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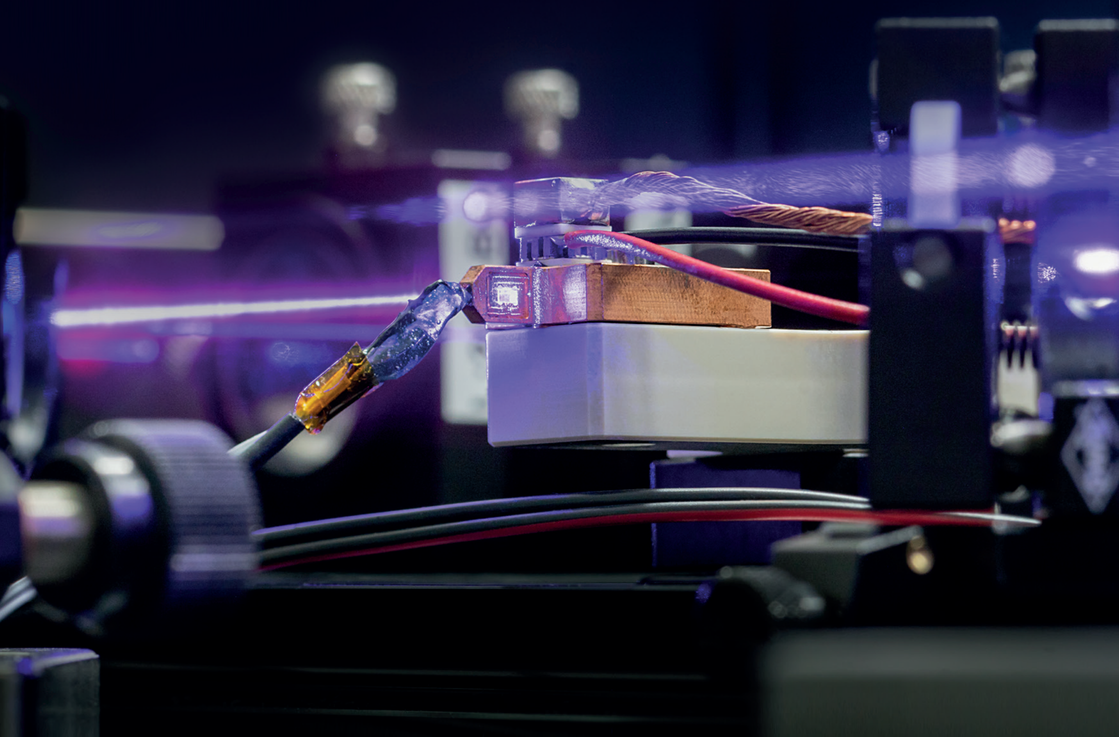
RESEARCH TOPICS IN

QUANTUM-ENHANCED IMAGING AND QUANTUM SOURCE DEVELOPMENT



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The Fraunhofer Institute for Applied Optics and Precision Engineering in Jena conducts applied optics research on behalf of the industry and as part of publicly funded research projects. The range of services includes system solutions, starting with new design concepts, through technology development, manufacturing and measurement methods to the construction of prototypes and pilot series for applications. The Fraunhofer IOF is also pioneering applied optical quantum technology, providing innovative solutions for science and industry wherever quantum-enhancement may lead to revolutionary applications.

We are looking for research candidates to join the »Quantum-Enhanced Imaging« team, led by Dr. rer. nat. Markus Gräfe. The research in the group focuses on the development of photonic quantum technology for application in imaging and sensing. This ranges from the development of novel quantum light sources to the implementation of innovative quantum-based schemes for imaging and metrology. A central goal is to transfer these approaches to practical quantum hardware for quantum imaging/microscopy and quantum sensing within the fields of life sciences and material analysis.

What you can expect from us

Photonics is a sophisticated quantum technology that combines a range of skills ranging from optical engineering to applications in quantum imaging and sensing. The Fraunhofer IOF provides access to the entire photonic process chain, starting at basic research in nonlinear optics and integrated photonics and photonic metrology, including optical engineering and micro-assembly technologies. This integration into the research site and ongoing international research collaborations will shorten development paths and provide more time for practical implementations. Students will thus have research opportunities in quantum imaging, technology development, applied photonics, and the industry.

The following projects are available:

- Quantum microscopy
- Quantum spectroscopy
- Ultra-bright and spectrally tailored photon pair sources

What we expect from you

With a background in physics, photonics, laser technology, electronics, engineering or a similar photonic study program, successful candidates will be enthusiastic to work in a multi-disciplinary team with collaborators from local research groups as well as international partners in academia and industry.

Prior knowledge in any of the following fields is preferable:

- Optics & metrology, nonlinear optics, electronics, electro-optics, imaging/microscopy, laser technology, quantum optics, integrated optics
- Basic scientific programming skills (e.g. MatLab, Python)
- Experimental skills and familiarity in handling basic laboratory equipment

Ultra-bright and spectrally tailored photon-pair sources

Photon pairs are a vital resource in quantum technological applications, in particular in the field of quantum-enhanced microscopy and spectroscopy. They are the working horse to implement various schemes for imaging and sensing, allowing, e.g., sub-shot noise microscopy or IR-spectroscopy with visible light.

In this project, you will develop novel photon pair sources with record brightness and tailored extreme spectral properties as required for quantum microscopy & spectroscopy. The work will involve the optimization of cavity-enhanced nonlinear optical devices and optical waveguides, theoretical model calculations, and proof-of-concept applications. In order to facilitate field deployment and modular integration with a variety of ongoing project collaborations, the sources will feature a compact footprint and address practical issues such as improved stability and spectral tuneability.

Quantum microscopy

Microscopy is a versatile tool without which modern life science and material analysis could not exist. However, there are intrinsic limitations in the interplay of the wavelength for investigation, the available detection efficiency in that spectral range and the acceptable photon dose for the specimen. Based on quantum optical effects one can overcome some of these restrictions by allowing the imaging in extreme wavelength ranges while detecting visible light only. Moreover, two-photon fluorescence microscopy with minimal photon doses becomes possible by harnessing photon-pairs.

In this project, you will develop and implement novel approaches for quantum imaging. The work will involve the optimization of quantum imaging setups, theoretical model calculations, and proof-of-concept applications. In particular, the development of an entangled two-photon fluorescence microscope is in focus. This includes the responsibility for all development steps from establishing a lab model to realizing a prototype. Naturally, this topic combines both fascinating research and successful collaboration with industry partners.

Quantum spectroscopy

Similar to microscopy, the spectroscopic analysis of substances is a crucial process in life and material sciences. One of the main obstacles in application is the lack of high-efficient detectors in vital spectral ranges. For instance, molecular fingerprint spectroscopy in the MIR suffers from poor detection efficiencies provided by InGaAs cameras. The utilization of correlated photon pairs and interferometric settings allows the achievement of spectroscopy in extreme spectral ranges while efficiently detecting visible light only. In addition, multi-photon spectroscopy of photosensitive substances becomes more efficient when harnessing photon pairs.

In this project, you will develop and implement novel approaches for quantum spectroscopy. The work will involve the theoretical modelling, experimental proof-of-concept realization, and transfer into applicable devices. Particular interest should be spent on benchmarking and comparison with standard spectroscopy techniques and demonstrating the feasibility and advantage for extreme wavelengths applications.

For more information see also: www.**iof.fraunhofer.de/qtech**

Application and Contact

If you are interested in one of our research topics please contact Markus Gräfe (including a CV and a short motivation letter), or use the form for unsolicited applications at our webpage: www.**iof.fraunhofer.de/en/jobs**

For further questions
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