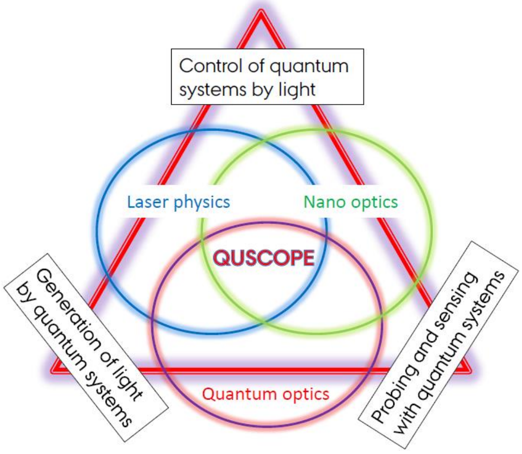
Villum Foundation Centre of Excellence

QUSCOPE



Annual Report, 2015.

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Annual report for QUSCOPE, 2015

Introduction

The Villum Foundation Centre of Excellence, QUSCOPE, is a collaborative effort among three research groups at the University of Aarhus and the University of Aalborg in Denmark. The purpose of QUSCOPE is to use the experience and insights in quantum optics, laser physics and nanooptics, developed in the three member teams in Aarhus and Aalborg. QUSCOPE studies optical processes on the quantum scale in different physical systems ranging from atoms and molecules to solid state devices under the unifying research themes: *quantum dynamics induced and controlled by light*, *generation of light by quantum systems* and *probing of quantum dynamics by light.*

QUSCOPE has been funded, based on a research application for the period January 1, 2014- December 31, 2018, and the Centre has now been in operation for two years. We have recruited several PhD students and postdocs, and many of our planned research projects are now running full steam.

We are happy that Professor Stephan W. Koch, Marburg, Germany, Professor Päivi Törmä, Helsinki, Finland, and Professor Jan Petter Hansen, Bergen, Norway, have accepted to serve as advisory board for the Centre of Excellence. Their insight and guidance will be helpful for our planning of new and long term research activities in QUSCOPE.

In this report, we present a brief summary of the current recruitment status, the activities, the budget, and the research achievements obtained so far in QUSCOPE.

We wish to draw attention to the QUSCOPE webpage which is continuously updated with news, activities in the Centre, publications, contact information, etc.:

http://phys.au.dk/forskning/forskningsomraader/quscope/

Staff and students

Durig 2015, QUSCOPE has consisted of the three group leaders, Klaus Mølmer, Thomas Garm Pedersen and Lars Bojer Madsen, 14 postdocs and 16 PhD students. The group leaders in addition supervise bachelor and master thesis projects within topics related to the QUSCOPE research. The Centre furthermore disposes of part time assistance from a secretary and an IT-expert.

The QUSCOPE research teams receive funding from different sources, including the Universities of Aarhus and Aalborg, Danish national sources, EU and the US. Since we want all students and postdocs to benefit from (and contribute to) the QUSCOPE activities and projects, we make no difference between them in our daily work, and we count all students and postdocs as members of QUSCOPE, irrespective of the actual funding sources covering their salaries and other expenses.

Postdocs:

Ralf Blattmann (Q)	April 1, 2015 – March 31, 2017
Mads L. Trolle (Q)	January 2015 – September 2015
Haruhide Miyagi	December 1, 2011 – November 30, 2016
Lukas Buchmann	October 1, 2015 – September 30, 2017
Siddharta Chattopadhay	May 1, 2014 – April 30, 2016
Daniel Reich (Q)	September 1, 2015 – August 31, 2016
Camille Lévêque (Q – 1 year)	November 1, 2014 – October 31, 2016
Andrew Wade	November 1, 2015 – April 30, 2016
Tarek Elsayed* (Q)	September 1, 2015 – August 31, 2017
Darko Dimitrovski* (Q)	September 2015 – September 2017
Yuan Zhang* (Q)	September 1, 2015 – August 31, 2017
Juan Omiste (Q – 1 year)	February 1, 2016 –January 31, 2017 and August 1, 2014 – July 31, 2015
Durga B. Dasari	December 1, 2012 – January 31, 2016
Malte C. Tichy	October 1, 2011 – September 30, 2015

*: Three postdocs were employed in September 2015 for two year periods to specifically strengthen the collaborative effort between the teams.

PhD students:

Christian Kraglund Andersen	August 1, 2011– July 31, 2016
Andrew Wade	May 15, 2012 – October 15, 2015
Jens Bækhøj	August 1, 2012 – July 31, 2016
Jens Svensmark	August 1, 2012 – July 31, 2016
Lun Yue	February 1, 2013 – January 1, 2016
Kenneth Hansen (Q)	October 1, 2014 – September 30, 2018
Chuan Yu (Q)	October 1, 2014 – September 30, 2017
Alexander Holm Kiilerich (Q)	August 1, 2014 – July 31, 2018
Eliska Greplova (Q)	November 1, 2014 – October 31, 2017
Farzad Bonabi (Q)	January 2015 – January 2018
Jinglei Zhang (Q)	April 15, 2015 – April 14, 2018
Jørgen Johansen Rørstad (Q)	December 1, 2015 – November 30, 2018
Qingli Jing	September 1, 2015 – July 31, 2018
Rene Petersen	September 2014 – August 2017
Søren Bruun	September 2013 – August 2016
Morten R. Thomsen	September 2013 – August 2016

“(Q)” denotes the postdocs and students, financed by the QUSCOPE grant.

QUSCOPE Centre Events, 2015

2015

January 29-30	Retreat for the full QUSCOPE Centre to Bramslev Gaard
January 5-16	PhD course in Aalborg on "Nonlinear nano-optics"
March 11	**Status and open problems of lattice field theories** Karl Jansen, DESY
March 12	**The challenge of achieving quantum supremacy in quantum simulators** Matthias Troyer, ETH Zürich
March 13	**Elucidating the dynamics of single photosynthetic light-harvesting complexes** Gabriela S. Schlau-Cohen, MIT
May 4	**Quantum Emulators – Simulating few- and many-body physics with Rydberg atoms** David Petrosyan, FORTH- Crete & AIAS Aarhus.
May 5	**Dynamical phase transitions as a resource for quantum enhanced metrology** Katarzyna Macieszczak , University of Nottingham
June 4	**Hybrid quantum systems: NV-centers, quantum dots and recent fantasies about rare-earth doped crystals** Signe Seidelin, Institut Néel, CNRS, Grenoble, France
August 31	**Strongly interacting bosons on optical lattice ladders with flux** Ulrich Schollwöck, University of Munich
Aug. 31-Sept. 1	**Study group and mini-course on Matrix Product States in Aarhus:** **Simulating strongly correlated quantum systems with matrix product states** Ulrich Schollwöck, University of Munich
November 16	**Optimized remote entanglement and stabilization with circuit QED** Felix Motzoi, University of California, Berkeley and Saarland University, Germany
December 14	**Thermalization in a 1D Rydberg gas: validity of the microcanonical ensemble hypothesis,** Ruben Cohen, Laboratoire Aimé Cotton, Orsay, France
December 16	**Fractional quantum Hall physics in lattice systems** Anne E.B. Nielsen
December 17	**QUSCOPE joint meeting, Aarhus**

Economy

Total spending by QUSCOPE in 2015.

Projekt 16437 (AU+AAU):	Forbrug 2015	Budget 2015	Rest pr. 31/12-15	
Løn Post doc	1.341.921	1.791.708,38	449.787	
Løn PHD	1.850.407	1.892.481,16	42.075	
Løn TAP support	397.764	397.264,11	(500)	
Drift	572.935	788.869,42	215.934	
Apparatur	70.958	149.000,00	78.042	
I ALT	**4.233.985**	**5.019.323**	**785.338**	**Overskud**

As described below, the underspending is due to the late employment of the last QUSCOPE PhD student. A student will be employed this year, and we have obtained co-financing to cover his or her grant beyond the duration of QUSCOPE, while the money, thus saved, will be transferred to other QUSCOPE expenses.

Aarhus:

Projekt 16437 (AU):	Forbrug 2015	Budget 2015	Rest pr. 31/12-15	
Løn Post doc	778.017,77	878.708,38	100.690,61	
Løn PHD	1.320.112,67	1.155.481,16	-164.631,51	
Løn TAP support	397.764,30	397.264,11	-500,19	
Drift	487.160,22	498.869,42	11.709,20	
Apparatur	70.958,00	149.000,00	78.042,00	
I ALT	**3.054.012,96**	**3.079.323,07**	**25.310,11**	**Overskud**

In Aarhus, the spending closely follows the budget, incorporating the underspending in 2014.

Aalborg:

Projekt 16437 (AAU):	Forbrug 2015	Budget 2015	Rest pr. 31/12-15	
Løn Post doc	563.903,12	913.000,00	349.096,88	
Løn PHD	530.293,91	737.000,00	206.706,09	
Løn TAP support	-	-	-	
Drift	85.775,05	290.000,00	204.224,95	
Apparatur	-	-	-	
I ALT	**1.179.972,08**	**1.940.000,00**	**760.027,92**	**Overskud**

In Aalborg, the PhD programs have been delayed due to lack of qualified applicants. Two programs have been started and will be fully financed by the QUSCOPE grant. A third program is planned to start Sep. 2016 and will be partly co-financed by the Institutes of Physics and Mathematics at Aalborg University.

For details from accounting service, see separate attachment to the report.

Research

QUSCOPE has initiated a number of projects. We present here a brief summary of some of our results obtained in 2015, organized by the research themes.

[Numbers in brackets] refer to the list of publications in the end of the report.

Theme A: Quantum dynamics induced and controlled by light

In relation to the research themes A.1: *Transient absorption* and A.2: *Electron nuclear correlation*, we have investigated the effects of nuclear motion on attosecond transient absorption spectroscopy (ATAS) [31,41] and in tunneling ionization of diatomic molecules [15].

In ATAS, it was shown that the nature of the nuclear motion, whether bound or dissociative, imprints unique features on the absorption spectra which, in turn, give access to nuclear motion on an ultrafast time scale. In the tunneling process [15], we developed a theory which treats both electronic and nuclear degrees of motion on an equal footing; quantum mechanically and correctly includes dipole and long-range effects. The formulation of theory in this tunneling domain is very important in view of the current development of intense short-pulsed laser sources with carrier wavelengths in the mid-infrared.

A novel approach to nonperturbative effects, such as tunneling ionization based on hypergeometric resummation of divergent series has been developed and published in Phys. Rev. Lett. [49].

In relation to the research theme A.3: *Quantum information with neutral atoms*, we have used the so-called measurement back action to prepare particularly correlated states of atomic gases [39,59] with possible applications for precision measurements and quantum information tasks. We have devised new methods to prepare single neutral atom states for quantum computing [30], and we have characterized the role of errors in the corresponding gate schemes [19]

In relation to the research theme A.4: *Quantum information with hybrid, atomic and solid state systems*, we have presented an overview of the challenges and a series of solutions to connect very different systems at the quantum level [25], and, together with experimentalists, we have demonstrated transfer and storage of quantum states from short lived superconducting electronic circuits into long lived spin ensembles [40].

Theme B: Generation of light by quantum systems

In relation to the research themes B.1: *Single-electron models of HHG* and B.2 *Many-electron models HHG*, we mention the works [32] and [47] performed in an international collaboration and based on experimental data from the group of Prof. H.J. Wörner at ETH Zürich, Switzerland.

In [32], it was shown how the method of high-order harmonic spectroscopy (HHS) is capable of capturing the modification of molecular orbitals. Moreover, it was pointed out that such modification should be taken into account in various tomographic methods currently being developed in emerging attosecond science technologies.

In the work [47], the HHS method was used to measure and control charge migration in a molecule for the first time. In both cases QUSCOPE contributed to the theory component of the works.

In the works [33,54,55,51], the linear and nonlinear optical response of solid-state systems was analyzed. In the case of MoS2, we have demonstrated that many-body effects are indispensable by comparison to measured nonlinear spectra [55]. Similarly, pronounced many-body effects in radiative lifetimes and intraband polarization have been predicted for various low dimensional materials [54, 51].

In relation to the research themes B.3: *Plasmon enhanced matter-light interactions,* we have developed theory for plasmonic lasing by coupling of molecular emitters to metallic nano-particles. Our theory in particular treats the collective coupling of many emitters to the field mode, and it derives the quantized plasmon field number distribution and phase fluctuations. The methods developed will be further employed to other schemes, including excitation of plasmons with laser excited atoms in thin films and nanocrystals.

In relation to the research themes B.4: *Cavity QED and near field quantum optics*, and B.5: *Propagating light and cascaded quantum systems*, we have developed schemes for sensing of very weak spin signals by their resonant coupling to the near field surrounding a resonator waveguide [50], see also research theme C5. Our 2014 proposal for detection of propagating microwave photons by a cascaded conjunction of a $\lambda/4$ resonator and a superconducting qubit has been further developed, and we have made simulations to help interpret the outcome of a first prototype, developed in Jena according to our design. In relation to theme C.5, we have proposed and analyzed the use of cascaded Josephson Parametric Amplifiers to squeeze a probe microwave field and amplify it in a noiseless manner after weak interaction with a medium.

Theme C: Probing of quantum dynamics by light

In relation to the research theme C.1: *Ultrafast phenomena in atoms and molecules*, we highlight the work on electron vortices induced in helium by photoionization by circularly polarized pulses [43]. The time-dependent Schrödinger equation was solved in fully 6 dimensions, which is unique in the world at this point, and the results were analyzed by analytical theory. The discovered vortex patterns are examples of matter-wave interferences, they find application in attosecond physics and carry information about electron dynamics on ultrafast timescales.

In relation to the research theme C.2: *Ultrafast phenomena; Condensed matter system*, a framework has been developed for simulations of electron dynamics in two-dimensional materials under pulsed excitation. The materials graphene and boron-nitride have been chosen and preliminary results for HHG as well as Rabi oscillations have been identified.

In relation to the research theme C.3: *Magneto-optical spectroscopy*, a PhD program has been initiated, which will focus on the magneto-optical response of two-dimensional materials with and without many-body interactions.

In relation to the research theme C.4: *Conditional quantum dynamics, heralding and feedback* we have developed a new autonomous protocols in which one microscopic system, inside a cryostat can automatically perform measurements and provide feedback on another one. This can be used to implement classical flip-flop gates at low power levels [20] and to prepare or correct quantum states [58]. The autonomous character of this protocol alleviates the need for expensive and technically demanding communication lines between the quantum system held at few mK temperatures and the laboratory control hardware at room temperature, and it may pave the way towards control of classical and quantum systems with many components.

In relation to the research theme C.5: *Quantum metrology; quantum Bayes inference,* we have established theories for the use of quantum systems as highly sensitive probes of, e.g., magnetic fields or motional disturbances. Measurement outcomes are random, but when “God plays dice”, the system is kicked, and we have clarified that by observing the transient dynamics after these kicks, and thereby inducing new kicks, we gain more information than is available in the average system behavior [2,16]. With experimental partners in Paris, we have demonstrated how a hybrid proposal [25,40] for quantum computing with microwave resonators and spin doped crystals can be rigged into a highly sensitive detector of spin dopants in materials [50]. In our proposal, the spin material is located just few nanometers away from a superconducting wave guide resonator. A coherent excitation of the spin dephases quickly but can be revived later by spin echo techniques, and the resonator then emits a signal that permits identification of only few hundred spins, an improvement by several orders of magnitude over previous methods.

In relation to the research theme C.6: *Extension of quantum measurement theories: new challenges,* QUSCOPE has added new insight into the foundations of quantum optics by new analyses of the evolution of quantum systems, conditioned on the detection of their emitted radiation. Applications range from collaboration with Nobel laureate Serge Haroche on the preparation and verification of photon number states in cavities [37] over the explanation of temporal correlations in the microwave radiation from superconducting circuits [26,66] to a firmly established theoretical connection between optical correlation functions and conditioned dynamics [48].

Publications

At a glance:

QUSCOPE published 43 articles in 2015, including 1 Science, 1 Nature Nanotechnology, 1 Nature Communications, 1 PNAS, 6 Physical Review Letters and 2 Invited News and Views articles in Nature and Nature Physics.

9 of our articles in 2015 were selected for special mentioning by editors of the scientific journals.

Full QUSCOPE list of publications:

2014

1. P. Haikka and K. Mølmer, *Dissipative Landau-Zener level crossing subject to continuous measurement: Excitation despite decay*, Phys. Rev. A **89**, 052114 (2014).
2. Alexander Holm Kiilerich and Klaus Mølmer, *Estimation of atomic interaction parameters by photon counting*, Phys. Rev. A **89**, 052110 (2014).
3. Malte C. Tichy, Klaus Mayer, Andreas Buchleitner, and Klaus Mølmer, *Stringent and Efficient Assessment of Boson-Sampling Devices*, Phys. Rev. Lett. **113**, 020502 (2014).
4. Haruhide Miyagi and Lars Bojer Madsen, *Time-dependent restricted-active-space self-consistent-field theory for laser-driven many-electron dynamics. II. Extended formulation and numerical analysis*, Phys. Rev. A **89**, 063416 (pages 15) (2014).
5. Lauge Christensen, Jens H. Nielsen, Christian B. Brandt, Christian B. Madsen, Lars Bojer Madsen, Craig S. Slater, Alexandra Lauer, Mark Brouard, Mikael P. Johansson, Benjamin Shepperson, and Henrik Stapelfeldt, *Dynamic Stark Control of Torsional Motion by a Pair of Laser Pulses*, Phys. Rev. Lett. **113**, 073005 (2014).
6. Klaus Mølmer, *Quantum memory: Needle in a haystack*, Nature Physics **10**, 707–708 | news & views (2014).
7. D. Dimitrovski, J. Maurer, H. Stapelfeldt, and L. B. Madsen, *Low-Energy Photoelectrons in Strong-Field Ionization by Laser Pulses with Large Ellipticity*, Phys.Rev.Lett. **113**, 103005 (2014).
8. David Petrosyan and Klaus Mølmer, *Binding Potentials and Interaction Gates between Microwave-Dressed Rydberg Atoms*, Phys. Rev. Lett. **113**, 123003 (2014).
9. Malte C. Tichy and Christian Kraglund Andersen, *Comment on "Contextuality in Bosonic Bunching"*, Phys. Rev. Lett. **113**, 138901 (2014).
10. Hamed Saberi, Tomáš Opatrný, Klaus Mølmer, and Adolfo del Campo, *Adiabatic tracking of quantum many-body dynamics*, Phys. Rev. A **90**, 060301(R) (2014).
11. Lun Yue and Lars Bojer Madsen, *Dissociative ionization of H_2^+ using intense femtosecond XUV laser pulses*, Phys. Rev. A **90**, 063408 (2014).
12. S. Bauch, L. K. Sørensen, and L. B. Madsen, *Time-dependent generalized-active-space configuration-interaction approach to photoionization dynamics of atoms and molecules*, Phys. Rev. A **90**, 062508 (2014).
13. D. D. Bhaktavatsala Rao and Klaus Mølmer, *Deterministic entanglement of Rydberg ensembles by engineered dissipation*, Phys. Rev. A **90**, 062319 (2014).

14. John J. L. Morton and Klaus Mølmer, *Quantum information: Spin memories in for the long haul*, Nature **517** 153–154| news & views (2015).
15. Jens Svensmark, Oleg I. Tolstikhin, and Lars Bojer Madsen, *Coulomb and dipole effects in tunneling ionization of molecules including nuclear motion*, Phys. Rev. A **91**, 013408 (2015). *PRA Kaleidoscope Images: January 2015.*
16. Alexander Holm Kiilerich and Klaus Mølmer, *Parameter estimation by multichannel photon counting*, Phys. Rev. A **91**, 012119 (2015).
17. Klaus Mølmer, *Hypothesis Testing with Open Quantum Systems*, Phys. Rev. Lett. **114**, 040401 (2015) (Editor's Suggestion).
18. Malte C Tichy, Young-Sik Ra, Hyang-Tag Lim, Clemens Gneiting, Yoon-Ho Kim and Klaus Mølmer, *Double-Fock superposition interferometry for differential diagnosis of decoherence*, New J. Phys. **17** 023008 (2015).
19. Jake Gulliksen, Durga Bhaktavatsala Rao Dasari and Klaus Mølmer, *Characterization of how dissipation and dephasing errors accumulate in quantum computers*, EPJ Quantum Technology 2015, **2**:4 (2015).
20. Christian Kraglund Andersen and Klaus Mølmer, *Circuit QED Flip-Flop Memory with All-Microwave Switching*, Phys. Rev. Applied **3**, 024002 (2015).
21. Malte C. Tichy, *Sampling of partially distinguishable bosons and the relation to the multidimensional permanent*, Phys. Rev. A **91**, 022316 (2015).
22. N. I. Shvetsov-Shilovski, L. B. Madsen, and E. Räsänen, *Suppression of strong-field ionization by optimal pulse shaping: Application to hydrogen and the hydrogen molecular ion*, Phys. Rev. A **91**, 023425 (2015).
23. Christian Kraglund Andersen and Klaus Mølmer, *Multi-frequency modes in superconducting resonators: Bridging frequency gaps in off-resonant couplings*, Phys. Rev. A **91**, 023828 (2015).
24. Thomas Garm Pedersen, *Self-consistent model of edge doping in graphene*, Phys. Rev. B **91**, 085428 (2015).
25. Gershon Kurizki, Patrice Bertet, Yuimaru Kubo, Klaus Mølmer, David Petrosyan, Peter Rabl, and Jörg Schmiedmayer, *Quantum technologies with hybrid systems*, PNAS **112**, 3866–3873 (2015).
26. D. Tan, S. Weber, I. Siddiqi, K. Mølmer, K. W. Murch, *Prediction and Retrodiction for a Continuously Monitored Superconducting Qubit*, Phys. Rev. Lett. **114**, 090403 (2015). Editor's Suggestions, see also Physics, News and Commentary.
27. D. Dimitrovski and L. B. Madsen, *Theory of low-energy photoelectrons in strong-field ionization by laser pulses with large ellipticity*, Phys. Rev. A **91**, 033409 (2015). *PRA Kaleidoscope Images: March 2015.*
28. M. R. Thomsen, S. J. Brun, and T. G. Pedersen, *Stability and magnetization of free-standing and graphene-embedded iron membranes*, Phys. Rev. B **91**, 125439 (2015).
29. Maciej Dominik Śpiewanowski and Lars Bojer Madsen, *Alignment- and orientation-dependent strong-field ionization of molecules: Field-induced orbital distortion effects*, Phys. Rev. A **91**, 043406 (2015).
30. David Petrosyan, D. D. Bhaktavatsala Rao and Klaus Mølmer, *Filtering single atoms from Rydberg blockaded mesoscopic ensembles*, Phys. Rev. A **91**, 043402 (2015).
31. Jens E. Bækhøj, Lun Yue, and Lars Bojer Madsen, *Nuclear-motion effects in attosecond transient-absorption spectroscopy of molecules*, Phys. Rev. A **91**, 043408 (2015).
32. P. M. Kraus, O. I. Tolstikhin, D. Baykusheva, A. Rupenyan, J. Schneider, C. Z. Bisgaard,T. Morishita, F. Jensen, L. B. Madsen and H. J. Wörner, *Observation of laser-induced electronic structure in oriented polyatomic molecules*, Nature Communications **6**, Article number: 7039 (pages 8) (2015). See also the press coverage in Rømer.
33. Søren J. Brun and Thomas G. Pedersen, *Intense and tunable second-harmonic generation in biased bilayer graphene*, Phys. Rev. B **91**, 205405 (2015).
34. René Petersen and Thomas Garm Pedersen, *Bandgap scaling in bilayer graphene antidot lattices*, J. Phys.: Condens. Matter 27, 225502 (2015).
35. D. Dimitrovski, J. Maurer, H. Stapelfeldt and L. B. Madsen, *Observation of low-energy electrons in the photoelectron energy distribution from strong-field ionization of naphthalene by circularly polarized pulses*, J.

Phys. B: At. Mol. Opt. Phys. **48,** 121001 (2015). Part of Journal of Physics B's Highlights of 2015 and Editor's choice.

36. Yao-Chung Tsao, Thomas Søndergaard, Peter Kjær Kristensen, Rita Rizzoli, Kjeld Pedersen and Thomas Garm Pedersen, *Rapid fabrication and trimming of nanostructured backside reflectors for enhanced optical absorption in a-Si:H solar cells*, Appl. Phys. A, 120:417–425 (2015).
37. T. Rybarczyk, B. Peaudecerf, M. Penasa, S. Gerlich, B. Julsgaard, K. Mølmer, S. Gleyzes, M. Brune, J. M. Raimond, S. Haroche, and I. Dotsenko, *Forward-backward analysis of the photon-number evolution in a cavity*, Phys. Rev. A **91**, 062116 (2015).
38. Lun Yue (岳仑) and Lars Bojer Madsen, *Characterization of Molecular Breakup by Very Intense Femtosecond XUV Laser Pulses*, Phys. Rev. Lett. **115**, 033001 (2015).
39. Andrew C. J. Wade, Jacob F. Sherson, and Klaus Mølmer, *Squeezing and Entanglement of Density Oscillations in a Bose-Einstein Condensate*, Phys. Rev. Lett. **115**, 060401 (2015).
40. C. Grezes, B. Julsgaard, Y. Kubo, W. L. Ma, M. Stern, A. Bienfait, K. Nakamura, J. Isoya, S. Onoda, T. Ohshima, V. Jacques, D. Vion, D. Esteve, R. B. Liu, K. Mølmer, and P. Bertet, *Storage and retrieval of microwave fields at the single-photon level in a spin ensemble*, Phys. Rev. A **92**, 020301(R) (2015).
41. Jens E. Bækhøj and Lars Bojer Madsen, *Light-induced structures in attosecond transient-absorption spectroscopy of molecules*, Phys. Rev. A **92**, 023407 (2015).
42. Thomas Garm Pedersen, *Analytical models of optical response in one-dimensional semiconductors*, Physics Letters A, **379** 1785–1790 (2015).
43. J. M. Ngoko Djiokap, S. X. Hu, L. B. Madsen, N. L. Manakov, A. V. Meremianin, and Anthony F. Starace, *Electron Vortices in Photoionization by Circularly Polarized Attosecond Pulses*, Phys. Rev. Lett. **115**, 113004 (2015). On the Cover of PRL**115**; Highlighted in Nature Physics.
44. Qing Xu and Klaus Mølmer, *Intensity and amplitude correlations in the fluorescence from atoms with interacting Rydberg states*, Phys. Rev. A **92**, 033830 (2015).
45. Alexander Holm Kiilerich and Klaus Mølmer, *Quantum Zeno effect in parameter estimation*, Phys. Rev. A **92**, 032124 (2015). "Editors' Suggestion".
46. D Dimitrovski, J Maurer, H Stapelfeldt and L B Madsen, *Strong-field ionization of three-dimensionally aligned naphthalene molecules: orbital modification and imprints of orbital nodal planes*, J. Phys. B: At. Mol. Opt. Phys, **48**, 245601 (2015). Part of Journal of Physics B's Highlights of 2015 and Editor's choice.
47. P. M. Kraus, B. Mignolet,D. Baykusheva,A. Rupenyan,L. Horný, E. F. Penka, G. Grassi, O. I. Tolstikhin, J. Schneider,F. Jensen, L. B. Madsen, A. D. Bandrauk, F. Remacle, H. J. Wörner, *Measurement and laser control of attosecond charge migration in ionized iodoacetylene*, Science **350**, 790-795 (2015). See also Perspective
48. Qing Xu, Eliska Greplova, Brian Julsgaard and Klaus Mølmer, *Correlation functions and conditioned quantum dynamics in photodetection theory*, Phys. Scr. **90** (2015) 128004.
49. Héctor Mera, Thomas G. Pedersen, and Branislav K. Nikolić, *Nonperturbative Quantum Physics from Low-Order Perturbation Theory*, Phys. Rev. Lett. **115**, 143001 (2015).
50. A. Bienfait, J. J. Pla, Y. Kubo, M. Stern, X. Zhou, C. C. Lo, C. D. Weis, T. Schenkel, M.L.W. Thewalt, D. Vion, D. Esteve, B. Julsgaard, K. Moelmer, J.J.L. Morton, and P. Bertet, *Reaching the quantum limit of sensitivity in electron spin resonance*, Nature Nanotechnology (2015).
51. Thomas Garm Pedersen, *Intraband effects in excitonic second-harmonic generation*, Phys. Rev. B **92**, 235432 (2015).
52. Samuel G. Walt, N. Bhargava Ram, Aaron von Conta, Oleg I. Tolstikhin, Lars Bojer Madsen, Frank Jensen, and Hans Jakob Wörner, *Role of Multi-Electron Effects in the Asymmetry of Strong-Field Ionization and Fragmentation of Polar Molecules: The Methyl Halide Series*, J. Phys. Chem. A, **119** (49), 11772–11782 (2015).
53. S. Chattopadhyay, S. Bauch, and L. B. Madsen, *Electron-correlation effects in enhanced ionization of molecules: A time-dependent generalized-active-space configuration-interaction study*, Phys. Rev. A **92**, 063423 (2015).
54. M.L. Trolle and T. Garm Pedersen, *Excitonic lifetimes and optical response of carbon nanotubes modulated by electrostatic gating*, Phys Rev. B. **92**, 085431 (2015).

55. M.L. Trolle, Y.-C. Tsao, K. Pedersen, and T. Garm Pedersen, *Observation of excitonic resonances in the second harmonic spectrum of MoS2*, Phys. Rev. B. **92**, 161409(R) (2015).
56. M. R. Thomsen, M. Ervasti, A. Harju, and T. Garm Pedersen, *Spin relaxation in hydrogenated graphene*, Phys. Rev. B. **92**, 195408 (2015).

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