QCD	Liu, Urbach
A.3	Universality and EFT for threshold states	Brambilla (f), Jia
A.4	Hadronic parity violation	Kaiser, Zhu
A.5	Quark mass dependence of heavy-light systems	Guo, Meißner, P. Wang

- Project area B: **Emergence of Structure**

B.1	Nucleon form factors	Dong, Meißner
B.2	Hadron spectroscopy	Huang (f), Zhu, Zou
B.3	Hadronic molecules with heavy meson loops	Hanhart, Guo, Zhao
B.4	Boxed exotica	Liu, Rusetsky
B.5	Exotic states from lattice QCD	Chen, Urbach
B.6	Hadronic systems with strange quarks	Rusetsky, Weise
B.7	Chiral dynamics of nuclei & hypernuclei	Meißner, Nogga, Kaiser
B.8	Quarkonium interactions in hadronic, nuclear and thermal matter	Jia, Vairo, J. Wang

Projects strongly intertwined across the areas

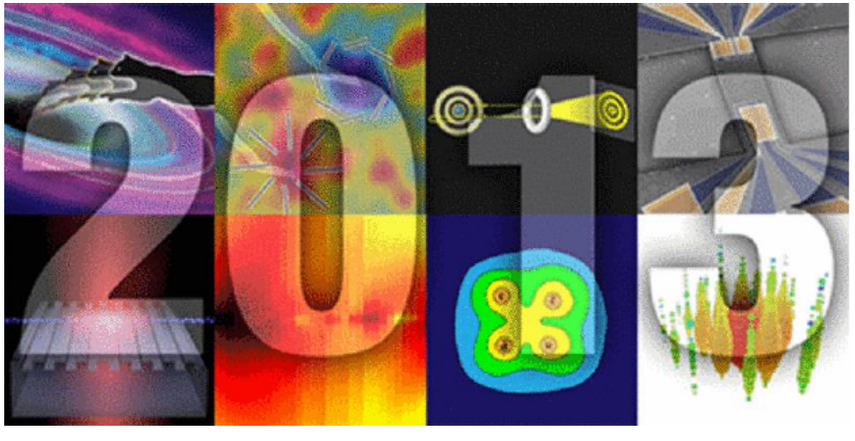
$\Rightarrow$ 10 of 13 projects have chinese & german project leaders!

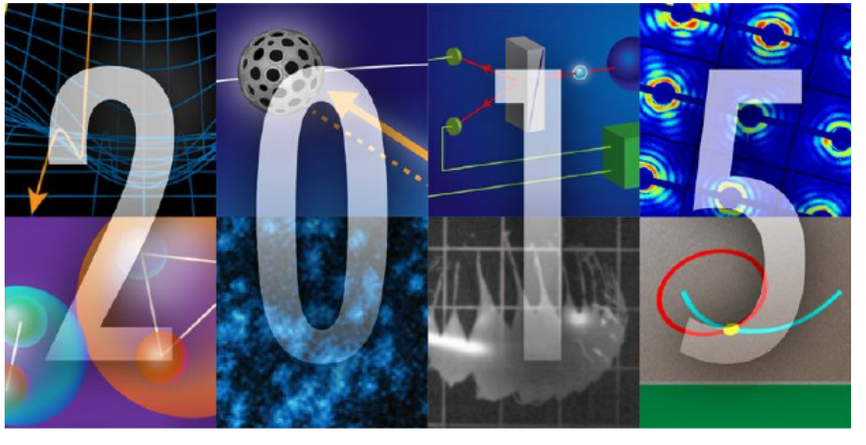
Research highlights

- Top highlights in strong QCD during FP1 (APS)

#1: Discovery of the Zc(3900)
by BESIII & Belle

#2: Discovery of the Pc states
by LHCb





↪ **CRC PIs played a leading role for predictions and explanations**

W. Chen, H.X. Chen, X. Liu, S.L. Zhu, Phys. Rept. **639** (2016) 1 1093 cites

F.K. Guo, C. Hanhart, U.-G. Meißner, Q. Zhao, B.S. Zou, [inspirehep, May 29th, 2024]
Rev. Mod. Phys. **90** (2018) 015004 1132 cites

Structural Developments

Major changes over time

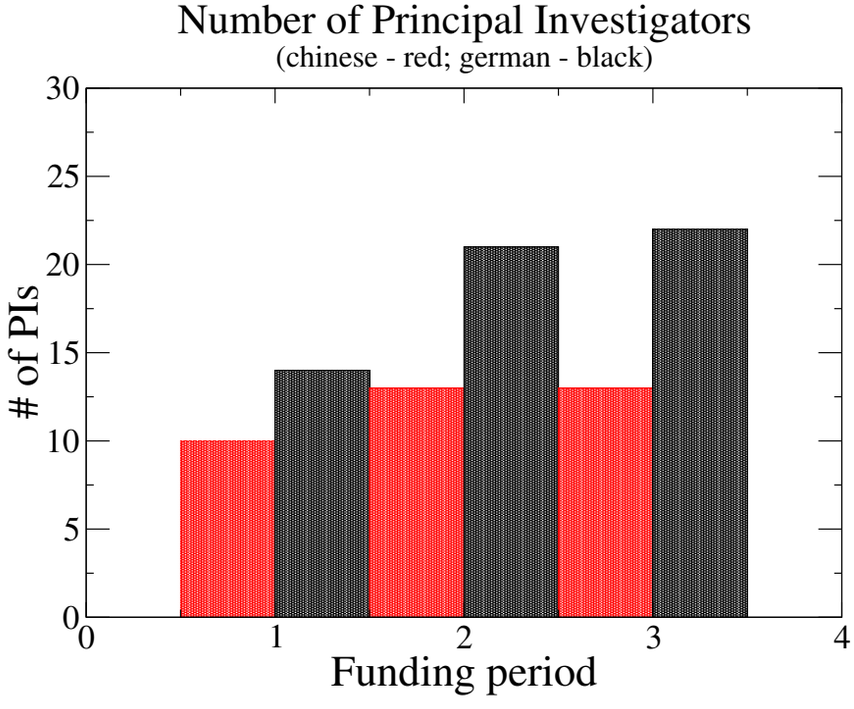
- The CRC is a living organism:
  - some projects get finished, new ones appear
  - some project leaders leave, new ones emerge (esp. younger ones)
- Founding period 1 (FP1) showed that this large scale collaboration indeed works
  $\rightarrow$ enlarge it!
- Largest structural developement from FP1 to FP2:
  - Include more **nuclear physics** projects ($\mathbf{3} \rightarrow \mathbf{6}$)
  - New nodes: RUB on the German side and ITP on the Chinese side
- Strengthen the connection to/collaboration with experiment
  - 3 experimental PIs in analysis projects (partly mixed with theoreticians)

$\hookrightarrow$ Visible increase in the number of PIs: $\mathbf{24} \rightarrow \mathbf{34} \rightarrow \mathbf{35}$

FP1 FP2 FP3

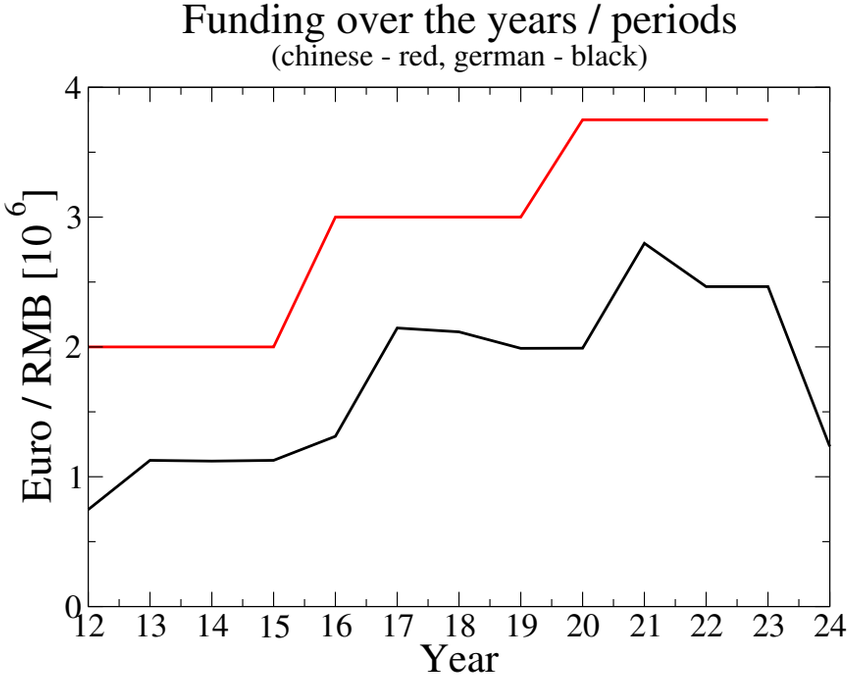
Major changes over time II

- Increased # of PIs



	Bonn	FZJ	TUM	RUB	IHEP	ITP	PKU
FP1	7	3	4	-	8	-	2
FP2	8	4	5	4	7	3	3
FP3	8	4	6	4	6	3	4

- increased funding



— Chinese funding only per fiscal year (lump sum)
— German funding with start of FP (07/12, 07/16, 01/21)
— German funding includes GPU cluster (irregular)
— German funding w/o Programmpauschale (20-22%)
— Fundings in terms of personal **comparable**

Project areas FP2

- Project area A: **Symmetries**

A.1	Flavor symmetries and final-state interactions in hadronic decays	Guo, Haidenbauer, Kubis, Paul **(N)**
A.2	Hadron dynamics on the lattice	Liu, Urbach
A.3	Effective field theories for threshold phenomena	Brambilla (f), Jia
A.4	Hadronic parity violation **(E)**	Kaiser, Zhu
A.5	Quark mass dependence of hadronic observables	Guo, Meißner, P. Wang
A.7	Precision calculations in hadronic decays **(N)**	Dreiner, Kubis, Lü **(N)**
A.8	Charmless exclusive B decays **(N)**	Beneke **(N)**, Lü **(N)**
A.9	EFT for nuclear electroweak currents: Foundations and applications **(N)**	Epelbaum **(N)**, Kaiser, Krebs **(N)**

- Project area B: **Emergence of Structure**

B.1	Partonic structure of nucleons and nuclei	Dong, Polyakov **(N)**
B.2	Hadron spectroscopy	Huang (f), Zhu, Zou
B.3	Hadronic molecules with heavy meson loops	Hanhart, Q. Wang (f) **(N)**, Zhao
B.4	Boxed exotica	Liu, Rusetsky
B.5	Exotic states from lattice QCD	Chen, Urbach
B.6	Strangeness in hadronic and nuclear systems	Nogga, Rusetsky, Zhou
B.7	Chiral symmetry in nuclear physics	Epelbaum **(N)**, Kaiser, Meng **(N)**
B.8	Quarkonium interactions in hadronic and nuclear matter	Jia, Vairo
B.9	Lattice nuclear physics **(N)**	Krebs **(N)**, Luu, Meißner
B.10	Partial wave analysis **(N)**	Thoma (f) **(N)**, Wiedner **(N)**
B.11	Coupled-channel dynamics **(N)**	Rönchen (f) **(N)**, Zou

One major hurdle

- The NSFC terminated the contract for co-funded CRCs in January 2016
  - just one month before the review for FP2 in Beijing
  - this was not told to the PIs
  - FP2 was not in jeopardy, but what about FP3?
- I started a 2.5 year long series of talks
  - NSFC Presidents, vice-presidents, rector of PKU, CAS president, ...
  - Chinese spokesperson helpful but had to avoid any confrontation
  - 2-page memo for the NSFC in September 2018 detailing all the successes of the CRC → next slide

On Nov. 9th, 2018, we were informed that we can apply for a third funding period! [and then the DFG also agreed]

Memo to the NSFC

Proposal for funding of the third period of the CRC 110

Ulf-G. Meißner and Bing-Song Zou (Spokespersons)

The second funding period of the Sino-German Collaborative Research Center CRC 110 "Symmetries and the Emergence of Structure in QCD" will end on June 30th, 2020 (December 31st, 2019, from the NSFC side). Originally, the CRC was set up for three possible funding periods of 4 years each within the old NSFC-DFG funding scheme for the Sino-German Joint Interdisciplinary Research Program. However, within the new funding scheme between the NSFC and the DFG, the third funding period can not be funded. However, the DFG is very much in favor of a third funding period. As the Sino-German collaboration has developed tremendously since the start of the CRC 110 in July 2012, we believe that there are numerous reasons to keep this internationally highly visible collaboration alive with the old funding scheme. We thus propose that the NSFC provides 3 million RMB each year for the following four years (2020 - 2023) outside the new NSFC-DFG funding scheme to continue this successful enterprise. We mention that the DFG provides more than 2 million Euro each year to the CRC 110.

The reasons for continuing funding the CRC in the proposed way are manifold as listed here:

1) The CRC has to be considered as a very successful collaboration. Within this framework, more than 500 papers (with more than 11000 citations in total) have been published since June 2012, from which more than 110 have both Chinese and German authors. These include 26 articles in *Physical Review Letters*, 2 articles in *Reviews of Modern Physics*, 2 articles in *Physics Reports* and 2 publications in *Nature*.

2) The CRC 110 is a *career booster* for young scientists. So far we have (had) 2 Chinese postdocs acting as PIs in Germany. 5 postdocs and students working within the CRC 110 succeeded in getting funded by the 1000 Talents Project for Young Professionals (4 of them were post-docs in the German CRC nodes: Bonn, Jülich and Munich), and another one was funded by the 100 Talents Project of CAS (PhD from Bonn). Up to now, we have (had) 22 Chinese postdocs at the German nodes as well as 6 Chinese graduate students obtaining/having obtained their PhD from a German CRC institutions. Various of these post-docs have taken faculty positions in China. Furthermore, there are frequent exchanges of postdocs and students from both sides with stays that range from 3 months to one year.

3) The researchers from the CRC have pioneered the field of predictions and interpretations of multiquark states (tetra- and pentaquarks), whose discoveries have been selected as American Physical Society Highlights of the years 2013 and 2015. Relevant papers from CRC are: 2 *Physical Review Letters* and 1 *Physics Reports* from Prof. Shi-Lin Zhu's group, 2 *Physical Review Letters* by the Bonn-Jülich-IHEP collaboration, and 1 *Reviews of Modern Physics* (RMP) from Chinese and German PIs. This is the first-ever RMP review on nuclear and particle physics with the first institution being from China.

4) Within the CRC, we have developed the so-called "Nuclear lattice simulations". This is a very new and successful approach for many-body physics, in particular for the studies of nuclear structure and reactions. Important publications are 6 *Physical Review Letters* (2 of them coauthored by two Chinese postdocs and 1 Chinese graduate student), 1 article in *Nature* and 1 more review in *Reviews of Modern Physics*. This important new technique can now be imported to China.

5) The lattice QCD practitioners from China get more computing time from the German supercomputers through collaboration with the German PIs. Within the CRC, the Chinese and German researchers have done ground-breaking work for hadron-hadron scattering and heavy meson decays. They also profit very much from the formal developments done in this CRC.

6) The CRC brings together in the same collaboration both nuclear and particle physicists. This is *world-wide unique* and one of the strong pillars of the collaboration. Through the exchange of methods used in these fields, both senior and junior researchers benefit from this. It also opens the doors for new approaches like the mentioned nuclear lattice simulations, which combine effective field theory methods from nuclear physics with Monte Carlo computation methods used in particle and hadronic physics.

7) The CRC has funded or co-funded 18 international workshops/schools/conferences, 7 of which took place in China. This clearly contributes to the high international standing many of the CRC researches have obtained.

8) The work performed within the CRC 110 has also been recognized by prizes and awards. We mention as examples the "Lise Meitner Prize" of the European Physical Society, 2016, the PIFI Fellowship for Distinguished Scientists, 2018, 2 NSFC Outstanding Youth Grants, 2 NSFC Key Projects, and "The Excellent PHD Thesis of the Chinese Academy of Sciences, 2015".

Clearly, all this could only be achieved because of the **long-lasting** and **large-scale** cooperation, as provided by the CRC framework. It would simply have been impossible in any other funding scheme. We believe that the CRC is a beacon for Sino-German collaborations, or international collaborations in general, and we expect many more exciting results in physics and a further deepening of the ties between the participating institutions in the years to come. In view of all this, we consider the above mentioned funding request reasonable and believe that it should be provided by the NSFC.

Prof. Ulf-G. Meißner Prof. Bing-Song Zou

Beijing, September 3rd, 2018

Project areas FP3

- Project area A: **Symmetries**

A.1	Flavor symmetries and final-state interactions in hadronic decays	Guo, Kubis, Paul
A.2	Hadron dynamics on the lattice	Liu, Luu, Urbach
A.3	Effective field theories for threshold phenomena	Brambilla (f), Jia
A.5	Quark mass dependence of hadronic observables	Guo, Meißner
A.7	Precision calculations in hadron and beyond the standard model physics	Dreiner, Lü
A.8	Charmless exclusive B decays	Beneke, Lü
A.9	EFT for nuclear electroweak currents: Foundations and applications	Kaiser, Krebs
A.10 **(N)**	Symmetry-violating hadronic interactions from lattice QCD	Luu, Petschlies, Urbach
A.11 **(N)**	Hadronic transition form factors from analyticity	Kubis, van Dyk **(N)**

- Project area B: **Emergence of Structure**

B.1	Partonic structure of nucleons and nuclei	Dong, Polyakov
B.2	Hadron spectroscopy	Chen, Zhu, Zou
B.3	Hadronic molecules with heavy meson loops	Hanhart, Wang (f), Zhao
B.4	Boxed hadrons	Liu, Rusetsky
B.5 (E)	Exotic states from lattice QCD	Chen, Urbach
B.6	Strangeness in nuclear systems	Nogga, Zhou
B.7	Chiral symmetry in nuclear physics	Epelbaum, Kaiser, Meng
B.8	Quarkonium production and decay	Jia, Vairo
B.9	Lattice nuclear physics	Epelbaum, Meißner
B.10	Partial wave analysis	Thoma (f), Wiedner
B.11	Coupled-channel dynamics	Rönchen (f), Zou
B.12 **(N)**	Parton distribution functions on the lattice	Feng **(N)**, Steffens (f) **(N)**

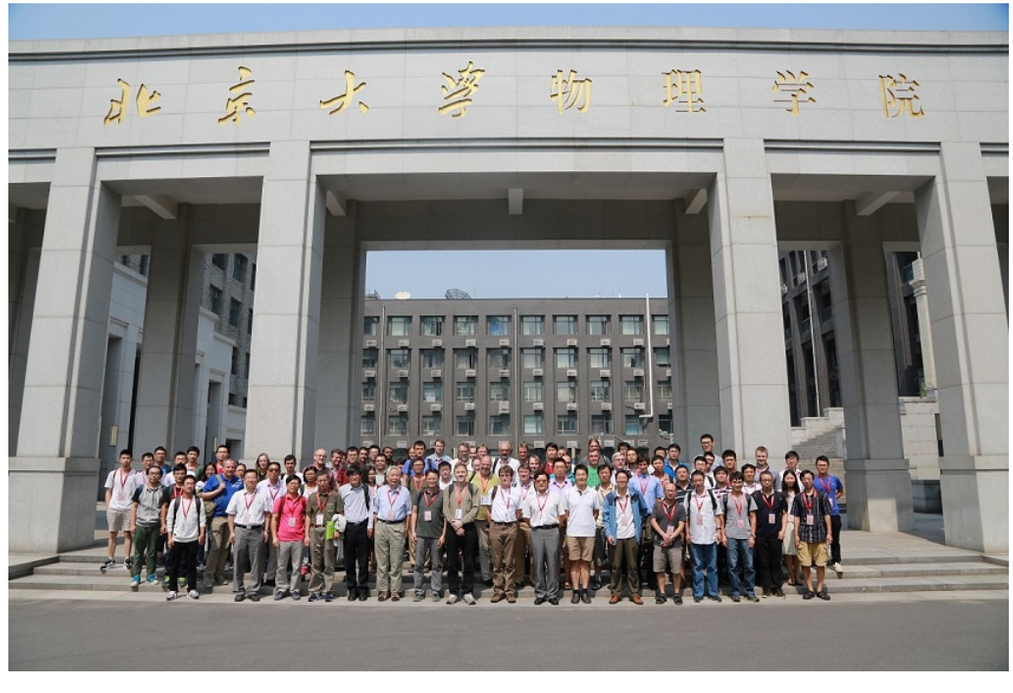
Status and Achievements

Making the CRC work I

- Large CRC meetings,
  always in China/once per FP

  2012 KITPC, Beijing [initial meeting]
  2014 Weihai
  2017 School of Physics, PKU
  2022 ITP, Beijing
  2024 Bonn [final meeting]

- Purposes:
  - get to know each other
  - Chinese midterm review
  - develop strategies for next FP
  - Initial and final meeting



Making the CRC work II

- Measures within the CRC:

  - ⋆ CRC focus workshops: recent developments/smaller groups
  - ⋆ CRC contribution to larger meetings/programs
  - ⋆ many mutual visits of PIs, Post-Docs and students

    $\hookrightarrow$ **collaborations have visibly increased over time**
  - ⋆ more than $\sim \mathbf{150}$ finished and one-going PhD thesis
  - ⋆ Joint graduate (Ph.D.) students (one chinese and one german supervisor)

next slides

  - ⋆ Bi-annual Hadron Physics Summer School at FZ Jülich

    $\hookrightarrow$ **recruitmenent of students and postdocs**
  - ⋆ Associaton of an Emmy-Noether group in FP2 $\rightarrow$ PI in FP3 (D. van Dyk)

First steps towards a common graduate education

- research phase of the PhD (3 years)
- students have at least two supervisors
- students spend time at the home & the host institution
- MSc courses mutually accepted

Sept. 17, 2012

- similar MoU with the ITP of the CAS

universitätbonn
Rheinische Friedrich-Wilhelms-Universität Bonn

北京大學 PEKING UNIVERSITY

Memorandum of Understanding

between

The Faculty of Mathematics and Natural Sciences, University of Bonn, Bonn, Germany

and

The School of Physics, Peking University, Beijing, China

regarding a

Common Ph.D. program in Physics

First steps towards a common graduate education cont'd

- MoU w/ IHEP signed March 21st, 2014

- First commonly supervised student:

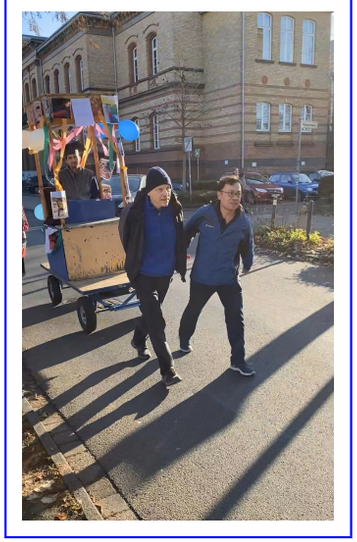
  Martin Cleven / PhD Dec. 12, 2013
  "Systematic Study of Hadronic Molecules in the Heavy Quark Sector"
  1. Supervisor: UGM
  2. Supervisor: Prof. Qiang Zhao
  3. Supervisor: Prof. Christoph Hanhart

- Further commonly supervised students

  Menglin Du (PhD 2017)

  Ripunjay Acharya (PhD 2019)

  Thomas Vonk (PhD 2022)

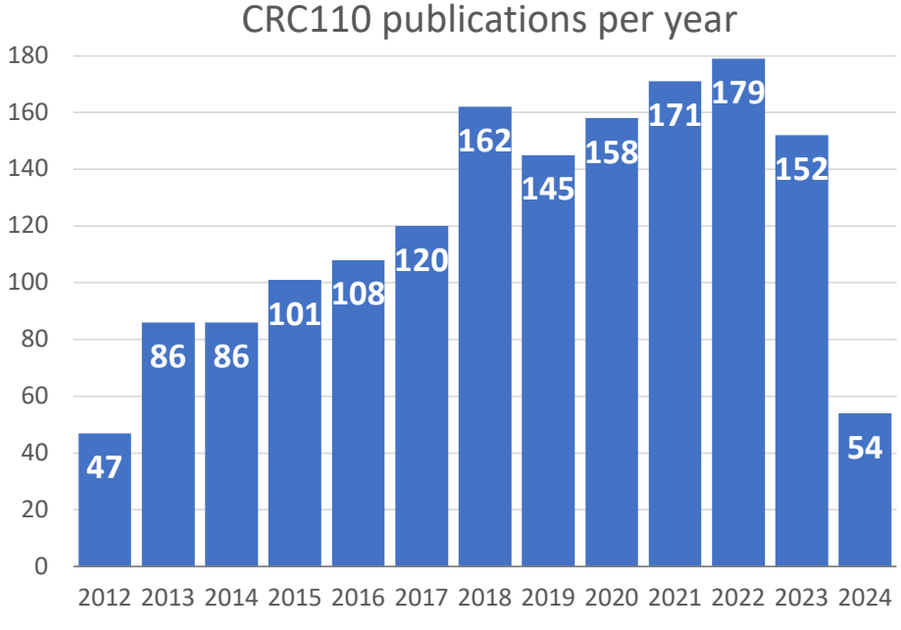


Making the CRC work III

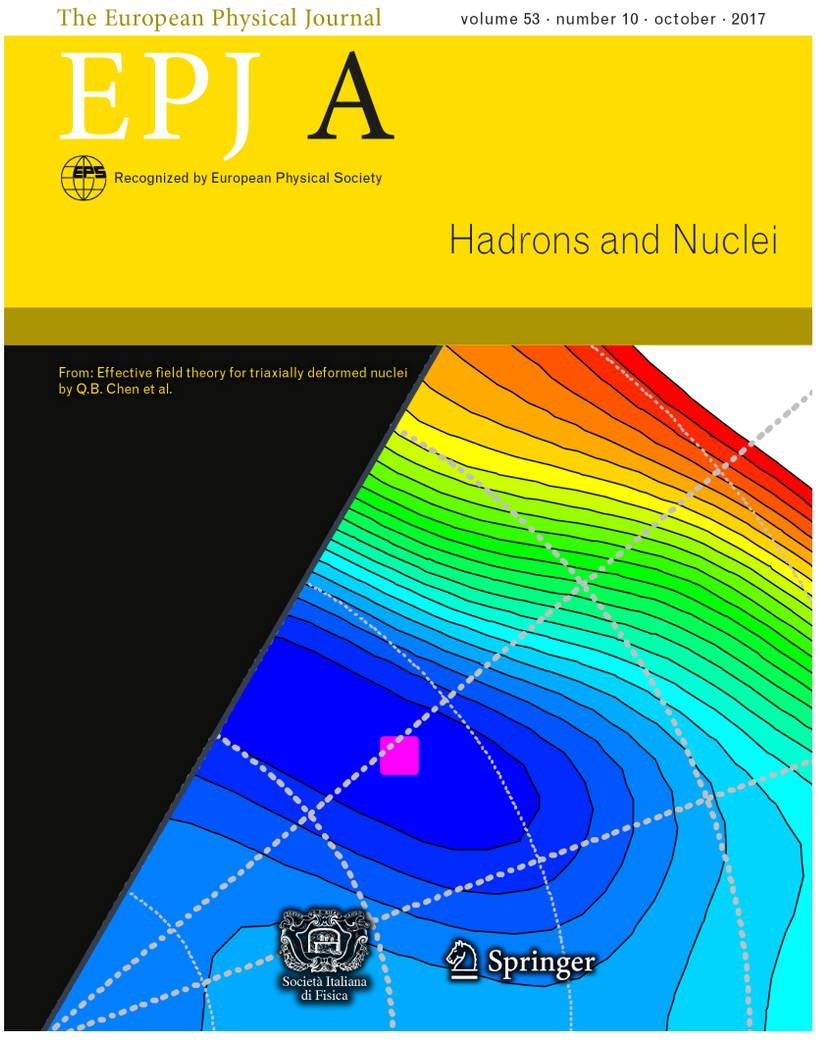
- One measure of success: Publications

  - ⋆ more than 1300 as of today
  - ⋆ about 1/5 w/ two CRC nodes
  - ⋆ 1^{st} sino-german *Rev. Mod. Phys.*

    [Guo, Hanhart, UGM, Wang, Zhao, Zou]
  - ⋆ One textbook out of project B.9



TUM-Bonn-PKU collaboration



Effective field theory for triaxially deformed nuclei

Chen, Kaiser, UGM, Meng, EPJA 53 (2017) 204

Publications

- Very visible publications from the CRC

Already more than 1100 cites

REVIEWS OF MODERN PHYSICS, VOLUME 90, JANUARY–MARCH 2018

Hadronic molecules

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Bing-Song Zou¶

CAS Key Laboratory of Theoretical Physics, Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing 100190, China and School of Physical Sciences, University of Chinese Academy of Sciences, Beijing 100049, China

(published 8 February 2018)

A large number of experimental discoveries especially in the heavy quarkonium sector that did not meet the expectations of the until then very successful quark model led to a renaissance of hadron spectroscopy. Among various explanations of the internal structure of these excitations, hadronic molecules, being analogs of light nuclei, play a unique role since for those predictions can be made with controlled uncertainty. Experimental evidence of various candidates of hadronic molecules and methods of identifying such structures are reviewed. Nonrelativistic effective field theories are the suitable framework for studying hadronic molecules and are discussed in both the continuum and finite volumes. Also pertinent lattice QCD results are presented. Further, the production mechanisms and decays of hadronic molecules are discussed and comments are given on the reliability of certain assertions often made in the literature.

DOI: 10.1103/RevModPhys.90.015004

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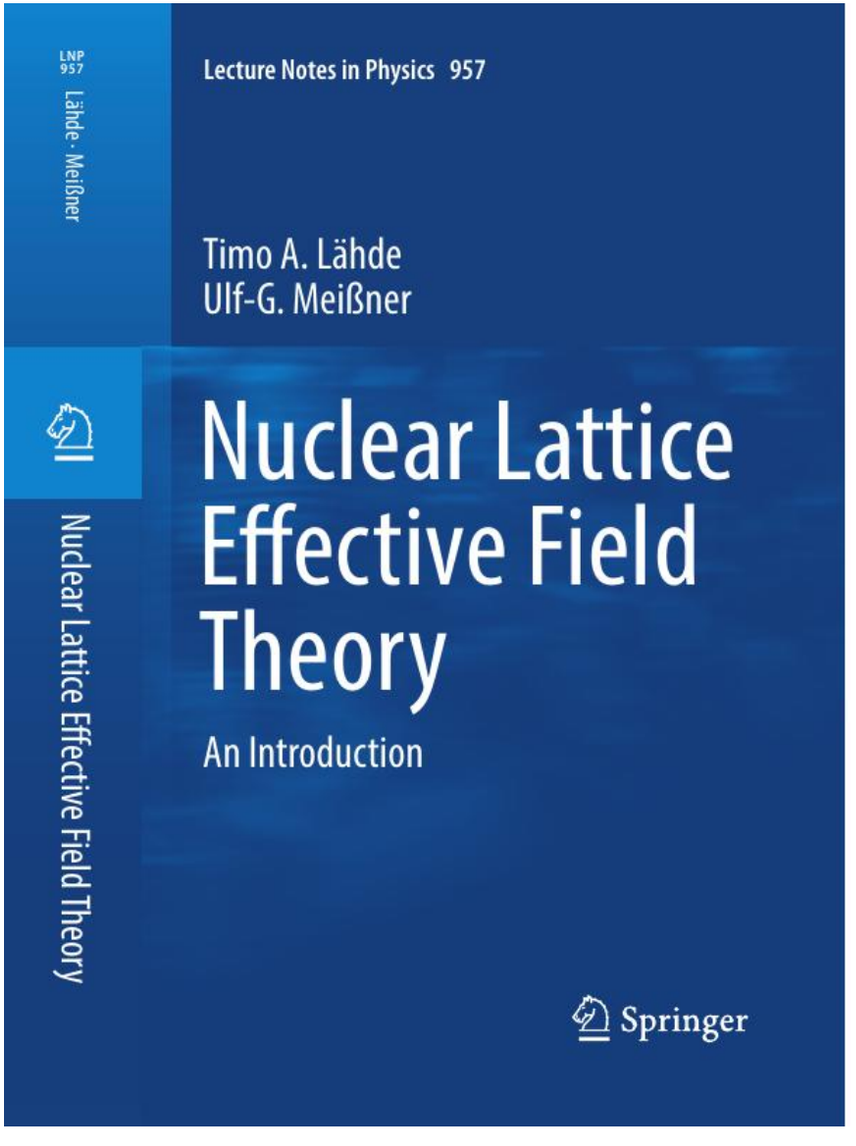


Outreach

- Special projects on outreach - multiple activities → just discuss one → talk by C. Hanhart

- Physik-Show http://physikshow.uni-bonn.de
  - predates the CRC
  - experiments performed by students
  - large appeal to young people/general public
  - EPS HEPP Division Outreach Prize 2009
  - travel to other places and catalyse similar events there (Barcelona, Oxford, . . .)
  - crowning trip to Beijing as a bridge between the cultures in March 2016
  - second trip to China (Beijing/Shanghai) in spring 2020 cancelled (covid)

  ↪ visible boost from the CRC

  ↪ brings people together!

Careers

- A career booster for Chinese students and postdocs

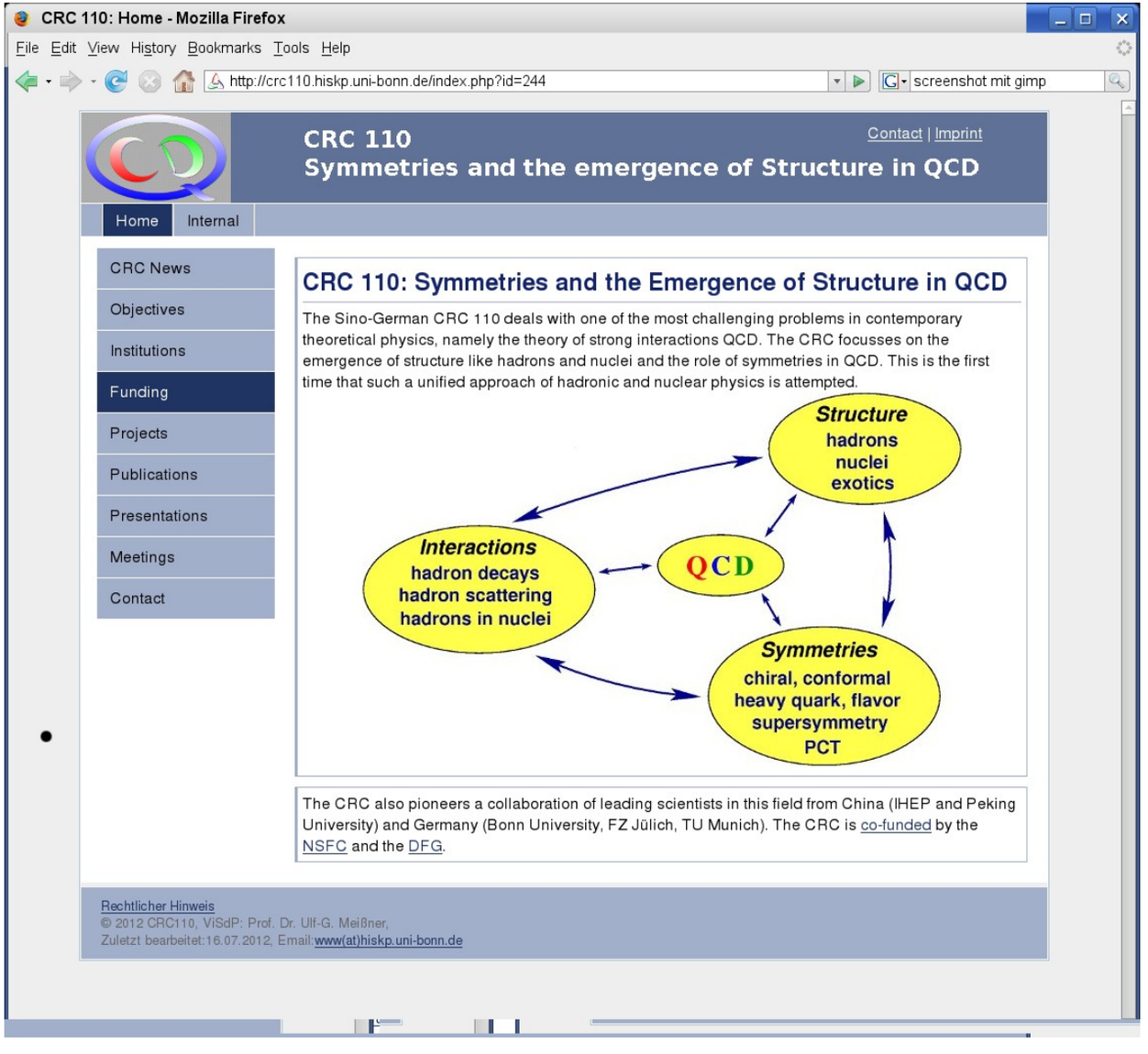
Name	Position CRC	Position now	Institution
Yun-Hua Chen	postdoc	Assoc. Prof.	University of Science and Technology Beijing
Qibo Chen	postdoc	Prof.	East China Normal University
Lingyun Dai*	postdoc	Prof.	Hunan University
Menglin Du*	student	Postdoc	Valencia Univ./IFIC
Fengkun Guo*	PI Bonn	Prof.	Institute of Theoretical Physics, CAS
Xianwei Kang	student	Assoc. Prof.	Beijing Normal University
Ning Li	postdoc	Assoc. Prof.	Sun Yat-sen University
Liuming Liu	postdoc	Prof.	Institute of Modern Physics, CAS
Xiao-Hai Liu	postdoc	Assoc. Prof.	Tianjin University
Bingnan Lyu*	postdoc	Assoc. Prof.	Graduate School of Chinese Academy of Eng. Physics
Li Ma	postdoc	Lecturer	Beijing Jiaotong University
Jing-Yi Pang	postdoc	Lecturer	University of Shanghai for Science and Technology
Shihang Shen	postdoc	Assoc. Prof.	Beihang University
Qian Wang*	PI Bonn	Prof.	South China Normal University
Wei Wang*	postdoc	Prof.	Shanghai Jiaotong University
Jia-Jun Wu*	postdoc	Assoc. Prof.	University of Chinese Academy of Sciences
Chuwen Xiao	postdoc	Prof.	Central South University
Xiaonu Xiong	postdoc	Prof.	Central South University
Zhi Yang	student	Assoc. Prof.	Univ. of Electric Science and Technology of China
Deliang Yao	postdoc	Prof.	Hunan University

[* Winner of national young talents program]

- but not only for the Chinese ... $\rightarrow$ final report

Much more info

http://crc110.hiskp.uni-bonn.de



Perspectives

Summary and outlook

- The CRC 110 is a **success story** !
- The CRC 110 will officially end June $30^{\mathbf{th}}$, 2024

CRC110 = Role model for a long-term & successful Sino-German collaboration

- What next?

  $\hookrightarrow$ such type of collaboration driven by individuals

  $\hookrightarrow$ situation in China is changing / disimproving

  $\hookrightarrow$ smaller scale application via PIFI of CAS

  $\hookrightarrow$ Chinese could do the next big jump in fundamental physics, but they are hesitant to do so ... but this is another story ...

UNIVERSITÄT BONN

JÜLICH Forschungszentrum

RUB

Technische Universität München

Thank you for your attention !

Thank you all for making this a success !

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北京大學 PEKING UNIVERSITY