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Preface to the Special Issue of Molecular Physics in Honour of Professor Wim Ubachs

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EDITORIAL

Preface to the Special Issue of Molecular Physics in Honour of Professor Wim Ubachs

This special issue collects articles by colleagues and friends of Wim Ubachs that were submitted on the occasion of his official retirement from the Vrije Universiteit Amsterdam. The topics covered by the special issue span a broad range of scientific activities at the intersection of molecular physics, molecular spectroscopy, atmospheric chemistry, astrophysics, and fundamental physics. These topics were at the heart of Wim's extraordinary career over the past 40 years, reflected by over 350 publications and numerous scientific breakthroughs. The special issue is a tribute to Wim's scientific achievements and to the important role he has played and still plays in these fields. It follows a symposium organised in his honour at the Vrije Universiteit at the occasion of his formal and mandatory retirement.

Wim's scientific career is devoted to precision molecular spectroscopy, with contributions covering all main aspects of this discipline: the development of new instruments, of new spectroscopic methods and their applications to fundamental investigations of molecular structure and dynamics, to atmospheric chemistry and astrophysics, and even to problems related to physics beyond the standard model. Those who have worked closely with Wim were profoundly influenced by his approach to science, and his ability to recognise emerging fields and how to make original contributions in these fields by combining his experience with the experience of those he sought and found as collaborators. Wim's passion and enthusiasm for molecular spectroscopy in particular, and for science in general, his pragmatic approach to new problems, and his ability to work with others inspired numerous collaborations. Through a rare combination of great personal charm, generosity, persuasion and scientific excellence, he inspired generations of PhD students and postdocs and brought numerous national and international collaborations to a success.

Those who visited Wim and his group in Amsterdam or enjoyed his visits to their own institutions were taken by his personal warmth, and with time could share with him more than just science. Wim and his wife Ghislaine offered their generous hospitality to many scientists who came to Amsterdam. Every year they organised a Christmas get-together for the research group, often including ex-members. Their home – a house on a canal in earlier years and a spacious apartment in the very centre of the city more recently – has been arranged with superb taste by Ghislaine and Wim, with the help of their son Jef. On these occasions their friends could discover more facets of the family life (of the Ubachs): their love for concerts and opera performances, sports activities such as bicycle riding in the Dutch plains around Amsterdam, or hiking in the somewhat steeper Alps during their visits abroad. Social exchanges and discussions with Wim, Ghislaine, Jef, and many of their friends coming from a non-scientific background have always been, and still are, inspiring and enriching.

The introductory part of this special issue includes Wim's curriculum vitae and lists of his PhD students, postdocs, and main collaborators. It also includes Wim's full publications list, offering the opportunity of discovering or rediscovering individual items of his incredibly rich and diverse scientific output.

Wim Ubachs received his education from Nijmegen University (now Radboud University), with a Doctorandus degree (equivalent to a Masters degree) in 1982 on a project in solid-state physics carried out at the High-Magnetic-Field Laboratory in Nijmegen. For his PhD-project, which he completed in 1986 under the supervision of Antony Dymanus and Hans ter Meulen, also at Nijmegen, he performed high-resolution spectroscopy of diatomic hydrides (OH, SH, CH, NH) using a narrowband tunable ultraviolet laser. Immediately after his PhD, he visited the Dalian Institute of Chemical Physics for four months in 1986 as one of the first Dutch physicists visiting China and working in Mainland China, based on a bilateral agreement between the Netherlands Ministry of Science and Education and the Chinese Academy of Sciences. After a postdoctoral fellowship at Stanford University with Richard N. Zare, learning about extreme-ultraviolet (XUV) lasers, he returned to the Netherlands in 1988 to join the Atomic Physics research group led by Wim Hogervorst at the Vrije Universiteit Amsterdam, first as a Lecturer, then a Senior Lecturer, before becoming Full Professor in 2003. In Amsterdam, he started a line of research on broadly tunable, narrowband XUV laser radiation and its application in precision molecular

spectroscopy, as one of the first in Europe. This subject remained a central theme throughout his career. Particular highlights were the first laser excitation of helium at 58 nm and the determination of the Lamb shift in the ground state of helium with one of his first PhD students and later colleague Kjeld Eikema, initially using a narrowband Fourier-transform-limited XUV laser source, and later employing XUV Ramsey spectroscopy using pulses from a frequency-comb laser.

The research program on precision spectroscopy with XUV lasers developed in various directions. The narrow bandwidth XUV radiation sources allowed for detailed measurements of perturbation and predissociation phenomena in the carbon monoxide and nitrogen molecules, in connection to astrophysics and atmospheric physics. This line of research was strengthened when the vacuum-ultraviolet Fourier-transform spectrometer was opened at the DESIRS beamline of the synchrotron 'Soleil' in Paris in 2007. Wim and his group became frequent users of this advanced facility, investigating pre-dissociation in electronically excited states of N_2 and CO. He also measured the lifetimes of excited states in these molecules by time-domain pump-probe spectroscopy using VUV picosecond lasers during multiple visits and collaborating with scientists from the Lund Laser Centre.

An important focus of his work in XUV laser spectroscopy concerned measurements in molecular hydrogen, starting with a first publication in 1994 and eventually leading to over 100 papers on the subject, with activities still on-going. XUV-laser sources were combined in multiple-laser resonance techniques, demonstrating the excitation of long-lived outer-well states above the ionisation limit, that are resistant to autoionisation. He opened the subject of 'heavy Rydberg states', first probing such states in the time domain via coherent spectroscopy, and later also in the frequency domain through a spectroscopic measurement of a Rydberg series in the H^+H^- system, analogous to a 'heavy Bohr atom'. The application of double-resonance techniques in the hydrogen molecule also involved measurements of inter-Rydberg transitions in H_2 as a possible carrier of the diffuse interstellar bands.

In a separate activity, Wim and his group exploited cavity ring-down (CRD) spectroscopy to determine the absorption cross sections of water vapour in the visible range for the retrieval of the water–vapour column density from satellite data (from the GOME and SCIAMACHY satellites). With this technique, he established the first direct measurement of Rayleigh-scattering cross sections of gases, which had previously always been extracted from refractive indices since Rayleigh's first derivation. In a collaboration with Harold Linnartz from the Leiden Laboratory of Astrophysics, the CRD setup was combined with a slit-jet plasma-expansion source for the spectroscopic investigation of carbon-chain molecules, with the goal of identifying possible carriers of the Diffuse Interstellar Bands. Several ultraviolet bands of C_3 could be detected in a translucent interstellar cloud, a Renner-Teller analysis was performed for C_6H in its electronically excited manifold, and the structures of C_9H_3 and $C_{11}H_3$ were determined from isotopic substitution in the plasma. Wim also applied CRD spectroscopy to the study of collision-induced resonances in the O_2–O_2 system, of relevance for the analysis of clouds in the atmosphere from satellite data. As a further application of molecular spectroscopy in atmospheric physics, Wim and his group developed a powerful approach for measuring Rayleigh–Brillouin scattering spectral profiles of molecular gases including air, in connection to the ADM-Aeolus satellite mission of the European Space Agency to observe the Earth's wind profile based on LIDAR. Besides obtaining pressure- and temperature-dependent scattering profiles, this work also led to methods of determining bulk viscosities and thermodynamic properties of gases.

In the past two decades, the main focus of Wim's work has been on precision spectroscopy of hydrogen molecules for testing fundamental physics theories. Through laboratory laser spectroscopy, the transition frequencies of over 160 lines in the Lyman and Werner bands were measured at a relative frequency accuracy $(\Delta\nu/\nu)$ of 5×10^{-8}. The same lines could be detected in astronomical spectra of absorbing galaxies in the line of sight of distant quasars. Wim and his team, in collaboration with Michael Murphy (Melbourne), performed observations at the ESO Very Large Telescope on various quasars. From a detailed analysis of the 10 best H_2/HD high-redshift absorbers and a quantitative comparison of the laboratory with the quasar data, an upper limit for a possible space-time variation of the proton-to-electron mass ratio was derived: this constant of nature varied by less than 5×10^{-6} over the past 10–12 billion years, if at all. The team also put a constraint on a dependence of this constant on gravitational fields by analysing H_2 absorption in the photosphere of white dwarf stars in our galaxy using data from the Hubble Space Telescope. In a parallel effort, his team, in particular involving colleague Hendrick Bethlem, had discovered, from calculations, that the methanol molecule is the most sensitive probe to detect a possible variation of the proton-to-electron mass ratio. This finding ignited a program in radio astronomy (collaborating with Karl Menten of the Max Planck Institute at Bonn), using the Effelsberg, IRAM and ALMA radio telescopes detecting methanol, all in one single absorbing galaxy at redshift $z = 0.88$, which led to a constraint on a varying proton-to-electron

mass ratio of less than 10^{-7} at half the age of the Universe.

The precision measurements of hydrogen molecules in Wim's team were extended to all six isotopomers H_2, HD, D_2, HT, DT and T_2, with the goal of testing quantum-electrodynamics (QED) calculations in molecules. In particular, the dissociation and ionisation energies of H_2, D_2 and HD were determined in a collaboration involving Amsterdam, Zurich (group of Frédéric Merkt) and Orsay (Christian Jungen). The results were compared with the results of full theoretical calculations including nonadiabatic, relativistic and QED corrections performed by Krzysztof Pachucki (Warsaw) and his co-workers, finding excellent agreement so far. Wim also demonstrated spectroscopy of the highest vibrational states (up to $v = 14$) in hydrogen by the innovative method of photodissociation of H_2S to test molecular quantum mechanics at large internuclear separations. Besides testing QED calculations in molecules, the extensive range of results on molecular hydrogen also led to constraints on the existence of potential 'fifth' forces and higher dimensions in the realm of physics beyond the Standard Model of Particle Physics.

Wim was involved in other spectroscopic studies of molecules for fundamental physics. In Amsterdam, he collaborated with his colleague Jeroen Koelemeij to perform a precision measurement of vibrational transitions in the HD^+ ion, which has led to the determination of the value for the proton-to-electron mass ratio at the parts-per-trillion level, currently the most precise determination of this fundamental property of nature. He is also involved in a Netherlands collaboration (NL-eEDM), with scientists from Groningen University, aimed at measuring the electric dipole moment of the electron (eEDM), using the BaF molecule. His recent work in precision metrology of neutral hydrogen is devoted to investigations of ro-vibrational transitions in the ground state. Using a novel approach based on NICE-OHMS (noise-immune cavity-enhanced optical-heterodyne molecular spectroscopy), his group performed saturation spectroscopy on the very weak (2-0) overtone transitions in HD. Very recently, this work was extended to measure a Lamb dip in a quadrupole transition of a molecule, in this case H_2, opening a new territory of precision metrology for testing fundamental physics.

Wim's activity had impact beyond the scientific activities listed above. Based on his unique experience in XUV-laser radiation, Wim played a key role in setting up the LaserLaB in Amsterdam with Wim Hogervorst, which rapidly became a central facility of the Vrije Universiteit, gathering groups workings in areas as diverse as chemistry, biophysics and metrology. He was also strategically and scientifically involved in establishing the Advanced Research Center for NanoLithography (ARCNL) on the Amsterdam Science Campus, which is funded by the company ASML (world market leader in wafer stepper equipment for the production of computer chips), the Dutch Research Council (NWO) and the two Amsterdam universities, the Vrije Universiteit Amsterdam and the University of Amsterdam. In 2014, he set up a 'second' group at ARCNL, with Oscar Versolato and Ronnie Hoekstra, devoted to the investigation of laser-produced plasma of tin microdroplets for the generation of Extreme Ultraviolet light (at 13.5 nm) used in the advanced lithography machines of ASML.

The vigour of Wim's activities at the Vrije Universiteit on hydrogen metrology, and his activities within the NL-eEDM collaboration, and at ARCNL, have not been affected by his official retirement. It is a great joy for all his colleagues and friends to see these activities flourishing.

Wim, on behalf of all your friends and colleagues, we thank you and wish you much success in your numerous post-retirement projects!

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k.s.e.eikema@vu.nl
Christian Jungen
CNRS, Laboratoire Aimé Cotton, Université Paris-Saclay, Orsay, France
Frédéric Merkt
Laboratory of Physical Chemistry, ETH Zurich, Zurich, Switzerland
merkt@phys.chem.ethz.ch

Appendix 1: Curriculum Vitae of Wim Ubachs

Affiliations
(1) Department of Physics and Astronomy, Vrije Universiteit Amsterdam, Emeritus professor
(2) Advanced Research Center for NanoLithography, Amsterdam
Research ID: F-5649-2011
URL for web sites: www.few.vu.nl/ wimu and https://arcnl.nl/research-groups/euv-plasma-processes
Email: w.m.g.ubachs@vu.nl; ubachs@arcnl.nl

- **EDUCATION**
  - 1986 PhD, Department of Physics and Astronomy, Radboud University of Nijmegen, Netherlands; Thesis entitled "High-resolution laser spectroscopy of diatomic hydrides", with advisors Prof. Antony Dymanus and Prof. Hans ter Meulen.
  - 1982 Master of Physics, Department of Physics and Astronomy, Solid State Physics and High-Magnetic Field Laboratory, Radboud University of Nijmegen, Netherlands
- **PREVIOUS POSITIONS**
  - 1986 Visiting Scientist (KNAW scholarship) at the Dalian Institute of Chemical Physics, Chinese Academy of Sciences, Dalian, China
  - 1987–1988 PostDoctoral Fellow, Department of Chemistry, Stanford University, USA
  - 1988–2003 Lecturer and Senior Lecturer at Department of Physics, Vrije Universiteit Amsterdam
  - 2001–2004 Endowed Professor, Technical University Eindhoven, The Netherlands
  - 2003– Full Professor of Atomic, Molecular and Laser Physics, Vrije Universiteit Amsterdam
- **INSTITUTIONAL RESPONSIBILITIES**
  - 2000–2010 Director of Laser Centre Vrije Universiteit Amsterdam
  - 2010–2014 Head of Department of Physics, Vrije Universiteit Amsterdam
- **FELLOWSHIPS AND AWARDS**
  - 2002 Guest Professorship, ETH Zürich, Switzerland
  - 2006 Guest Professorship at the Tokyo University of Science
  - 2012 Prize, Templeton Foundation, New Frontiers in Astronomy and Cosmology
  - 2015 ERC Advanced grant
  - 2017 Appointed Fellow of the American Physical Society
- **COMMISSIONS OF TRUST**
  - 2010–2014 Scientific Advisory Board, FOM Institute AMOLF, Amsterdam
  - 2008–2012 Scientific Advisory Board, National Laser Centre of South Africa, Pretoria
  - 2012– Review panel member, German Excellence Initiative for University Research (various)
  - 2007– Editorial Board Molecular Physics
    Editorial Board: Journal of Molecular Spectroscopy
  - 2003–2013 International Scientific Committees: HRMS Dijon; ICOLS
  - 2005–2011 Board of "Stichting Physica", Dutch funding organization supporting outreach activities
  - 2005–2009 Board of EPS-AMO Division
  - 2003–2010 Member of Participants Council of LaserLaB-Europe
  - 2009–2011 Member of the Strategic and Technical Advisory Committee of the VIRGO gravitational wave detector
  - 2021– Scientific Advisory Committee, HFML-FELIX infrastructure at Radboud University Nijmegen
- **MEMBERSHIPS OF SCIENTIFIC SOCIETIES**
  - > 25 years Member of Netherlands Physical Society (NNV), European Physical Society (EPS) and American Physical Society (APS)
- **REFEREEING**

Ubachs has been a regular referee for a large number of journals, most notably Phys. Rev. Lett., Phys. Rev. A, J. Phys. B, Optics Letters, Optics Express, Science. In addition, he was referee panel member for DPG (Germany) and Alexander von Humboldt Foundation (Germany), NSF (USA), EPSRC (UK), as well as Australian, South-African, French, Swiss, and Canadian national funding agencies.
Highlights and awards for refereeing:

- Outstanding reviewer for the Journal of Molecular Spectroscopy
- Outstanding reviewer for the Journal of Quantitative Spectroscopy and Radiative Transfer
- Top reviewer for The Journal of Chemical Physics (2015)

- **SCIENTIFIC COLLABORATIONS**

Wim Ubachs has collaborated with many scientists from all over the world:

The team of Quantum Metrology and Laser Applications (formerly Atomic Physics) at LaserLab VU Amsterdam: Wim Hogervorst, Kjeld Eikema, Wim Vassen, Edcel Salumbides, Hendrick Bethlem, Jeroen Koelemeij, Max Beyer and Laura Dreissen;

The colleagues at ARCNL: Oscar Versolato and Ronnie Hoekstra from the EUV Plasma Physics Processes and EUV Source group, Stefan Witte from the EUV Generation and Imaging group, and John Sheil from the Plasma Theory and Modelling group;

The eEDM-NL team: Steven Hoekstra, Hendrick Bethlem, Anastasia Borschevsky, Klaus Jungmann, Rob Timmermans, Lorenz Willmann, Groningen (Netherlands) – Measurement of the electric dipole moment of the electron;

Frédéric Merkt, ETH Zürich (Switzerland) – Precision spectroscopy of molecular hydrogen;

Krzysztof Pachucki, University of Warsaw, and Jacek Komasa and Mariusz Puchalski, University of Poznan (Poland) – QED tests of hydrogen molecules;

Harold Linnartz, Leiden University (Netherlands) and DongFeng Zhao, USTC Hefei (China) – Cavity-ring-down spectroscopy and laboratory astrophysics;

Michael Murphy, Swinburne University, and John Webb, UNSW Sydney (Australia) – Astronomical observation, quasar absorption spectra and varying constants;

Christian Jungen, Laboratoire Aimé Cotton, Orsay (France) – Excited states of molecular hydrogen;

Lutoslaw Wolniewicz – Double well states in hydrogen;

Shuiming Hu and Cunfeng Cheng, USTC Hefei (China) – Precision spectroscopy of molecular hydrogen;

Karl Menten and Christian Henkel, Max Planck Institut für Radioastronomie Bonn (Germany), Dr. Sebastien Muller, Onsala Space Observatory (Sweden), Nissim Kanekar, Tata Institute, Pune (India) and Sergei Levshakov, Ioffe Institute, St. Petersburg (Russia) – Radio astronomy for varying constants;

Nelson de Oliveira and Laurent Nahon, Synchrotron Soleil Paris (France) – synchrotron FT-VUV studies of molecules;

Isabelle Kleiner, LISA and Université Diderot Paris (France) – Polyatomic molecules and varying constants;

Anne L'Huillier and Claes-Göran Wahlström, Lund Laser Centre (Sweden) – Lifetime studies in CO and nitrogen molecules with picosecond VUV-lasers;

Patrice Cacciani, Université de Lille (France) – Predissociation in carbon monoxide;

Rafal Hakalla, University Rzeszow (Poland) and Bob Field, MIT (USA) – Spectroscopy of carbon monoxide;

Peter Sorokin and Jim Glownia, IBM New York – Diffuse Interstellar bands

Brenton Lewis and Ken Baldwin, ANU Canberra (Australia) – Predissociation studies of nitrogen;

Lydia Tchang-Brillet and Evelyne Roueff, Observatoire de Paris, Meudon (France) – VUV spectroscopy of molecules, and theory of varying constants in hydrogen molecules;

Alan Heays and Ewine van Dishoeck, Leiden University (Netherlands) – Astrochemistry studies;

Steven Stolte and Kees de Lange, VU Amsterdam (Netherlands) – Molecular photoionisation and photodissociation studies;

Attila G. Császár and Roland Tobias, Budapest (Hungary), and Cristina Puzzarini (Bologna) – Saturation spectroscopy of water;

Kun Liang, Huazhong University, Wuhan (China), Benjamin Witschas, DLR Oberpfaffenhofen (Germany), Willem van de Water, TU Delft (Netherlands), and Wilson Marques Jr, Curitiba (Brasil) – Rayleigh-Brillouin scattering in gases;

Magnus Schlösser, Karlsruhe Institute of Technology (Germany) – Spectroscopy of tritiated hydrogen molecules;

Jean-Philippe Karr and Laurent Hilico, Laboratoire Kastler Brossel, ENS, Paris (France) and Vladimir Korobov, Bogoliubov Laboratory, Dubna (Russia) – Spectroscopy of HD^+;

Taco Visser, VU Amsterdam and Institute of Optics, Rochester (USA) – Plasmonics;

José Crespo, Max Planck Institute for Nuclear Physics, Heidelberg (Germany) – EBIT spectroscopy of Sn ions.

Bert Schellekens and Beatriz Gato-Rivera (Nikhef, Amsterdam) – Extra dimensions

- **PhD STUDENTS OF WIM UBACHS**

Wim Ubachs supervised a large number of PhD students and acted as Promotor or Co-Promotor at their Thesis defence. Below a full list of PhD students is given with name, country of origin, Thesis title and date of defence:

Kin Fung Lai (HongKong)
Laser precision spectroscopy on hydrogen isotopologues:
Tritiated molecules and vibrationally excited H_2
Defense: 28 June 2022

Joel Hussels (Netherlands)
Improved determination of the dissociation energy of H_2, HD, and D_2
Defense: 6 Dec 2021

Ruben Schupp (Germany)
Spectral characterization of solid-state laser-driven plasma sources of EUV light
Defense: 17 Mar 2021

Ruud van der Beek (Netherlands)
Bloch oscillations of meta-stable helium in an optical lattice
Defense: 17 Mar 2021

Joris Scheers (Netherlands)
Charge-state-resolved spectroscopy of multiply-charged tin ions
Defense: 10 Nov 2020

Xia Zhang (China)
Theoretical study of rotationally inelastic scattering of molecules
Defense: 5 March 2020

Francesco Torretti (Italy)
Spectroscopy of highly-charged Sn ions for extreme ultraviolet nanolithography
Defense: 19 December 2019

Yuanqing Wang (China)
Spontaneous Rayleigh-Brillouin Scattering in Molecular Gases
Defense: 4 December 2019

Xavier Bacalla (Philippines)
Electronic Spectroscopy of Molecules of Astrophysical Interest;
Towards improving our knowledge of the DIB carriers
Defense: 2 July 2019 (Leiden)

Mart-Johan Deuzeman (Netherlands)
Generation and interaction of energetic tin ions
Defense: 21 June 2019 (Groningen)

Sayan Patra (India)
Towards Doppler-free two-photon spectroscopy of trapped and cooled HD^+ ions
Defense: 9 May 2019

Dmitry Kurilovich (Belarus)
Laser-induced dynamics of liquid tin microdroplets
Defense: 4 April 2019

Madhu Talluri Trivikram (India)
High-Precision REMPI and CARS studies on molecular hydrogen and tritium
Defense: 7 February 2019

Bob Rengelink (Netherlands)
A magic wavelength optical dipole trap for high-precision spectroscopy of ultracold metastable helium
Defense: 10 December 2018

Robert Altman (Netherlands)
Ramsey-comb spectroscopy in the deep ultraviolet for tests of molecular quantum theory
Defense: 13 November 2018

Aernout van der Poel (Netherlands)
Cold Collisions in a Molecular Synchrotron
Defense: 13 March 2018

Mario Dapra (Italy)
Search for drifting constants of nature via optical and radio astronomy
Defense: 20 November 2017

Adonis Silva Flores (Philippines)
An ultracold, optically trapped mixture of ^{87}Rb and metastable ^{4}He atoms
Defense: 30 May 2017

Remy Notermans (Netherlands)
High-Precision spectroscopy of Forbidden Transitions in Ultracold ^{4}He and ^{3}He
Defense: 15 March 2017

Jurriaan Biesheuvel (Netherlands)
Probing QED and fundamental constants through vibrational spectroscopy of HD^{+}
Defense: 28 June 2016

Mingli Niu (China)
High Resolution Laser and Synchrotron Spectroscopic Studies on H_2 and CO
Defense: 30 November 2015

Mohammad Rafiee Fanood (Iran)
Molecular chirality under the reaction microscope:
Mass-selective photoelectron circular dichroism of pure and multi-component enantiomeric mixtures
Defense: 22 October 2015

Congsen Meng (China)
Femtosecond laser detection of xenon and Stark decelerated polyatomic molecules
Defense: 30 June 2015

Julija Bagdonaite (Lithuania)
Search for a variation of the proton-electron mass ratio from molecular hydrogen and methanol
Defense: 7 April 2015

Ziyu Gu (China)
Spontaneous Rayleigh-Brillouin Scattering on Atmospheric Gases
Defense: 23 March 2015

Adrian J. de Nijs (Netherlands)
Molecular radicals in the search for drifting constants
Defense: 2 October 2014

Marina Quintero Perez (Spain)
Preparation of an ultra-cold sample of ammonia molecules for precision measurements
Defense: 8 September 2014

Mohammad Ali Haddad (Iran)
Cavity Ring-Down Laser Spectroscopy of Carbon-Chain Molecules
Defense: 24 March 2014

Paul Jansen (Netherlands)
Polyatomic molecules for probing a possible variation of the proton-to-electron mass ratio
Defense: 1 July 2013

Gareth Dickenson (South Africa)
Laser and Synchrotron Spectroscopic Studies of Molecular Hydrogen
Defense: 8 May 2013

Shreyas Raghunathan (India)
Studies in Physical optics; Coherence Theory and Surface Plasmons
Defense: 3 May 2013 (TU Delft)

Rob van Rooij (Netherlands)
Frequency Metrology in Quantum Degenerate Helium
Defense: 8 June 2012

Dominik Kandula (Poland)
XUV Frequency Comb Metrology and the Ground State of Helium
Defense: 1 December 2011

Anne Lisa Wolf (Netherlands)
Frequency comb spectroscopy on trapped calcium ions
Defense: 7 July 2011

Thomas van Dijk (Netherlands)
Experimental and Theoretical studies in Optical Coherence Theory
Defense: 4 April 2011

Maria Ofelia Vieitez Hornos (Uruguay)
XUV laser studies of Rydberg-valence states in N_2 and H^+H^- heavy Rydberg states
Defense: 2 June 2010

Toncho Ivanov (Bulgaria)
XUV spectroscopy of highly excited states in H_2, HD and D_2
Defense: 7 December 2010

Dmitry Ityaksov (Russia)
Cavity Ring-Down Optical Extinction Measurements of Atmospheric Molecules
Defense: 30 November 2009

Edcel John Salumbides (Philippines)
Laser metrology studies for probing variation of fundamental constants
Defense: 26 May 2009

Lineke van der Sneppen (Netherlands)
Liquid-phase cavity ring-down spectroscopy for improved analytical detection sensitivity
Defense: 10 November 2008

Sandro Hannemann (Germany)
Deep-ultraviolet frequency metrology with a narrowband titanium: sapphire laser
Defense: 24 May 2007

Arjan Sprengers (Netherlands)
Extreme ultraviolet laser excitation of molecular nitrogen; perturbations and predissociation
Defense: 29 June 2006

Marc Smits (Netherlands)
Multi active electron effects in the strong field ionization of transition metal atoms and clusters
Defense: 22 February 2005

Maarten Sneep (Netherlands)
The atmosphere in the laboratory: cavity ring-down measurements on scattering and absorption
Defense: 23 November 2004

Fernando Brandi (Italy)
Table-top tunable narrow-band extreme ultraviolet sources: from low to high-order optical harmonic generation
Defense: 1 July 2004

Ruediger Lang (Germany)
Spectral Sampling Techniques for Atmospheric modeling
Defense: 31 October 2002

Arno de Lange (Netherlands)
XUV Multi-resonance spectroscopy of hydrogen and nitrogen
Defense: 14 February 2002

Iavor Velchev (Bulgaria)
Stimulated Brillouin Scattering Pulse Compression and Harmonic Generation
Defense: 7 June 2001

Hans Naus (Netherlands)
Cavity Ring-Down Spectroscopy on Atmospheric Molecules
Defense: 13 February 2001

Elmar Reinhold (Germany)
Extreme Ultraviolet Laser Spectroscopy of the hydrogen molecule: excited states with large internuclear separation
Defense: 18 May 2000

Paul Hinnen (Netherlands)
XUV-laser spectroscopy of H_2 and the mystery of the diffuse interstellar bands
Defense: 15 September 1997

Kjeld Eikema (Netherlands)
QED and the ground state of helium; precision extreme ultraviolet laser spectroscopy
Defense: 24 June 1996

Robert van Leeuwen (Netherlands)
Electron correlation in autoionizing states of barium
Defense: 11 December 1995

Pieternel Levelt (Netherlands)
A coherent XUV-source for high resolution spectroscopy: application to diatomic molecules
Defense: 11 November 1992

Ilse Aben (Netherlands)
Resonance CARS in I_2 and Br_2
Defense: 29 September 1992

Robert de Graaf (Netherlands)
Dielectronic states in barium
Defense: 17 October 1991

PhD students currently working with Wim Ubachs as (Co)-Supervisor:
Frank Cozijn (Netherlands), Meissa Diouf (Senegal), Lars Behnke (Germany)
Zoi Bouza (Greece), **Charlaine Roth** (Switzerland), **Maarten Mooij** (Netherlands)
Elmer Gründeman (Netherlands), **Wander van der Meer** (Netherlands)
Yahia Mostafa (Egypt)

Post-Docs having worked with Wim Ubachs:
Stephan Schiemann, Wojtek Majewski, Dragomir Neshev, Urs Hollenstein, Josselin Philip, Eric-Jan van Duijn, Alan Heays, DongFeng Zhao, CunFeng Cheng, Chris Medcraft, Matthias Germann

Appendix 2: Publication list of Wim Ubachs

[387] F.M.J. Cozijn, M.L. Diouf, W. Ubachs,
Lamb dip of a quadrupole transition in H_2
arXiv: 2303.17818 (2023).

[386] A. Boeschoten, V.R. Marshall, T.B. Meijknecht, A. Touwen, H.L. Bethlem, A. Borschevsky, S. Hoekstra, J.W.F. van Hofslot, K. Jungmann, M.C. Mooij, R.G.E. Timmermans, W. Ubachs, L. Willmann,
Novel spin-precession method for sensitive EDM searches
arXiv: 2303.06402 (2003).

[385] K.-F. Lai, M. Beyer, W. Ubachs,
Spectroscopic study of the $F^1\Sigma_g^+$ outer well state in H_2, HD and D_2
J. Mol. Spectr. 393, 111778 (2023).

[384] M.L. Diouf, R. Tobias, F.M.J. Cozijn, E.J. Salumbides, C. Fabri, C. Puzzarini, A.G. Csaszar, W. Ubachs,
Parity-pair-mixing effects in nonlinear spectroscopy of HDO
Opt. Express 30, 46040-46059 (2022).

[383] F.M.J. Cozijn, M.L. Diouf, W. Ubachs,
Saturation spectroscopy of R(0), R(2) and P(2) lines in the (2-0) band of HD
Eur. J. Phys. D 76, 220 (2022).

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