DOQS 2016

Workshop on Many-body Dynamics and Open Quantum Systems

DOQS 2016 Glasgow

30/08 — 02/09/2016

Technology & Innovation Centre

University of Strathclyde
Glasgow, Scotland

IMPP

Contents

Dear Participants of the DOQS 2016 workshop,

It is a great pleasure to welcome you all to Glasgow, and to the Technology and Innovation Centre of the University of Strathclyde. We have 114 registered participants from 16 countries at the meeting, which is an important event within the International Max-Planck Partnership between Scottish Universities and the German Max Planck Institutes on "Measurement and Observation at the Quantum Limit". We would like to thank all of our sponsors for their invaluable support of the meeting, as well as the University of Strathclyde, and the city of Glasgow.
This workshop hosts world-leading theorists and experimentalists from the fields of quantum optics and quantum many-body systems, working with cold atomic and molecular gases, optical lattices, photons, cavities, cold ions, Rydberg atoms and polar molecules. A focus of the workshop is the understanding of interactions between a quantum system and its environment, and how these open quantum system dynamics combine with the behaviour of many-body AMO systems.

We hope you enjoy your time in Glasgow, and find the workshop inspiring and productive.

Best wishes,

Andrew Daley and Stefan Kuhr, conference co-chairs

Invited Speakers

Mari-Carmen Bañuls	MPQTheory, Garching, Germany
Immanuel Bloch	MPQ, Garching / LMU, Munich, Germany
Frédéric Chevy	École Normale Supérieure, Paris, France
Ignacio Cirac	MPQTheory, Garching, Germany
Nigel Cooper	University of Cambridge, UK
Eugene Demler	Harvard University, Cambridge, USA
Thierry Giamarchi	DQMP, University of Geneva, Switzerland
Klemens Hammerer	Leibniz Universität Hannover, Germany
Dieter Jaksch	University of Oxford, UK
Igor Lesanovsky	University of Nottingham, UK
Mikhail Lukin	Harvard University, Cambridge, USA
Patrik Öhberg	Herriot-Watt University, Edinburgh, UK
William D. Phillips	NIST / JQI Maryland, USA
Cindy Regal	JILA, University of Colorado, USA
Mark Saffman	University of Wisconsin-Madison, USA
Luis Santos	ITP, Leibniz Universität Hannover, Germany
Monika Schleier-Smith	Stanford University, USA

Hot Topic Speakers

Thorsten Ackemann	University of Strathclyde, Glasgow, UK
Piotr Deuar	Polish Academy of Sciences, Warsaw, Poland
Jonathan Keeling	University of St Andrews, UK
Zala Lenarčič	ITP, University of Cologne, Germany
Anton Mazurenko	Harvard University, Cambridge, USA
Matthias Sonnleitner	University of Glasgow, UK

Organising committee

Stefan Kuhr & Andrew Daley (Conference Co-chairs)	University of Strathclyde, UK
Audrey McKinnon, Jorge Yago & Jan-Philipp Schröder	University of Strathclyde, UK

Associated research groups at the University of Strathclyde:

Experimental Quantum Optics and Photonics
Computational Nonlinear & Quantum Optics

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MOGLabs: Lasers and Electronics for Research

Radiant Dyes Laser

Glasgow City Council

2 Information

Conference website

`http://doqs2016.phys.strath.ac.uk/`

Conference venue

Technology and Innovation Centre
University of Strathclyde
99 George St.
Glasgow
G1 1RD
+44 (0) 141 444 7000

Lab tours

University of Strathclyde
John Anderson Building
107 Rottenrow East
Glasgow
G4 0NG

Civic reception

City Chambers
George Square
Glasgow
G2 1DU

Conference dinner

Trades Hall Of Glasgow
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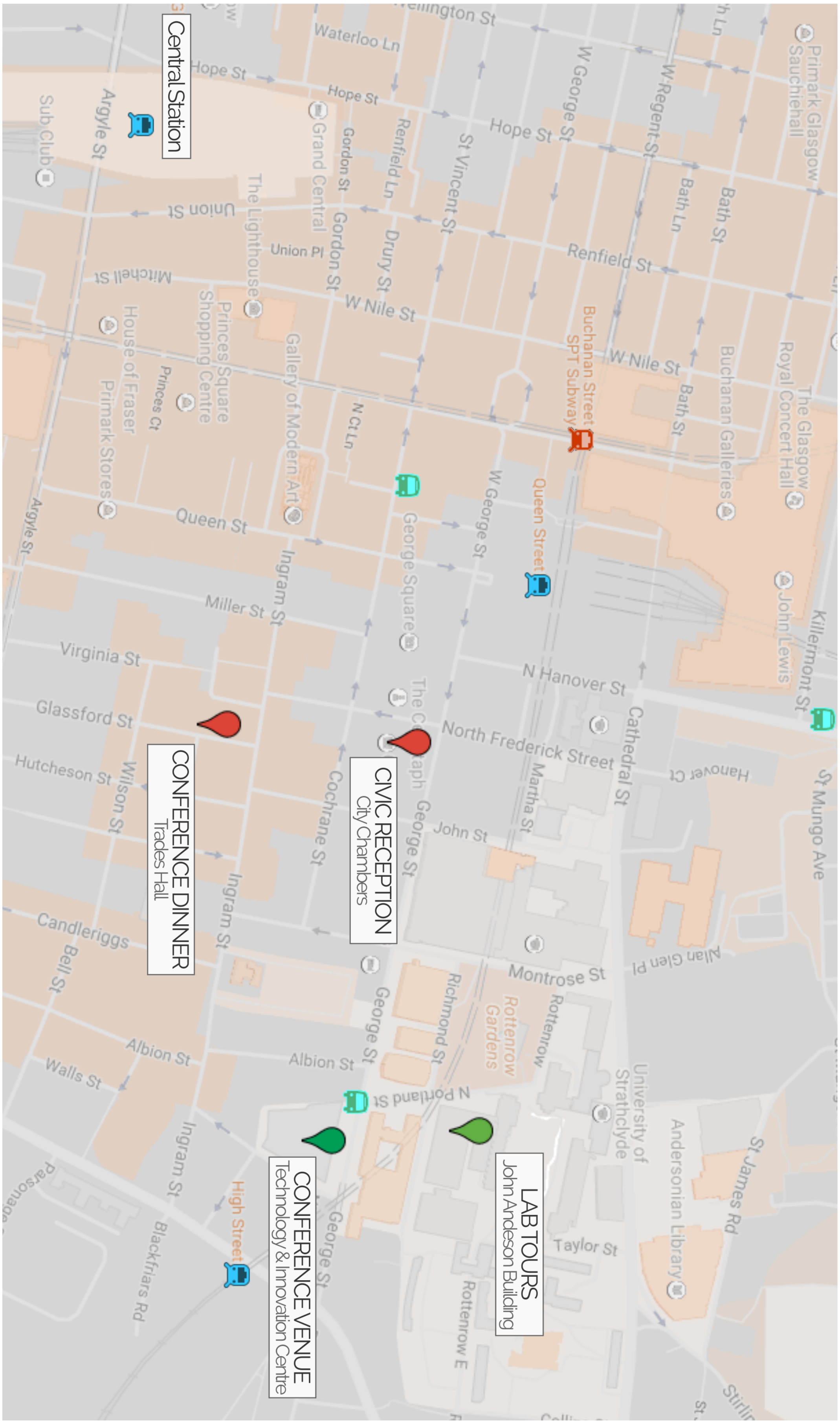
3 Map



Central Station
CONFERENCE DINNER
Trades Hall
CIVIC RECEPTION
City Chambers
CONFERENCE VENUE
Technology & Innovation Centre
LAB TOURS
John Anderson Building

4 Schedule

	Tuesday 30 August	Wednesday 31 August	Thursday 01 September	Friday 02 September
9.00-9.45 am		BLOCH	SAFFMAN	CIRAC
9.45 - 10.30 am	Registration and Coffee	COOPER	LESANOVSKY	LUKIN
10.30 - 11.00 am	WELCOME	COFFEE BREAK	COFFEE BREAK	COFFEE BREAK
11.00 - 11.45 am	PHILLIPS	GIAMARCHI	CHEVY	BAÑULS
11.45 - 12.30 pm	JAKSCH	LENARČIČ MAZURENKO	DEUAR SONNLEITNER	DEMLER
12.30 - 2.15 pm	LUNCH	LUNCH	LUNCH	LUNCH
2.15-3.00 pm	REGAL	SANTOS	SCHLEIER SMITH	
3.00-3.45 pm	ACKEMANN KEELING	HAMMERER	ÖHBERG	
3.45-6.00 pm	POSTERS	LAB TOURS	POSTERS	
6.00-6.30 pm			FREE EVENING	
6.30 pm	CIVIC RECEPTION City Chambers	CONFERENCE DINNER Trades Hall Glasgow		

5 Full Programme

Tuesday, 30th August

9.45 am	**Registration**
10.00 am	Coffee
10.30 am	*Welcome and introduction*
	Session 1
11.00 am	*Persistent Superfluid Currents in a Ring: Thermal Effects* William D. Phillips, NIST and University of Maryland, USA
11.45 am	*Optically Driven Many-body Quantum Systems* Dieter Jaksch, University of Oxford, UK
12.30 pm	Lunch
	Session 2
2.15 pm	*Entanglement and spin-motional dynamics with ground state neutral atoms in optical tweezers* Cindy Regal, University of Colorado, USA
3.00 pm	*Hot Topic: Magnetic ordering via light-induced interactions and diffractive spatial coupling* Thorsten Ackemann, University of Strathclyde, UK
3.25 pm	*Hot Topic: Supermode-Density-Wave-Polariton Condensation, and Meissner-like Effect with Multimode Cavity-QED* Jonathan Keeling, University of St Andrews, UK
3.50 pm	Poster Session 1
6.30 pm	Civic Reception at the City Chambers

Wednesday, 31st August

Session 3

9.00 am	*Probing Many-Body Localisation from an Ultracold Atom Perspective* Immanuel Bloch, MPQ/Ludwig-Maximilians-Universität München, Germany
9.45 am	*Superradiance-induced particle flow via dynamical gauge coupling* Nigel Cooper, University of Cambridge, UK

10.30 am Coffee Break

Session 4

11.00 am	*Out of equilibrium phenomena in cold atomic systems* Thierry Giamarchi, DQMP, University of Geneva, Switzerland
11.45 am	*Hot Topic: Pumping approximately integrable systems* Zala Lenarčič, University of Cologne, Germany
12.10 pm	*Hot Topic: Probing Antiferromagnetic Ordering and Dynamics with the Fermi Gas Microscope* Anton Mazurenko, Harvard University, USA

12.35 pm Lunch

Session 5

2.15 pm	*Dynamics of dipolar quantum gases: quantum droplets, lattice dynamics, and spin transport* Luis Santos, Leibniz Universität Hannover, Germany
3.00 pm	*Light-Matter Interfaces for Quantum Simulations and Information Processing* Klemens Hammerer, Albert-Einstein Institute, University of Hannover, Germany

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3.45 pm *Lab tours*
John Anderson Building, University of Strathclyde

6.30 pm Conference dinner at Trades Hall Of Glasgow

Thursday, 01st September

Session 6

9.00 am	*Coherent and dissipative control of neutral atom qubits* Mark Saffman, University of Wisconsin-Madison, USA
9.45 am	*Exploring far-from-equilibrium physics with Rydberg gases* Igor Lesanovsky, University of Nottingham, UK

10.30 am Coffee Break

Session 7

11.00 am	*From ultraslow to ultrafast.* *Analog simulation of Weyl fermions using ultracold atoms* Frédéric Chevy, École Normale Supérieure, France
11.45 am	*Hot Topic: The Wigner SGPE:* *a c-field description of open systems that includes quantum fluctuations* *and is stable at long times* Piotr Deuar, Polish Academy of Sciences, Poland
12.10 pm	*Hot Topic: Vacuum friction and energy conservation in non-relativistic QED* Matthias Sonnleitner, University of Glasgow, UK

12.35 pm Lunch

Session 8

2.15 pm	*Echoes of Entanglement: from Quantum Metrology to Scrambling* Monika Schleier-Smith, Stanford University, USA
3.00 pm	*Synthetic magnetism: from chiral dynamics to charged black holes* Patrik Öhberg, Herriot-Watt University, UK

3.45 pm Poster Session 2

Friday, 02nd September

	Session 9
9.00 am	*Tensor Network Techniques and systems out of equilibrium* Ignacio Cirac, MPQ, Germany
9.45 am	*Quantum dynamics of strongly interacting spins, atoms and photons* Mikhail Lukin, Harvard University, USA
10.30 am	Coffee Break
	Session 10
11.00 am	*Tensor networks, dynamics and the many body localization problem* Mari-Carmen Bañuls
11.45 am	*Bose polarons* Eugene Demler
12.30 pm	Lunch

6 Talk Abtracts: Tuesday, 30th August

Tues. 11.00 AM

Persistent Superfluid Currents in a Ring: Thermal Effects

William D. Phillips

Joint Quantum Institute
NIST and University of Maryland, USA

Ring, or toroidal, traps for neutral atoms are attractive geometries for studying quantum fluid behavior, in part because of the topological stability of quantized, persistent, superfluid, atomic currents around the ring. The stability of persistent currents is not, however, perfect, due to a number of processes that make this an open quantum system. In particular, the introduction of a perturbation into the ring creates a weak-link or Josephson junction whereby the quantized persistent current can change/decay. Here we discuss the effect of non-zero temperature on such processes.

Tues. 11.45 AM

Optically Driven Many-body Quantum Systems

Dieter Jaksch

University of Oxford, UK

Recent experiments [1,2] indicate that selective optical driving of phonons may generate or enhance ordered phases in strongly correlated quantum materials. In this talk I will discuss quantum optically inspired models that may help explain and engineer such phenomena. Specifically, I will consider a driven fermionic Hubbard model in the strongly correlated limit where the onsite interaction dominates over the kinetic energy [3]. The driving is modelled as an alternating periodic modulation of the lattice site energy offsets. I will show how this modulation changes the nature of the system into an attractive Luttinger liquid and how it leads to enhanced fermion pairing in one spatial dimension. I will present results at zero and finite temperatures and discuss the prospect of observing driven out-of-equilibrium superconductivity in this model system.

[1] D. Fausti, R. I. Tobey, N. Dean, S. Kaiser, A. Dienst, M. C. Hoffmann, S. Pyon, T. Takayama, H. Takagi, and A. Cavalleri, Light-Induced Superconductivity in a Stripe-Ordered Cuprate, Science 331, 189 (2011).

[2] M. Mitrano, A. Cantaluppi, D. Nicoletti, S. Kaiser, A. Perucchi, S. Lupi, P. Di Pietro, D. Pontiroli, M. Ricco, S.R. Clark, D. Jaksch and A. Cavalleri, Possible light-induced superconductivity in K3C60 at high temperature, Nature 530, 461-464 (2016).

[3] J. Coulthard, S.R. Clark, S. Al-Assam, A. Cavalleri and D. Jaksch, Enhancement of superexchange pairing in the periodically-driven Hubbard model, arXiv:1608.03964 (2016).

Tues. 2.15 PM

Entanglement and spin-motional dynamics with ground state neutral atoms in optical tweezers

Cindy Regal

University of Colorado, USA

I will discuss our experiments with Raman-cooled neutral atoms in sets of optical tweezers. Recent and future work focuses on the Hong-Ou-Mandel effect with atoms, entanglement via spin exchange, microscopic Kondo lattice physics, and measurement-induced entanglement. I will discuss the implications for microscopic control of larger quantum systems.

Tues. 3.00 PM

Magnetic ordering via light-induced interactions and diffractive spatial coupling

Thorsten Ackemann

University of Strathclyde, Glasgow, UK

We discuss a novel approach to the simulation of magnetic ordering phenomena via interactions between cold atoms mediated by multi-mode light fields undergoing diffraction. After adiabatic elimination of the light fields, the theoretical description can be reduced to equations of motion involving the atomic magnetization only, with the light field and the optical density appearing only in the coupling parameters. The experimental system is a cloud of laser-cooled 87Rb atoms driven by a laser beam in the presence of a retro-reflecting plane mirror. Above a threshold, spin patterns form spontaneously in the atomic medium as well as in the light field, sustaining each other via positive feedback. The spatial scale of the magnetization patterns is given by diffractive phase shifts in the feedback loop between cloud and mirror. We discuss the transition between ferromagnetic states of opposite sign (hexagons and honeycombs) via an anti-ferromagnetic state (squares) at zero field, if the longitudinal magnetic field is varied. An interesting long-term aspect is that the level scheme of Rb allows for the spontaneous formation of higher order multipoles structures (e.g. alignment) than a simple magnetic dipole.

[1] I. Kresic, P. M. Gomes, A. Camara, G. Labeyrie, G. L. Oppo, W. J. Firth, G. R. M. Robb, E. Tesio, P. F. Griffin, A. S. Arnold, R. Kaiser, and T. Ackemann, Spin pattern formation in cold atoms via the single-mirror feedback scheme, Optical Society of America (2015).

Supermode-Density-Wave-Polariton Condensation, and Meissner-like Effect with Multimode Cavity-QED

Jonathan Keeling

University of St Andrews, St Andrews, UK

I will present work in collaboration with the Lev group (Stanford), demonstrating of condensation of supermode-density-wave-polaritons in a multimode cavity. In a nearly confocal optical cavity, atoms can couple to multiple cavity modes simultaneously. Due to transverse pumping, these multiple cavity modes hybridise with atomic density waves, leading to new "supermode polaritons", where the cavity mode composition varies with pumping. Above a critical pumping strength, condensation of one of these modes occurs. The nature of the condensate mode differs from the dressed cavity modes below threshold.
This experiment demonstrates the potential of multimode cavity QED to explore physics associated with varying spatial profiles of light. As an illustration of this, I will discuss theoretical work, showing how such a multimode cavity can be used to explore the bulk Meissner effect with synthetic magnetic fields. In most cold-atom realisations of magnetic fields, the applied field is static, set by the lasers. Single mode cavities allow some degree of dynamics of the gauge field, but no spatial freedom. We show how a multimode cavity allows sufficient freedom to demonstrate a Meissner effect, whereby an atomic BEC can expel the applied synthetic gauge field.

[1] A. J. Kollár, A. Papageorge, V. D. Vaidya, Y. Guo, K. Ballantine, J. Keeling, B. L. Lev.

7 Talk Abstracts: Wednesday, 31st August

Wed. 9.00 AM

Probing Many-Body Localisation from an Ultracold Atom Perspective

Immanuel Bloch

Max Planck Institute of Quantum Optics, Garching, Germany
Ludwig-Maximilians University, Munich, Germany

A fundamental assumption in statistical physics is that generic closed quantum many-body systems thermalise under their own dynamics. Recently, the emergence of many-body localised (MBL) systems has questioned this concept, challenging our understanding of the connection between statistical physics and quantum mechanics. In my talk, I will report on several recent experiments carried out in our group on the observation of Many-Body Localisation in different scenarios, ranging from 1D fermionic quantum gas mixtures in driven and undriven Aubry-André type disorder potentials and 2D systems of interacting bosons in 2D random potentials. It is shown that the memory of the system on its initial non-equilibrium state can serve as a useful indicator for a non-ergodic, MBL phase.
Our experiments represent a demonstration and in-depth characterisation of many-body localisation, often in regimes not accessible with state-of-the-art simulations on classical computers.

Wed. 9.45 AM

Superradiance-induced particle flow via dynamical gauge coupling

Nigel Cooper

University of Cambridge, UK

I shall describe theoretical results concerning the non-equilibrium dynamics of fermions that are gauge-coupled to a cavity mode via Raman-assisted hopping in a one dimensional lattice. For an infinite lattice, there is a superradiant phase with infinitesimal pumping threshold which induces a directed particle flow. I shall describe the fate of this flow in a finite lattice with boundaries, from studies of the non-equilibrium dynamics including fluctuation effects. The short time dynamics is dominated by superradiance, while the long time behaviour is governed by cavity fluctuations. There are multiple possible steady states in the finite lattice, wich can be understood in terms of coherent bosonic excitations above a Fermi surface in real space.
[1] Wei Zheng and Nigel R. Cooper, Superradiance induced particle flow via dynamical gauge coupling, arXiv:1604.06630, (2016).

Out of equilibrium phenomena in cold atomic systems

Thierry Giamarchi

DQMP, University of Geneva, Switzerland

From a theoretical point of view treating systems that are out of equilibrium (OEQ), is one of the most difficult challenges of quantum many body physics. Indeed, in this case many of our theoretical tools, such as the concept of temperature, are not applicable. Recently cold atomic systems have provided remarkable realizations of such situations. I will discuss some of these situations such as local quenches in bosonic systems [1] or OEQ dynamics in coupled Luttinger liquids [2] and specially on the remarkable case of the transport of particle or charge current between two reservoirs. One way to tackle this situation, is to sweep the problem under the rug and treat the problem in linear response. There are however many cases when the linear response is not enough and when a full solution of the non-equilibrium problem is needed. This is in particular the case for quantum point contacts or junctions where the full current-voltage characteristics gives direct information on the physics of the problem. I will thus in particular focus on a recent study [3] which was able to realize a tunable, ballistic quantum point contact between two fermi reservoirs with a tunable interaction allowing to reach unitarity and to provide a theoretical description of the OEQ corresponding problem. In such a system the current has been shown to originate from multiple Andreev reflections which leads to a very non-linear current-chemical potential characteristics. The geometry of the contact can be changed showing a competition between superfluidity and thermally activated transport which leads to a conductance minimum and poses several theoretical questions for its theoretical description.

[1] A. Kantian, U. Schollwöck, and T. Giamarchi, PRL 113, 070601 (2014).
[2] L. Foini and T. Giamarchi, PRA 91, 023627 (2015).
[3] D. Husmann, S. Uchino, S. Krinner, M. Lebrat, T. Giamarchi, T. Esslinger, J.-P. Brantut, Science 350, 1498 (2015).

Wed. 11.45 AM

Pumping approximately integrable systems

Zala Lenarčič

Institute for theoretical physics, University of Cologne, Germany

When a degree of freedom is approximately protected by a conservation law even weak perturbations can cause a strong response in that quantity and can drive the many-particle system far from its equilibrium steady state. This principle has already been utilized in open systems, for example, to obtain the Bose-Einstein condensates of exciton-polaritons or photons in a cavity. A similar platform can be provided by integrable quantum models with infinitely many (quasi-)local conserved quantities, which are theoretically interesting yet experimentally always only approximately realized. I will present our theory of weakly open driven integrable models on an example of the 1D Heisenberg XXZ chain. I will argue that the concept of the generalized Gibbs ensembles, introduced to describe the equilibration of closed integrable systems, can be approximately but efficiently used even in the presence of weak coupling to a non-thermal environment and/or other weak integrability-breaking driving terms. As a concrete manifestation and experimental confirmation of our theory I will suggest novel heat and spin pumps exploiting the property that these currents are approximately conserved quantities within our model.

[1] F. Lange, Z. Lenarcic, and A. Rosch, Pumping approximately integrable systems, arXiv:1608.03563 (2016).

Wed. 12.10 PM

Probing Antiferromagnetic Ordering and Dynamics with the Fermi Gas Microscope

Anton Mazurenko

Harvard University, Cambridge, USA

Microscopy of 2D Fermi gases in optical lattices has enabled precise studies of the Hubbard model at the single site level. In our experiment we prepare a balanced two-component spin mixture of Li-6 with repulsive interactions in a square optical lattice. In addition to observing ordering of the charge degree of freedom in the metal to Mott-insulator transition, we have recently observed antiferromagnetic correlations at temperatures below the magnetic exchange energy. The single-site resolution also gives direct access to the spin correlation function, where a growing correlation length is observed for lower temperatures. Recently, we have used a digital micromirror device in the image plane of the microscope to create arbitrary atomic potential landscapes. By reshaping the trap we have implemented an entropy redistribution scheme, which reduces the experimentally achievable temperature by about a factor of two. These temperatures approach the regime of long-range magnetic ordering, with measured antiferromagnetic correlations as far as seven sites away. We will also report on our most recent progress towards studying quantum walks of single holes in one- and two-dimensional systems.

[1] Maxwell F. Parsons, Christie S. Chiu, Geoffrey Ji, Daniel Greif, and Markus Greiner.

Dynamics of dipolar quantum gases: quantum droplets, lattice dynamics, and spin transport

Luis Santos

Institut für Theoretische Physik, Leibniz Universität Hannover, Germany

I will focus in this talk on three different scenarios in which the physics of dipolar gases differs significantly from that of non-dipolar counterparts. I will first comment on how quantum fluctuations stabilize self-bound droplets in dipolar Bose-Einstein condensates [1,2], discussing in particular the role played by beyond mean-field corrections in recent erbium experiments on excitations and dynamics of dipolar condensates [3]. In the second part I will show that the combination of energy conservation and long-range interactions leads to an interesting non-equilibrium dynamics of polar gases in optical lattices. I will focus in particular on the possibility of observing in these systems quasi-many-body localization in the absence of quenched disorder [4]. In the last part of the talk I will discuss the dipole-assisted transport of rotational excitations among immobile molecules in an optical lattice. In this system the combination of long-range hops and a sparse lattice filling results in an intriguing model with off-diagonal disorder, in which the nature of the excitations depends crucially on dimensionality and filling. In particular, I will show that in 3D lattices excitations undergo for decreasing filling an ergodic to non-ergodic transition, and that at low filling the excitations are not localized, but dominantly non-ergodic [5].

[1] F. Wächtler and L. Santos, Phys. Rev. A 93, 061603(R) (2016).
[2] F. Wächtler and L. Santos, Ground-state properties and elementary excitations of quantum droplets in dipolar Bose-Einstein condensates, arXiv:1605.08676 (2016).
[3] L. Chomaz, S. Baier, D. Petter, M. J. Mark, F. Wächtler, L. Santos, and F. Ferlaino, Quantum-fluctuation-driven crossover from a dilute Bose-Einstein condensate to a macro-droplet in a dipolar quantum fluid, arXiv: 1607.06613.
[4] L. Barbiero, C. Menotti, A. Recati, and L. Santos, Out-of-equilibrium states and quasi-many-body localization in polar lattice gases, Phys. Rev. B 92, 180406(R) (2015).
[5] X. Deng, B. Altshuler, G. V. Shlyapnikov, and L. Santos, Quantum Levy Flights and Multifractality of Dipolar Excitations in a Random System, Phys. Rev. Lett. 117, 020401 (2016).

Light-Matter Interfaces for Quantum Simulations and Information Processing

Klemens Hammerer

Institute for Theoretical Physics and Institute for Gravitational Physics (Albert-Einstein Institute), University of Hannover, Germany

Radiation pressure is now a limiting factor in laser-based sensing of positions and forces, as witnessed in a large range of systems from gravitational wave detectors to micromechanical devices. Despite being a limiting factor in some applications, the quantum coherent nature of radiation pressure effects in these systems enables fascinating perspectives for fundamental tests of physics realizing textbook experiments in quantum physics. Beyond fundamental tests, radiation pressure has become a newly mechanism for manipulating quantum states of light and matter and can be exploited for applications in quantum information processing and communication.

Thur. 9.00 AM

Coherent and dissipative control of neutral atom qubits

Mark Saffman

University of Wisconsin-Madison, USA

Optically trapped neutral atoms are being actively developed for quantum simulation, computing, and communication applications. Recent experiments have demonstrated high fidelity single qubit gates and moderate fidelity entanglement, with low cross talk in multi-dimensional arrays of qubits. While coherent control techniques have received the most attention, also dissipative methods have the potential for creating many body entanglement and novel spin phases, and combinations of coherent and dissipative dynamics may prove superior to either approach alone. An outstanding challenge in a many body setting is implementation of local control while suppressing undesired decoherence of proximal spins due to light scattering. I will describe an architecture that uses multiple internal levels to spectrally isolate coherent and dissipative processes.

Thur. 9.45 AM

Exploring far-from-equilibrium physics with Rydberg gases

Igor Lesanovsky

University of Nottingham, UK

In recent years cold atomic gases have been established as a versatile platform for the study of many-body phenomena. Especially atoms excited to highly-lying electronic states — so-called Rydberg atoms — offer rather intriguing possibilities for the exploration of strongly correlated dynamics.

In this talk I will show that the out-of-equilibrium behaviour of these systems is governed by emergent kinetic constraints, which are often used to mimic dynamical arrest or excluded volume effects in idealised models of glass forming substances. In Rydberg gases exposed to a noisy environment these constraints emerge naturally and lead to a remarkably rich dynamics although the final stationary state might be entirely uncorrelated and trivial.

Dynamical features include a self-similar relaxation, the existence of correlated growth as well as the emergence of non-equilibrium phase transitions of the directed percolation universality class, whose experimental observation so far has been challenging. Moreover, Rydberg gases offer an opportunity for the systematic exploration of the role of competing quantum and classical dynamical effects on the aforementioned non-equilibrium phase transitions.

I will conclude by briefly discussing how the above findings can be employed to gain a new understanding on the dynamics of Dynamic Nuclear Polarisation which is an out-of-equilibrium method for drastically enhancing the performance of Magnetic Resonance Imaging applications.

Thur. 11.00 AM

From ultraslow to ultrafast. Analog simulation of Weyl fermions using ultracold atoms

Frédéric Chevy

École Normale Supérieure, Paris, France

Weyl fermions are solutions of Dirac's Equation describing massless particles and as sush constitue one of the cornerstones of the Standard Model of particle physics. Using a unitary transformation, it is possible to map the dynamics of harmonically trapped Weyl particles onto that of atoms confined in a magnetic quadrupole potential. We show that even in the absence of interparticle interactions, the non-linearity of the single particle Hamiltonian leads to a quasi-thermalization of an ideal gas of Weyl fermions towards a non Boltzmanian state that we characterize using simple arguments. Finally, we suggest possible experimental pathways towards the experimental study of the peculiar topological features of Weyl fermions.

Thur. 11.45 AM

The Wigner SGPE: a c-field description of open systems that includes quantum fluctuations and is stable at long times

Piotr Deuar

Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

C-field calculations such as the Stochastic Gross-Pitaevskii equation (SGPE) are a mainstay of simulations of the dynamics and stationary properties of quantum Bose gases at nonzero temperature. They allow for temperatures too high to treat with other methods, open system boundaries, strong fluctuations and defects, as well as the study of single experimental realizations. They do however omit any quantum fluctuations.

We have derived an extended version of the SGPE that preserves quantum fluctuations, starting from the master equation of Gardiner and Davis. Thus, a very tractable, nonlinear description of the system has been obtained in terms of complex-valued fields, making no assumption of a condensate. We have demonstrated that it includes quantum fluctuations, depletion, shot noise, antibunching, as well as retaining strongly nonlinear effects such as spontaneous solitons.

In contrast to the usual "truncated Wigner" approach of adding virtual vacuum noise into the initial conditions, this method preserves quantum fluctuations even into the long-time stationary state.

[1] Piotr Deuar, Joanna Pietraszewicz, Nick Proukakis, Tomasz Swislocki.

Thur. 12.10 PM

Vacuum friction and energy conservation in non-relativistic QED

Matthias Sonnleitner

University of Glasgow, UK

We show how a simple calculation on textbook level leads to the surprising result that an excited two-level atom moving through vacuum sees a (tiny) friction force in first order v/c. At first sight this seems to be in obvious contradiction to other calculations showing that the interaction with the vacuum does not change the velocity of an atom.
It is thus even more surprising that this change in the atom's momentum appears to be a necessary result of energy and momentum conservation in special relativity.
Although this is still work in progress we also discuss how the solution to this puzzle has implications on the interpretation of results drawn from the conventional non-relativistic description of a dipole interacting with a field.

[1] Matthias Sonnleitner, Nils Trautmann and Stephen M. Barnett.

Thur. 2.15 PM

Echoes of Entanglement: from Quantum Metrology to Scrambling

Monika Schleier-Smith

Stanford University, USA

In an open quantum system, one can never reverse the flow of time. However, in a nearly closed system with well controlled interactions among the constituent particles, approximate time reversal is not only conceivable but potentially very useful. Experimentally, time reversal means switching the sign of the Hamiltonian. I will discuss progress towards engineering spin models with switchable-sign interactions for applications ranging from entanglement-enhanced metrology to quantifying many-body quantum chaos. Our primary experimental platform consists of cold atoms strongly coupled to an optical cavity in a geometry that will enable versatile control over non-local, photon-mediated interactions. Intriguingly, similar non-local interactions feature in models for understanding the scrambling of quantum information in black holes, opening the intriguing prospect of probing this phenomenon in the laboratory.

Thur. 3.00 PM

Synthetic magnetism: from chiral dynamics to charged black holes

Patrik Öhberg

Herriot-Watt University, Edinburgh, UK

In this talk we will discuss synthetic magnetic fields for cold atoms and show how one can emulate a dynamical interacting gauge theory which involves nonlinear gauge potentials. The resulting superfluid dynamics is illustrated with a few examples where unconventional chiral properties emerge.

9 Talk Abstracts: Friday, 2nd September

Fri. 9.00 AM

Tensor Network Techniques and systems out of equilibrium

Ignacio Cirac

Max Planck Institute of Quantum Optics, Garching, Germany

Tensor networks can efficiently describe many-body quantum systems with local interactions in thermal equilibrium. Howevever, as a consequence of the violation of the area law, they cannot describe their dynamics, in general. Still, they may provide useful information about several physical aspects of many-body systems out of equilibrium. In this talk I will mention few of the applications of tensor networks realted to that problem: the computation of quasi-constants of motion, and the characterization of entangled many-body states.

Fri. 9.45 AM

Quantum dynamics of strongly interacting spins, atoms and photons

Mikhail Lukin

Harvard University, Cambridge, USA

We will describe several recent experiments aimed at exploring quantum dynamics of strongly interacting systems. These include realization of slow, critical thermalization of disordered, dipolar spin systems in black diamond, observation of robust, symmetry protected collisions between strongly interacting photons as well as atom-by-atom assembly and control of regular arrays of ultra cold atoms.

Fri. 11.00 AM

Tensor networks, dynamics and the many body localization problem

Mari-Carmen Bañuls

Max Planck Institute of Quantum Optics, Garching, Germany

Matrix Product States (MPS) are a very powerful tool to study ground states of one dimensional quantum systems, but a full description of the most general out of equilibrium setup is often out of reach. Their extension to operators (MPO) nevertheless offer several ways of numerically exploring out-of-equilibrium problems. One example application includes approximating the steady state of a dissipative quantum system. Another one is simulating the evolution of mixed states, and identifying the operators that show the slowest evolution and thus will give raise to large time scales in the system.

A well suited scenario for such studies is that of many body localization. Combining tensor network techniques and quantum information concepts, we can explore the characteristics of this kind of systems from a new perspective.

Bose polarons

Eugene Demler

Harvard University, Cambridge, USA

I will review recent theoretical progress in understanding impurity dynamics in Bose systems. Impurities with contact interaction as well as Rydberg impurities will be discussed.

10 Poster Session 1: Tuesday, 30th August

(1) **Entanglement and thermodynamics after a quantum quench in integrable systems**
Vincenzo Alba, and Pasquale Calabrese
SISSA, Trieste, Italy

(2) **Scaling of an ultracold Rydberg gas driven out of equilibrium**
Alda Arias, Stephan Helmrich, and Shannon Whitlock
University of Heidelberg, Germany

(3) **Meissner-type effect for an artificial gauge field in multimode cavity QED**
Kyle Ballantine, Benjamin Lev, and Jonathan Keeling
University of St Andrews, UK

(4) **Measurement quench for probing characteristic length scales of many-body systems**
Abolfazl Bayat
University College London, UK

(5) **Spin models for 2-site resonant tunnelling dynamics of bosons in a tilted optical lattice**
Anton Buyskikh(1), David Pekker(2), and Andrew J. Daley(1)
(1) University of Strathclyde & SUPA, Glasgow, UK
(2) University of Pittsburgh, USA

(6) **Measuring total correlations via the Operator Schmidt Decomposition**
Matteo Caiaffa, and Marco Piani
University of Strathclyde, Glasgow, UK

(7) **Quantum-enhanced metrology with single-mode coherent states**
Lewis Clark
University of Leeds, UK

(8) **Towards the Implementation of Quantum Probes in Spin-Dependent Lattices**
Craig Colquhoun, A. Di Carli, and E. Haller
University of Strathclyde, Glasgow, UK

(9) **Using graphene to transform the performance and functionality of atom chips**
Rosy Crawford, Yijia Zhou, Nathan Welch, Peter Krüger, and Mark Fromhold
University of Nottingham, UK

(10) **Observation of Four-body Ring-exchange Interactions and Anyonic Fractional Statistics**
Han-Ning Dai, Bing Yang, Andreas Reingruber, Hui Sun, Xiao-Fan Xu, Yu-Ao Chen, Zhen-Sheng Yuan, and Jian-Wei Pan
Universität Heidelberg, Germany

(11) **Probing superfluidity in a quasi two-dimensional Bose gas through its local dynamics**
C. De Rossi, Romain Dubessy, K. Merloti, M. de GoÃńr de Herve, T. Badr, A. Perrin, L. Longchambon, and H. Perrin
LPL / University Paris 13, Villetaneuse, France

(12) **Dynamics of partially distinguishable bosons in a double well**
Gabriel Dufour, Tobias Brünner, Alberto Rodriguez, and Andreas Buchleitner
University of Freiburg, Germany

(13) **Dissipation in the Fano Model**
Daniel Finkelstein-Shapiro, Monica Calatayud, Osman Atabek, Vladimiro Mujica, Arne Keller, Tonu Pullerits, and Thorsten Hansen
Lund University, Sweden

(14) **Bogoliubov dispersion relation for a fluid of light in a rubidium atomic vapor**
Stefano Pierini, Dhruv Sharma, Alberto Bramati, and Quentin Glorieux
LKB - ENS Paris - UPMC, France

(15) **Collective strong coupling of cold potassium atoms in a ring cavity**
Jon Goldwin, Robert Culver, Andreas Lampis, Balázs Megyeri, Komal Pahwa, Lawrence Mudarikwa, Michael Holynski, and Philippe W Courteille
University of Birmingham, UK

(16) **Engineering magnetic ordering in optical lattices via adiabatic cooling of bosons**
Araceli Venegas Gomez, and Andrew J. Daley
University of Strathclyde, Glasgow, UK

(17) **Generalized Gibbs Ensemble in Nonintegrable Systems with an Extensive Number of Local Symmetries**
Ryusuke Hamazaki, Tatsuhiko N. Ikeda, and Masahito Ueda
University of Tokyo, Japan

(18) **Fresnel Holography for Atomic Waveguides and Miniaturised Rotation Sensing**
Victoria A. Henderson, Paul F. Griffin, Erling Riis, and Aidan S. Arnold
University of Strathclyde, Glasgow, UK

(19) **Towards taming exponentially large state spaces**
Ben Hourahine
University of Strathclyde, Glasgow, UK

(20) **Far-field resonance fluorescence from a dipole-interacting laser-driven cold atomic gas**
Ryan Jones, Reece Saint, and Beatriz Olmos
University of Nottingham, UK

(21) **Squeezing by flipping: strong dispersive regime of the quantum Rabi model**
Chaitanya Joshi, Elinor Irish, and Tim Spiller
University of York, UK

(22) **Exact numerics for generalised non-equilibrium Dicke models**
Peter Kirton, and Jonathan Keeling
University of St Andrews, UK

(23) **Self-organized magnetisation patterns in cold atoms**
Ivor Krešić, G.R.M. Robb, P. Gomes, P.F. Griffin, G.L. Oppo, A.S. Arnold, W.J. Firth, and T. Ackemann
University of Strathclyde, Glasgow, UK

(24) **Magnetically dressed Rydberg-Excitons in Cuprous Oxide**
Markus Kurz, Peter Gruenwald, and Stefan Scheel
University of Rostock, Germany

(25) **Sympathetic cooling of a single trapped atom in 3D by a reservoir gas**
Rosaria Gabriella Lena, and Andrew J. Daley
University of Strathclyde, Glasgow, UK

(26) **Modulation spectroscopy of ultracold fermions in optical superlattices**
Karla Loida, Jean-Sébastien Bernier, and Corinna Kollath
University of Bonn, Germany

(27) **Open and coupled quantum systems for enhanced solar energy harvesting**
Brendon Lovett
University of St Andrews, UK

(28) **Single-shot, phase-insensitive readout of an atom interferometer**
Andrew Rae MacKellar, Billy I. Robertson, James Halket, Jon D. Pritchard, Aidan S. Arnold, Erling Riis, and Paul F. Griffin
University of Strathclyde, Glasgow, UK

(29) **Diffractive optics for a compact, cold-atom microwave clock**
James Patrick McGilligan, Rachel Elvin, Paul F. Griffin, Erling Riis, and Aidan S. Arnold
University of Strathclyde, Glasgow, UK

(30) **The quantum repeaters of the future**
Filippo Miatto, and Norbert Lutkenhaus
Institute for Quantum Computing, Waterloo, Canada

11 Poster Session 2: Thursday, 1st September

(1) **Cavity-enhanced frequency up-conversion in rubidium vapour**
Rachel F. Offer, Johnathan W. C. Conway, Erling Riis, Sonja Franke-Arnold, and Aidan S. Arnold
University of Strathclyde, Glasgow, UK

(2) **Superfluid in helical container as a sensor of metric disturbances**
Alexey Okulov
Russian Academy of Sciences, Moskow, Russia

(3) **Quantum simulation of spin models and classical statistical methods: from Rydberg atoms to trapped ions**
Asier Pineiro Orioli, H. Schempp, A. Signoles, S. Helmrich, M. Ferreira-Cao, V. Gavryusev, M. Wall, A. Safavi-Naini, J. Schachenmayer, S. Whitlock, M. Weidemüller, J. Berges, and A. M. Rey
Heidelberg University & JILA, Germany

(4) **Transport in the Frustrated, Driven-Dissipative Sawtooth Lattice**
Edmund Thomas Owen, and M. J. Hartmann
Heriot-Watt University, Edinburgh, UK

(5) **Single-atom imaging of fermions in a quantum-gas microscope**
Bruno Peaudecerf, J. Hudson, A. Kelly, D. A. Cotta, M. Andia, E. Haller, and S. Kuhr
University of Strathclyde, Glasgow, UK

(6) **Should Entanglement Measures be Monogamous or Faithful?**
Cécilia Lancien, Sara Di Martino, Marcus Huber, Marco Piani, Gerardo Adesso, and Andreas Winter
University of Strathclyde, Glasgow, UK

(7) **An application of quantum Darwinism to structured environments**
Graeme Pleasance, and Barry M Garraway
University of Sussex, Falmer, UK

(8) **A Hybrid Atom-Photon-Superconductor Quantum Interface**
C. Picken, R. Legaie, and Jonathan D. Pritchard
University of Strathclyde, Glasgow, UK

(9) **Manipulating matter waves in an optical superlattice**
Brendan Reid, Maria Moreno-Cardoner, Jacob Sherson, and Gabriele de Chiara
Queen's University Belfast, UK

(10) **Driven open quantum systems and Floquet stroboscopic dynamics**
Sebastian Restrepo, J. Cerrillo, V. M. Bastidas, D. G. Angelakis, and T. Brandes
Technische Universität Berlin, Germany

(11) **Atom Interferometry: Single-shot, optical-phase-insensitive interferometry using Bose-Einstein condensates**
Billy I. Robertson, Andrew R. MacKellar, James Halket, Jonathan D. Pritchard, Aidan S. Arnold, Erling Riis, and Paul F. Griffin
University of Strathclyde, Glasgow, UK

(12) **Microscale integrated atom-photon junction**
Elisa Da Ros, Jonathan Nute, Pierre Jouve, Nathan Cooper, and Lucia Hackermüller
University of Nottingham, UK

(13) **A story of geometry and fluctuations in the stage of condensates**
Arko Roy, and Dilip Angom
Physical Research Laboratory, Ahmedabad, India

(14) **Free, Higher Derivative Scalar Field Drives Quantum Phase Transition**
S. Santhosh Kumar, and S. Shankaranarayanan
Indian Institute of Science Education and Research, Thiruvananthapuram, India

(15) **Towards quantum gases in novel optical lattice geometries**
Matteo Sbroscia, Konrad Viebahn, Oliver Brix, and Hendrik Von Raven
University of Cambridge, UK

(16) **Quantum engineering of a low-entropy gas of RbCs molecules in an optical lattice**
Andreas Schindewolf, Lukas Reichsöllner, Silva Mezinska, Beatrix Mayr, Rudolf Grimm, and Hanns-Christoph Nägerl
University of Innsbruck, Austria

(17) **Spatial light modulation for the generation of optical potentials in a quantum-gas microscope**
Jan-Philipp Schröder, B. Peaudecerf, and S. Kuhr
University of Strathclyde, Glasgow, UK

(18) **Dissipative and non-dissipative many-body dynamics in a cold Rydberg gas**
Cristiano Simonelli, M. Archimi, L. Asteria, D. Capecchi, G. Masella, F. Castellucci, E. Arimondo, D. Ciampini, and O. Morsch
University of Pisa, Pisa, Italy

(19) **Quantifying identical particle entanglement**
Enrico Sindici, and Marco Piani
University of Strathclyde & SUPA, Glasgow, UK

(20) **On-chip dressed-lattice for cold atoms: applications, advantages and challenges**
German A. Sinuco-Leon, and Barry M. Garraway
University of Sussex, Falmer, UK

(21) **Quantum Simulation with Light-Matter Systems**
Maria Laura Staffini, Kyle Ballantine, and Jonathan Keeling
University of St Andrews, UK

(22) **Restoring Positivity in Adiabatic Path Integral Techniques**
Aidan Strathearn, B.W. Lovett, and P. Kirton
University of St Andrews, UK

(23) **Moving Single Atoms**
Dustin Stuart, Naomi Holland, Klara Theophilo, and Axel Kuhn
University of Oxford, UK

(24) **Interacting bosons in an optical cavity**
Dandan Su
Goethe-Universität Frankfurt, Germany

(25) **Evolution of entanglement under an Ising-like Hamiltonian**
Konrad Szymanski, and Krzysztof Pawlowski
PAS/Jagiellonian University, Warsaw / Kraków, Poland

(26) **Measuring entanglement**
Luca Tagliacozzo
University of Strathclyde, Glasgow, UK

(27) **Can Quantum Gas Microscopes Directly Image Exotic Glassy Phases?**
Liam Walker, Graham Bruce, Steven Thomson, and Jonathan Keeling
University of St Andrews, UK

(28) **Minimum-error measurement strategies for the trine states**
Graeme Weir, Stephen M. Barnett, and Sarah Croke
University of Glasgow, UK

(29) **Adiabatic dynamics with classical noise in optical lattice**
Guanglei Xu, and Andrew Daley
University of Strathclyde, Glasgow, UK

(30) **Dissipative engineering of spin-entangled states in Fermi Gases**
Jorge Yago, Suzanne McEndoo, and Andrew Daley
University of Strathclyde, Glasgow, UK