

CW Location SIG**'What's a nanosecond between friends?'**1st May 2019**Delivered in partnership by The KTN, supported by UK5G
& hosted by National Physical Laboratory (NPL)**This SIG is championed by This SIG is championed by David Bartlett, **u-blox**; Bob Cockshott, **The KTN**
and Ben Tarlow, **Qualcomm Technologies International****Venue: National Physical Laboratory, Hampton Road, Teddington, Middlesex, TW11 0LW****AGENDA****10:30** Registration and networking with refreshments**11:00** Welcome from our host, **NPL** from **Dr Leon Lobo, National Physical Laboratory****11:05** Introduction to CW **Simon Mead, CEO, Cambridge Wireless****11:15** A word from our event supporter UK5G, **Robert Driver, UK5G****Session chaired by SIG Champion, David Bartlett, u-blox****11:20** **'Inertial sensing using cavity optomechanics'****Dr. Ying Lia Li, Physicist & entrepreneur, University College London**

In this talk I will discuss microcavities supporting optical whispering gallery mode resonances (WGMs) which exhibit an extreme sensitivity to the cavity motion. This optomechanical coupling alters the WGM linewidth and frequency, even when the cavity is displaced by picometers. By attaching the microresonator to a cantilever, we have created an accelerometer with high-linearity and strong optomechanical coupling to obtain micro-g ($g=9.81 \text{ ms}^{-2}$) sensitivity, suitable for navigation or vibration sensing. After field-testing a portable WGM accelerometer prototype on a vehicle sustaining car-crash like shocks, we are now progressing with a chip-scale version using semiconductor fabrication methods with the inclusion of a WGM gyroscope.

11:40 Q&A**11:45** **'High-performance MEMS oscillators for timing and inertial measurement systems'****Professor Ashwin Seshia, Cambridge University Engineering Department**

This talk will describe research results underpinning high-Q silicon MEMS oscillators for low-power miniature clocks and as building blocks in high-performance inertial sensors. Quality factors approaching 10 million at room temperature and short-term stabilities under 0.4 ppb have been demonstrated, and excellent long-term stabilities can be achieved through suitable packaging, and temperature compensation and oven control schemes. Further, nonlinear effects can be harnessed to provide additional features and benefits beyond those achievable using conventional crystal oscillator technologies.

12:05 Q&A**12:10** **'Ultra-precise timing applications'****Professor Kai Bongs, School of Physics and Astronomy, University of Birmingham & UK National Quantum Technology Hub in Sensors & Metrology**

Professor Bongs will be introducing the timing program of the UK National Quantum Technology Hub in Sensors and Timing. He will in particular discuss applications for optical clocks, from reference time provision in navigation to low phase noise oscillators for radar and distributed radar.

12:30 Q&A**12:45** **Networking Lunch****13:45** A word from our event partner, **Bob Cockshott, The KTN****Session chaired by SIG Champion, Ben Tarlow, Qualcomm Technologies International****13:50** **'Timing and Synchronisation with Atomic Clocks'****Patrick Gill, Co-Director, NPL Quantum Metrology Institute, National Physical Laboratory**

Patrick will discuss the various atomic clock and timing systems under development at NPL, and routes to high accuracy dissemination to end users in science, technology and industry.

14:10 Q&A

14:15 **'A feasibility study of using pulsars as a back-up time distribution system'**
Presented by John Haine on behalf of the CDT in Communications 2018/19 year 1 cohort at Bristol University.

14:35 Q&A

14:40 **'Timing for Internet of Things applications'**
Dr Chris Marshall, Senior Principal Engineer, u-blox UK
Chris will explore the timing needs of IoT applications, breaking them down into requirements for relative and for absolute timing. He will then discuss how these might be met - particularly in wireless connected devices.

15.00 Q&A

15:05 Concluding remarks from SIG Champion **Bob Cockshott, The KTN**

15:20 **Networking over refreshments**

16:00 **Event closes**

With the permission of the speakers, presentations will be loaded to the CW website on the day following the event

Profile of organisers

Cambridge Wireless (CW)

CW is the leading international community for companies involved in the research, development and application of wireless and mobile, internet, semiconductor and software technologies. With over 400 members from major network operators and device manufacturers to innovative start-ups and universities, CW stimulates debate and collaboration, harnesses and shares knowledge, and helps to build connections between academia and industry. CW's 19 Special Interest Groups (SIGs) provide its members with a dynamic forum where they can network with their peers, track the latest technology trends and business developments and position their organisations in key market sectors. CW also organises major conferences and start-up competitions along with other high-quality industry networking events and dinners. With headquarters at the heart of Cambridge, UK, CW partners with other international industry clusters and organisations to extend its reach and remain at the forefront of global developments and business opportunities. www.cambridgewireless.co.uk

Profile of sponsor

The KTN

The Knowledge Transfer Network promotes UK wealth creation through innovation and is a partner of Innovate UK, funded by BEIS. We connect UK business with sources of expertise and funding, and with potential collaborators. We do this by holding focused networking events, often in collaboration with other networks, and via our web site, newsletters, Twitter feeds, LinkedIn groups and extensive personal contacts. Our domain experts are active in numerous sectors, enabling us to provide uniquely broad coverage combined with deep, specialist knowledge. <https://ktn-uk.co.uk>

Profile of host

The National Physical Laboratory (NPL)

The National Physical Laboratory (NPL) is one of the UK's leading science and research facilities and a centre of excellence in developing and applying the most accurate measurement standards. These standards underpin an infrastructure of traceability throughout the UK and the world that ensures accuracy and consistency. www.npl.co.uk

Supported by

UK5G

UK5G is the new national innovation network dedicated to the promotion of research, collaboration and the commercial application of 5G in the UK. UK5G is a 'network of networks' to facilitate and encourage the engagement and coordination of organisations working on 5G activities across the UK. It will enhance links between ongoing research and development and other activities being undertaken by organisations across telecoms and other sectors, as well as the testbeds and trials that will be funded through the UK Government's 5G Testbeds and Trials

Programme. It will facilitate the joining up of businesses, large and small, academic institutions and the public sector throughout the UK. UK5G is independent and impartial. A senior national advisory board will advise the Government's 5G Testbeds and Trials Programme, providing expert feedback from industry, identifying their priorities and advising on future areas of focus. UK5G will be a focal point for international engagement into the UK's 5G eco-system - encouraging international participation and investment. www.uk5g.org

Profile of SIG Champions

David Bartlett, Senior Principal Engineer Positioning, u-blox

David Bartlett works in the positioning technology (R&D) group at u-blox with a focus on hybrid positioning: bringing together GNSS with terrestrial systems such as UWB and V2X, primarily in support of future autonomous vehicle, driverless car and robotics applications but also for IoT and indoor positioning. Prior to this he was CTO and co-founder of Omnisense delivering high precision indoor IoT tracking solutions. He also worked at Cambridge Positioning systems with a focus on cellular positioning and network aided GNSS techniques. www.u-blox.com

Bob Cockshott, PNT Lead; Quantum Lead, The KTN

After 25 years in the space industry working mainly on electro-optical payloads, Bob has spent the last 13 years in the government-funded Knowledge Transfer Network, supporting business in position, navigation and timing, and more recently also quantum technology. Bob has taken a special interest in GNSS vulnerability, and has organised international conferences on vulnerability and its mitigation. Bob is a member of the Cabinet Office PNT Technical Group and chairs the Royal Institute of Navigation's Technical Committee. Bob is a member of the International Time and Sync Forum Steering Group and is also a Cambridge Wireless Location Based Services SIG Champion. www.ktn-uk.co.uk

Ben Tarlow, Senior Staff Engineer, Qualcomm Technologies International

Ben has worked in positioning for 15 years, developing algorithms for satellite, cellular and other terrestrial RF technologies. At Qualcomm, Ben works in the Advanced Algorithms group, where current research areas in location are data fusion, use of sensor data for positioning and fitness applications; one day, he hopes to be given the remit to explore the area of olfactory positioning. Ben has a background in Pure Mathematics and a PhD in Combinatorics. He has over 20 different patents filed or granted, mostly on subjects relating to positioning. www.qualcomm.com

Profile of speakers

Professor Kai Bongs, School of Physics and Astronomy, University of Birmingham

Professor Kai Bongs is Director of the UK Quantum Technology Hub for Sensors and Metrology, where he drives the translation of gravity sensors and ultra-precise clocks into technology and applications across a diverse number of sectors, including climate, communications, energy, transport and urban development. He also leads the Midlands Ultracold Atom Research Centre at the University of Birmingham. His work has been disseminated through both invited and peer-reviewed presentations at international conferences and through high-impact publications (125 in total). His work has been cited over 7000 times and has a h-index of 39. Professor Bongs contributed to the Quantum technologies: Blackett review, a Government report published in 2016, which explored how the UK could benefit from the research, development, and commercialisation of quantum technologies. He has built extensive links with key industry partners, working with over 40 companies in over 30 projects. These industry partners include companies such as Teledyne e2v, Network Rail and BAE Systems. In 2017, Professor Bongs received the Josiah Mason award for Business Advancement in recognition of his leadership of the Quantum Technology Hub for Sensors and Metrology. At the beginning of this year, Professor Bongs was made Editor-in-Chief for the European Physical Journal (Quantum Technologies). He is also a Royal Society Wolfson Research Merit Fellow, as well as a Fellow of the Institute of Physics and the Institution of Engineering and Technology. www.birmingham.ac.uk/schools/physics

Patrick Gill, Co-Director, NPL Quantum Metrology Institute, National Physical Laboratory

Patrick Gill is a Senior NPL Fellow and co-Director of the NPL Quantum Metrology Institute, and heads up NPL Time & Frequency, where he is concerned with research into quantum frequency standards and atomic clocks and metrology, with wider application to fundamental physics, space science, satellite navigation and Earth observation, telecommunications, aerospace and defence. Patrick joined NPL in 1975 after completing his DPhil thesis at the University of Oxford. He is a visiting professor at Imperial College and at the University of Oxford. He was awarded the Rabi Award by the IEEE International Frequency Control Symposium in 2007, and won the IOP 2008 Young Medal

and Prize. His team received the 2014 Duke of Edinburgh award from the Royal Institute of Navigation for long term atomic clock development. Patrick was awarded an MBE for services to Science in The Queen's New Year's Honours List 2015. He was elected as a Fellow of the Royal Society in 2016. www.npl.co.uk

John Haine, University of Bristol (Communication Systems & Networks Research Group)

John Haine has spent his career in the electronics and communications industry, working for large corporations and with four Cambridge start-ups. His technical background includes R&D in radio circuitry and microwave circuit theory; and the design of novel radio systems for cordless telephony, mobile data, fixed wireless access and IoT communications. He has led standardisation activities in mobile data and FWA in ETSI, and contributed to WiMax in IEEE. At various times he has been involved in and led fund-raising and M&A activities. In 1999 he joined TTP Communications working on research, technology strategy and M&A; and after the company's acquisition by Motorola became Director of Technology Strategy in Motorola Mobile Devices. After leaving Motorola he was CTO Enterprise Systems with ip.access, a manufacturer of GSM picocells and 3G femtocells. In early 2010 he joined Cognovo, which was acquired by u-blox AG in 2012. He led u-blox' involvement in 3GPP NB-IoT standardisation and the company's initial development of the first modules for trials and demonstrations. Now retired from u-blox he is a Visiting Professor in Electronic and Electrical Engineering at Bristol University, where he chairs the Centre for Doctoral Training in Communications. He was founder chair and is Board Member Emeritus of the IoT Security Foundation. He served on the CW Board and now chairs the Editorial Board of the CW Journal. John has a first degree from Birmingham (1971) and a PhD from Leeds (1977) universities, and is a Life Member of the IEEE.

Dr. Ying Lia Li, Physicist & entrepreneur, University College London

Dr Ying Lia Li (Lia) received a 1st class MSci degree in physics from Imperial College and a Ph.D. from University College London. Lia has been building and optimising laser systems for over a decade. Between 2010-2012 she worked at the Advanced Technology Centre at BAE Systems, developing optical fibres for Eurofighter, MEMS pH sensors, and project management/bidding. In 2012 -2016 Lia completed a Ph.D. specialising in feedback control and laser cooling for creating macroscopic quantum ground states using optical microcavities. Her current position as an EPSRC Doctoral Prize fellow aims to use these microcavities as inertial sensors. She was invited to join the Nature/EF Innovation Forum to create an initial business case and has written for Nature Nanotechnology on the topic of commercialising research. Lia is a member of the Institute of Physics and the Optical Society of America.

www.yingliali.com

Dr Chris Marshall, Senior Principal Engineer, u-blox UK

Dr Chris Marshall is a Senior Principal Engineer with u-blox's Cellular Technology team in the UK. Following his graduation from Cambridge University and a PhD with Imperial College, London, he has enjoyed and led research and development projects and activities relating to wireless circuits, systems, and software, from communications (paging, 802.15.4, and cellular) to positioning systems. www.u-blox.com

Professor Ashwin Seshia, Cambridge University Engineering Department

Ashwin A. Seshia received his BTech in Engineering Physics in 1996 from IIT Bombay, MS and PhD degrees in Electrical Engineering and Computer Sciences from the University of California, Berkeley in 1999 and 2002 respectively, and the MA from the University of Cambridge in 2008. He joined the faculty of the Engineering Department at the University of Cambridge in October 2002 where he is presently a Professor of Microsystems Technology and a Fellow of Queens' College. He is a Fellow of the Institute of Physics, a Fellow of the Institution for Engineering and Technology and a senior member of the Institute of Electrical and Electronics Engineers. Prof Seshia serves on the editorial boards of the IEEE Journal of Microelectromechanical Systems, the IEEE Transactions on Nanotechnology and the IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control, and the technical program committees for the European Frequency and Time Forum and the IEEE Frequency Control Symposium.

www.eng.cam.ac.uk