Joe Bentley

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A keen and interested PhD student, excited to further the various cutting edge projects I am working on. I am an expert in the field of reducing quantum noise for high-precision measurements, and am a pioneer in combining this with the previously unrelated field of quantum network synthesis. I also have significant programming experience, and have developed my own software to facilitate the synthesis of quantum systems directly from their transfer functions.

Research interests

Quantum network synthesis; high-precision measurements; quantum optomechanics.

Education

University of Birmingham — Birmingham, UK
PhD in Quantum Optics, *close to completion* — October 2017–Present
Mentors: Dr. Haixing Miao, Professor Andreas Freise

MPhys in Physics — June 2013 – June 2017
First class with honours

Publications

All-optical PT symmetric amplifier in a gravitational wave detector
Joe Bentley, Yanbei Chen, Yiqiu Ma, Xiang Li, Denis Martynov, and Haixing Miao.
In preparation

Enhancing interferometer bandwidth without sacrificing sensitivity and stability: beyond single-mode and resolved-sideband approximation
Xiang Li, Yanbei Chen, Yiqiu Ma, George Smetana, *Joe Bentley*, Amit Ubhi, Haixing Miao, and Denis Martynov.
In preparation

Designing Heisenberg-limited linear detectors—a bottom-up approach
Joe Bentley, Hendra Nurdin, Xiang Li, Yanbei Chen, and Haixing Miao.
In preparation

Direct approach to realizing quantum filters for high-precision measurements
Joe Bentley, Hendra Nurdin, Yanbei Chen, and Haixing Miao.
Phys. Rev. A **103**, *013707* – *Published 7 January 2021*

A Broadband Signal Recycling Scheme for Approaching the Quantum Limit from Optical Losses

Teng Zhang, *Joe Bentley*, and Haixing Miao.
Galaxies **2021**, *9(1), 3* – *Published 1 January 2021*

Towards observing the neutron star collapse with gravitational wave detectors
Teng Zhang, George Smetana, Yikang Chen, *Joe Bentley*, William E. East, Denis Martynov, Haixing Miao, and Huan Yang.
arXiv:2011.06705 **[gr-qc]** – *Submitted 13 November 2020*

Converting the signal-recycling cavity into an unstable optomechanical filter to enhance the detection bandwidth of gravitational-wave detectors
Joe Bentley, Philip Jones, Denis Martynov, Andreas Freise, and Haixing Miao.
Phys. Rev. D **99**, *102001* – *Published 14 May 2019*

Research projects

An all-optical PT symmetric quantum amplifier
Previously by Xiang Li et.al. it was shown that a stable detector that surpasses the often-cited "Mizuno limit" can be produced by coupling two modes to the readout mode via a PT (parity-time) symmetric interaction. This setup utilised a mechanically suspended mirror to facilitate this interaction, and thus suffered greatly from thermal noise. Therefore we are now in the process of designing an all-optical setup that uses a non-linear crystal and thus does not suffer from thermal noise.

Designing the Optimal Detector 2019–Present
Until now, the design of new detectors for high-precision measurement has been almost entirely by a priori knowledge and intuition. However using novel ideas from quantum network synthesis and PT (parity-time) symmetric systems, for the first time we can systematically develop detectors with optimal sensitivity that achieves the Heisenberg limit, while also having a constraint on the complexity of the resulting setup.

Simba Source — Documentation 2019–Present
Since we now have a systematic approach to creating quantum systems from their transfer matrices, I designed and developed an ongoing Python software project to systematise this process. For example, given just the frequency-domain behaviour of the system a schematic diagram can be automatically created showing how various optical or mechanical components should be coupled to reproduce that behaviour.

Negative dispersion via Parametric Instability Fall 2019

Towards the end of 2019 I spent 6 weeks at the University of Western Australia working at their Gingin site. While there I had some significant hands-on experience with the optics and electronics, while also supporting them with significant theoretical guidance on an experiment to observe negative dispersion via parametric instability.

Transmission-readout setup 2017–2019

My first major PhD project was an unstable version of the PT symmetric amplifier mentioned above, in the case where there is no PT symmetry. This involved significant preliminary research in quantum optics, learning the wider field as well as the quantum noise formalism, and culminated in my first paper published in 2019.

Teaching experience

First year labs (University of Birmingham) 2017–2019

Experimental labs for first year undergraduate students. This involved learning an experiment in depth, grading weekly reports, and giving detailed and appropriate feedback. I learnt a lot about how to give appropriate and in-depth feedback for each student, as well as skills to improve my own reports and papers.

Second year computing labs (University of Birmingham) 2017–2018

Computing labs using the programming language Python for second year undergraduate students. Mostly this was focused on numerical simulations such as rocketry simulations. Being a high-pressure environment with many students and few teaching staff, it taught me how to manage a large number of students and judge who needs the most help.

Talks

All-optical realization of PT symmetric amplifier – Link

MQM telecon January 2021

Finding the optimal detector – Link

LVK September 2020 held virtually

A systematic approach to the realization of quantum optical systems – Link

Gravitational Wave Advanced Detector Workshop May (GWADW) 2019 in Elba

Unstable Filter Update: Thermal Noise and Controllability – Link

Sept 2018 LSC-Virgo Collaboration Meeting in Maastricht

Reducing the Shot Noise of Cosmic Explorer using an Unstable Optomechanical Filter – Link

LVC March 2018 at Sonoma State University

Skills

Programming

Proficient in: Python, Mathematica, C++, Javascript, HTML/CSS.
Familiar with: Matlab, Ruby, C, Rust, Haskell.

Languages

English (fluent), French (basic)

Other interests

I have a strong interest in music and music production, and have released my own short album as well as a few EPs. I was also in a band for my undergraduate years with some old school friends, which helped bring a sense of responsibility and gave me a lot of confidence. Also, I am very motivated and curious to learn new programming languages, as I greatly enjoy the learning process and also building things. Finally, I am also a Soto Zen Buddhist, which consists of daily meditation and therefore a lot of determination, persistence, and patience.