Faculty of Science – Department of Physics & Astronomy

Prof. Stephen Pistorius
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Title: Design, Development and Evaluation of a Portable Microwave Breast Cancer Detection Device
Number of Openings: 3

Project: Access to early breast cancer screening is limited in much of the world, resulting in increased mortality rates for women in disadvantaged communities. Microwave based breast cancer detection offers a safe and inexpensive approach to early breast cancer detection. We are building on our decade-long experience in microwave radar-based breast imaging research to develop and design, build and test a portable microwave breast cancer detection device suitable for use in these communities. This system will increase access and reduce mortality.

The system will incorporate an array of patch antennas and a source of microwave radiation (generated by a collection of nano-VNA's) operating in the 0.8-3.0 GHz range that can be swept across the breast to create a tomographic data set. The battery-powered system will be controlled using an advanced NVIDIA Jetson supercomputer and is designed to be operated by the patient, using an easy to understand graphical user interface, and will use Machine Learning to enable an immediate response as to the presence (or absence) of a significant breast abnormality. We are looking for students (according to their skills and experience) to help us develop and test various aspects of this device, including the development of a user interface, machine-learning based diagnosis, 3D printed phantom development, to name but a few.

Skills Required: The student must be an independent learner with strong communication skills, be creative and innovative, and able to work in a diverse team. Ideally, the student will have demonstrated experience that includes programming, data collection and analysis. Experience with electronics, Machine Learning, Matlab or Python will be an advantage.

Prof. Can-Ming Hu
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Project title: Developing cavity spintronics devices for microwave and quantum applications

Cavity Spintronics, which was initiated by our group around 2015, is an emerging field that studies the strong coupling between cavity microwaves and magnetic materials. Via the quantum physics of spin-photon entanglement on the one hand, and classical electrodynamic coupling on the other, this frontier connects some of the most exciting modern physics, such as quantum information and quantum optics, with one of the oldest science on the earth, the magnetism. Students working on this project will start with the intuitive example of coupled pendulums, gradually learn the concepts of coherent and dissipative couplings, and build simple devices that are useful for microwave and quantum applications. Motivated students will have the opportunity to get the valuable experience of doing cutting edge research by communicating, collaborating, and directly competing with talented students working in our competing groups at Yale, MIT, Cambridge, Tokyo University, and TU Munich, etc..

Profs. Wouter Deconinck, Michael Gericke, Juliette Mammei
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Project: Profs. Deconinck, Gericke, and Mammei work on multiple overlapping experimental subatomic physics projects in Winnipeg, at Jefferson Lab, Oak Ridge National Lab and NIST in the USA, at the University of Mainz (Germany), and at the new Electron-Ion Collider (EIC). They are currently involved in several precision tests of the Standard Model of particle physics, our current best theory of fundamental particles and their interactions, and are leading detector construction and software development efforts. These large international experiments provide opportunities to gain experience in particle detector technologies, fast read-out electronics, and large data analysis on high performance computer clusters around the world. For 2021 we anticipate projects on the Nab and BL3 experiments (neutron decay), the MOLLER experiment (electron scattering), and the EIC (polarimetry, research software). Through your work in our group, you will interact with researchers at universities and research laboratories around the world.

Prof. Dr. Christopher O'Dea
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Project: Super Massive Black Holes Change the Galaxies That Host Them

It is now clear the galaxies from with a super massive black hole at the center. About 0.1% of the normal mass of the galaxy is contained in the black hole. Substantial amounts of energy are released as matter accretes onto the black hole. This energy release has consequences for the evolution of the galaxy which hosts the black hole. In the most massive galaxies, this black hole "feedback" can shut down star formation and limit the size to which galaxies can grow. We obtain and analyze observations of galaxies in order to study the effects of black hole feedback.