

# Joe Bentley

**Email:** [joebentley10@gmail.com](mailto:joebentley10@gmail.com)

**Country:** Germany

**GitHub:** [joebentley](https://github.com/joebentley)

**Site:** [joebentleyphysics.com](http://joebentleyphysics.com)

**Citizenship:** UK

An early career researcher, 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; non-linear quantum optics, quantum optomechanics.

**Employment**      **Universität Hamburg**      Hamburg, DE  
Postdoctoral researcher      August 2021–Present

**Education**      **University of Birmingham**      Birmingham, UK  
PhD focussing on Quantum noise reduction      October 2017–June 2021  
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), German (basic-intermediate), 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 interested in visual design and especially using 3D graphics libraries such as three.js.