

Hendrik Bekker



Personal details

Date of birth:

29-04-1986

Nationality:

The Netherlands

Marital status:

Married

Children:

2-year-old daughter

Contact

Address:

Helmholtz Institute Mainz
Johannes Gutenberg University
55099 Mainz

Phone:

+49 (0) 157 7932 6645

Email:

hbekker@uni-mainz.de

Google Scholar:

<https://scholar.google.com/citations?user=B4a26YgAAAAJ>

ORCID:

<https://orcid.org/0000-0002-6535-696X>

Summary

My expertise is in probing physics beyond the Standard Model of particle physics employing exotic systems such as highly charged ions, molecules, and antimatter. For this purpose, I use a multitude of spectroscopic techniques, such as those applied in optical atomic clocks and nuclear magnetic resonance spectroscopy. So far, this has resulted in 26 peer-reviewed publications with in total 574 citations leading to an h-index of 15. Since the beginning of my scientific career, I paid great attention to building individual collaborations, working on different experiments at different research centers, aiming to build strong independent research work and extend my knowledge on different techniques.

Education

PhD in Physics, 2016, magna cum laude

Title: Optical and EUV spectroscopy of highly charged ions near the 4f –5s level crossing

Max-Planck-Institut für Kernphysik / Ruprecht-Karls-Universität, Heidelberg, Germany

Supervisor: Priv.-Doz. Dr. J. R. Crespo López-Urrutia

Master in Physics, 2012

Title: Ion transport in a radium ion spectroscopy experiment

TRIMUP group, Kernfysisch Versneller Instituut (KVI), University of Groningen, The Netherlands

Bachelor in Physics, 2010

Title: Ion scattering spectroscopy with a time of flight system

Hoekstra group, Kernfysisch Versneller Instituut, University of Groningen, The Netherlands

Current position

Junior group leader at the Helmholtz institute Mainz since August 2021

My main focus is the Cosmic Axion Spin Precession Experiments (CASPER). We design, build, and operate specialized precision nuclear magnetic resonance spectrometers aimed at probing the nature of dark matter. In this capacity, my responsibilities include the implementation of the scientific program in a timely manner, the supervision of several PhD students, and administrative duties concerning the budget. In this context I was also part of the local organizing committee of an international conference on dark matter (PATRAS).

Furthermore, I work on the antimatter-on-a-chip project, where we aim to co-trap positrons and antiprotons employing a radio-frequency trap. This project is still in its early stages and therefore requires significant planning, designing, and administrative work.

Meanwhile, I am in the process of habilitating on the topic of dark matter. As part of this program, I have created a new master level lecture course on the topic „The Search for Dark Matter”.

Previous research positions

May 2020 – July 2021: Wissenschaftlicher Mitarbeiter at Johannes Gutenberg-Universität Mainz, IPH.

As a postdoc in the group of prof. Budker at the Helmholtz Institute Mainz I worked on one of the setups of the cosmic axion spin precession experiments (CASPER). I successfully set the apparatus up for the first measurements while supervising an international group of students.

May 2019 – May 2020: Postdoc in the Zelevinsky group at Columbia University.

I worked on an experiment aimed at the development of a molecular Sr2 clock to probe possible fifth forces at the nanometer scale and to search for variation of the electron-to-proton mass ratio. Besides technical work in the laboratory, paper writing, and supervision of graduate students, duties included planning future measurements and upgrades.

May 2016 - May 2019: Postdoc at the Max-Planck-Institut für Kernphysik

This work included spectroscopic investigations of highly charged ions in order to find those suitable for future laser spectroscopy. A Nature Communications paper on Pr^{9+} was a major result which involved coordinating an international group of scientists.

Five most important publications

[1] **H. Bekker**, A. Borschevsky, Z. Harman, C. H. Keitel, T. Pfeifer, P. O. Schmidt, J. R. Crespo López-Urrutia, and J. C. Berengut, Detection of the 5p-4f Orbital Crossing and its Optical Clock Transition in Pr^{9+} , Nature Communications 10, 5651 (2019).

Contribution: It was my idea and initiative to target the Pr^{9+} ion. I performed all the measurements and analysis and wrote the manuscript. Furthermore, I coordinated the work of the involved theorists.

[2] P. V. Bilous, **H. Bekker**, J. C. Berengut, B. Seiferle, L. Von Der Wense, P. G. Thirolf, T. Pfeifer, J. R. Crespo López-Urrutia, and A. Pálffy, Electronic Bridge Excitation in Highly Charged ^{229}Th Ions, Physical Review Letters 124, 192502 (2020).

Contribution: Calculations to identify the most suitable charge state and modelling of the processes in the EBIT. Additionally, I wrote those parts concerning the experimental methods.

[3] K. H. Leung, I. Majewska, **H. Bekker**, C.-H. Lee, E. Tiberi, S. S. Kondov, R. Moszynski, and T. Zelevinsky, Transition Strength Measurements to Guide Magic Wavelength Selection in Optically Trapped Molecules, Phys. Rev. Lett. 125, 153001 (2020).

Contribution: Leading the lab-team during the measurements. Generating figures and writing text for the manuscript.

[4] A. V. Gramolin, A. Wickenbrock, D. Aybas, **H. Bekker**, D. Budker, G. P. Centers, N. L. Figueroa, D. F. Jackson Kimball, and A. O. Sushkov. Spectral Signatures of Axionlike Dark Matter, Physical Review D 105, 035029 (2022).

Contribution: Participation in discussions and writing, with a focus on the application of the theory to the existing setup. Presenting the work at international conferences.

[5] J. Jin, **H. Bekker**, T. Kirschbaum, Y. A. Litvinov, A. Pálffy, J. Sommerfeldt, A. Surzhykov, P. G. Thirolf, and D. Budker, Excitation and Probing of Low-Energy Nuclear States at High-Energy Storage Rings, arXiv, August 9, 2022. <http://arxiv.org/abs/2208.05042>.

Contribution: Investigating known and novel methods to perform laser spectroscopy on highly charged ions in a storage ring. Writing parts of the manuscript revolving around the use of electron beam ion traps.

Scientific output

- 26 peer reviewed papers
 - o 4 first author papers
 - o 1 Nature paper
 - o 1 Nature Communications paper
 - o 4 Phys. Rev. Letters
 - o 8 Phys. Rev. A
 - o 1 Phys. Rev. D
- 35+ conference presentations and seminars, of which invited:
 - o Physics Opportunities at 100-500 MHz Haloscopes, “CASPER, status and prospects” (Feb 18th 2022)
 - o PATRAS 2021, “Status of CASPER-gradient and study of its quantum sensitivity limits” (June 17th 2021)
 - o Quantum lunch seminar Los Alamos National Lab, “The Sr2 molecular lattice clock” (2020, cancelled due to Covid-19)
 - o SPIE photonics west OPTO San Francisco, “Molecular lattice clock with long vibrational coherence” (2020)
 - o Atomic physics seminar, University of California, Berkeley, “Probing QED and variation of the fine-structure constant with highly charged ions” (2018)
 - o Source workshop, Dublin, “Fundamental Studies of Sn7+-Sn14+ Ions with Applications for Laser Produced Plasma Sources” (2017)
 - o Atomic physics seminar, GSI, Darmstadt, “Spectroscopy of highly charged ions near the 4f-5s level crossing” (2016)

Organisation of scientific meetings

- 2022 Local organizer of the international “17th Patras Workshop on Axions, WIMPs and WISPs”
- 2022 Lead organizer of the “Workshop on searches for wave-like dark matter with quantum networks”
- 2018 Session chair: Precision Spectroscopy V, DPG Spring Meeting in Erlangen, Germany
- 2017 Session chair: Precision Spectroscopy II, DPG Spring Meeting in Mainz, Germany

Teaching activities

2022 – 2023 Lecturer – The search for dark matter, master-level lecture course developed by me at the Johannes Gutenberg-Universität Mainz, Germany

2019 Lecturer for the Science Honors Program - Experiments in Physics, Columbia University, New York City, USA

2016 – 2017 Tutor - Experimental Physics III (PEP3), bachelor-level course at the Ruprecht-Karls-Universität, Heidelberg, Germany

2012 – 2016 Tutor - Zeeman spectroscopy advanced experiment, bachelor-level course at the Ruprecht-Karls-Universität, Heidelberg, Germany

2010 – 2011 Tutor - Electronics experiments, bachelor-level course at the University of Groningen, The Netherlands

Publication list

- [1] J. Jin, H. Bekker, T. Kirschbaum, Y. A. Litvinov, A. Pálffy, J. Sommerfeldt, A. Surzhykov, P. G. Thirolf, and D. Budker, *Excitation and Probing of Low-Energy Nuclear States at High-Energy Storage Rings* (arXiv, 2022).
- [2] A. V. Gramolin, A. Wickenbrock, D. Aybas, H. Bekker, D. Budker, G. P. Centers, N. L. Figueroa, D. F. Jackson Kimball, and A. O. Sushkov, *Spectral Signatures of Axionlike Dark Matter*, *Physical Review D* **105**, 035029 (2022).
- [3] D. Aybas, H. Bekker, J. W. Blanchard, D. Budker, G. P. Centers, N. L. Figueroa, A. V. Gramolin, D. F. J. Kimball, A. Wickenbrock, and A. O. Sushkov, *Quantum Sensitivity Limits of Nuclear Magnetic Resonance Experiments Searching for New Fundamental Physics*, *Quantum Science and Technology* **6**, 034007 (2021).
- [4] N.-H. Rehbehn et al., *Sensitivity to New Physics of Isotope-Shift Studies Using the Coronal Lines of Highly Charged Calcium Ions*, *Physical Review A* **103**, L040801 (2021).
- [5] K. H. Leung, I. Majewska, H. Bekker, C.-H. Lee, E. Tiberi, S. S. Kondov, R. Moszynski, and T. Zelevinsky, *Transition Strength Measurements to Guide Magic Wavelength Selection in Optically Trapped Molecules*, *Physical Review Letters* **125**, 153001 (2020).
- [6] J. Scheers et al., *EUV Spectroscopy of Highly Charged Sn^{13+} - Sn^{15+} Ions in an Electron-Beam Ion Trap*, *Physical Review A* **101**, 062511 (2020).
- [7] P. V. Bilous, H. Bekker, J. C. Berengut, B. Seiferle, L. von der Wense, P. G. Thirolf, T. Pfeifer, J. R. C. López-Urrutia, and A. Pálffy, *Electronic Bridge Excitation in Highly Charged ^{229}Th Ions*, *Physical Review Letters* **124**, 192502 (2020).
- [8] R. X. Schüssler et al., *Detection of Metastable Electronic States by Penning Trap Mass Spectrometry*, *Nature* **581**, 42 (2020).
- [9] L. Mercadier et al., *Evidence of Extreme Ultraviolet Superfluorescence in Xenon*, *Physical Review Letters* **123**, 023201 (2019).
- [10] H. Bekker, A. Borschevsky, Z. Harman, C. H. Keitel, T. Pfeifer, P. O. Schmidt, J. R. Crespo López-Urrutia, and J. C. Berengut, *Detection of the $5p - 4f$ Orbital Crossing and Its Optical Clock Transition in Pr^{9+}* , *Nature Communications* **10**, 5651 (2019).
- [11] H. Bekker, C. Hensel, A. Daniel, A. Windberger, T. Pfeifer, and J. R. Crespo López-Urrutia, *Laboratory Precision Measurements of Optical Emissions from Coronal Iron*, *Physical Review A* **98**, 062514 (2018).
- [12] R. X. Schüssler et al., *Recent Developments at the High-Precision Mass Spectrometer PENTATRAN*, in *Proceedings of the 12th International Conference on Low Energy Antiproton Physics (LEAP2016)*, Vol. 18 (Journal of the Physical Society of Japan, 2017).
- [13] F. Torretti et al., *Optical Spectroscopy of Complex Open-4d-Shell Ions Sn^{7+} - Sn^{10+}* , *Physical Review A* **95**, 042503 (2017).
- [14] A. Windberger et al., *Analysis of the Fine Structure Sn^{11+} - Sn^{14+} Ions by Optical Spectroscopy in An Electron Beam Ion Trap*, *Physical Review A* **94**, 012506 (2016).
- [15] C. Shah et al., *Linear Polarization of x Rays Due to Dielectronic Recombination into Highly Charged Ions*, *Journal of Physics: Conference Series* **635**, 052091 (2015).
- [16] S. W. Epp et al., *Single-Photon Excitation of $K\alpha$ in Heliumlike Kr^{34+} : Results Supporting Quantum Electrodynamics Predictions*, *Physical Review A* **92**, 020502 (2015).
- [17] H. Jörg, Z. Hu, H. Bekker, M. A. Bleszenohl, D. Hollain, S. Fritzsche, A. Surzhykov, J. R. Crespo López-Urrutia, and S. Tashenov, *Linear Polarization of X-Ray Transitions Due to Dielectronic Recombination in Highly Charged Ions*, *Physical Review A* **91**, 042705 (2015).

- [18] R. Steinbrügge et al., *Absolute Measurement of Radiative and Auger Rates of K-shell-vacancy States in Highly Charged Fe Ions*, Physical Review A **91**, 032502 (2015).
- [19] H. Bekker, A. Windberger, O. O. Versolato, M. Binder, R. Klawitter, and J. R. C. López-Urrutia, *Forbidden Optical Transition in Ti-like Xe, Ba, and Ir*, AIP Conference Proceedings **1640**, 109 (2015).
- [20] H. Bekker et al., *Identifications of $5s_{1/2}$ - $5p_{3/2}$ and $5s^2 - 5s5p$ EUV Transitions of Promethium-like Pt, Ir, Os and Re*, Journal of Physics B: Atomic, Molecular and Optical Physics **48**, 144018 (2015).
- [21] A. Windberger et al., *Identification of the Predicted $5s$ - $4f$ Level Crossing Optical Lines with Applications to Metrology and Searches for the Variation of Fundamental Constants*, Physical Review Letters **114**, 150801 (2015).
- [22] M. Nuñez Portela et al., *Ra^+ Ion Trapping: Toward an Atomic Parity Violation Measurement and an Optical Clock*, Applied Physics B **114**, 173 (2014).
- [23] S. E. Müller et al., *First Test of Lorentz Invariance in the Weak Decay of Polarized Nuclei*, Physical Review D **88**, 071901 (2013).
- [24] C. Beilmann, P. Amaro, H. Bekker, Z. Harman, J. R. Crespo López-Urrutia, and S. Tashenov, *Higher-Order Resonant Electronic Recombination as a Manifestation of Configuration Interaction*, Physica Scripta **T156**, 014052 (2013).
- [25] M. Nuñez Portela et al., *Towards a Precise Measurement of Atomic Parity Violation in a Single Ra^+ ion*, Hyperfine Interactions **214**, 157 (2013).
- [26] A. Windberger et al., *Coulomb Crystals in a Cryogenic Paul Trap for Sympathetic Cooling of Molecular Ions and Highly Charged Ions*, AIP Conference Proceedings **1521**, 250 (2013).
- [27] E. Bodewits, H. Bekker, A. J. de Nijs, R. Hoekstra, D. Winklehner, B. Daniel, G. Kowarik, K. Dobes, and F. Aumayr, *Electron Emission Yields from Boron-like Ar Ions Impinging on Au(100)*, Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms **269**, 1203 (2011).