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Physics department

Fundamental solutions to real world problems

07 June 2019

Dr Pieter Neethling

Overview of the department

Laser Research Institute

- Applied Spectroscopy
- Laser Source development
- Custom photonics solutions

Nuclear Physics

- Environmental radiation monitoring
- Radiation detector design and construction

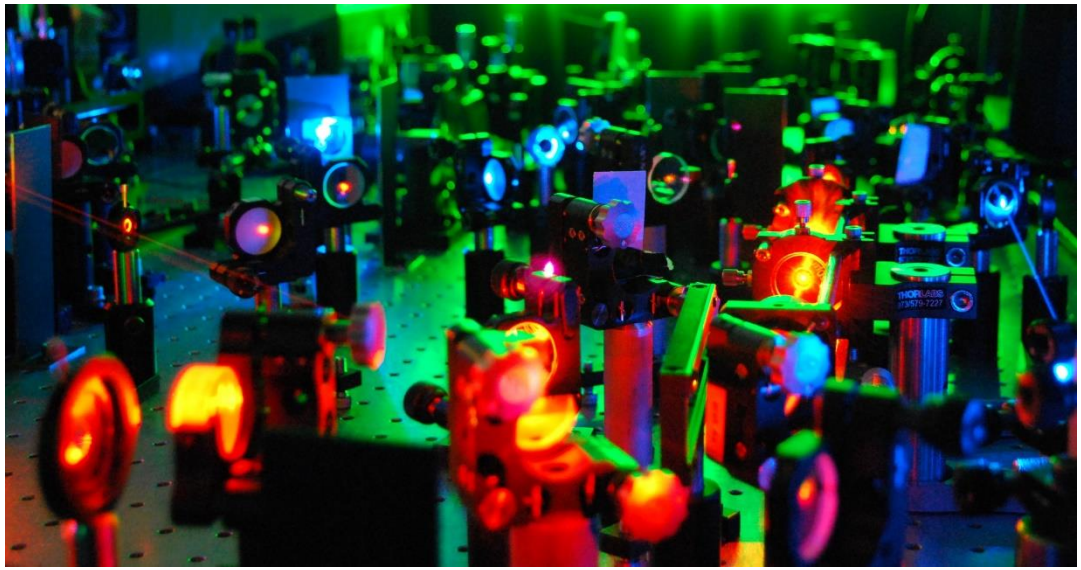
Theoretical Physics

- Modelling of complex networks
- Bayesian statistics

World class facilities

The Physics department has distinguished itself with regards to the research facilities and infrastructure available. These include:

- Two amplified femtosecond laser laboratories
- Nonlinear and single-molecule microscopy laboratories
- High resolution spectroscopy laboratory
- Ion trapping laboratory
- THz and Raman spectroscopy laboratories
- Optical tweezers
- Fibre laser development laboratory
- Nanoplasmonics laboratory
- Nuclear particle and radiation measurement facility
- Advanced numerical modelling



Industrial collaboration

Research partnerships

Contract research

Student placements – post graduate studies

Custom solutions

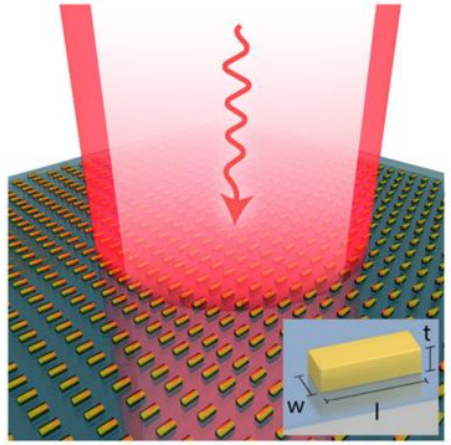
Problem identification

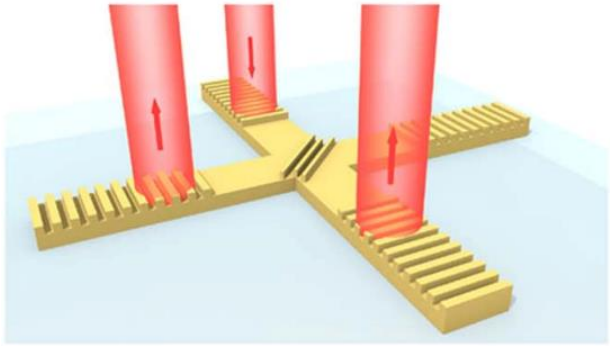
Viability studies

SARChI Professor in Photonics, Ultrafast and Ultra-intense Laser Science

– Prof Mark Tame (www.quantumnanophotonics.org)

- Components for emergent quantum technologies
- Nano structured metamaterials
- Control light and its microscopic dynamics in unusual ways.
- Nanophotonic circuitry
- Confinement of light fields to ultra-intense nanoscale hotspots.
- Development of single-photon sources, switches and sensors

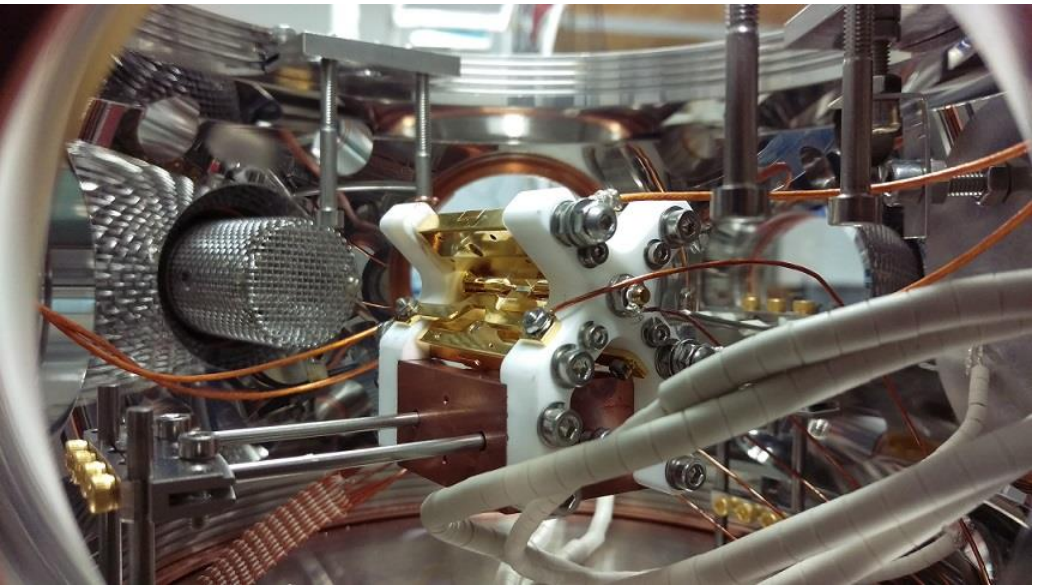




CSIR Research Chair in Quantum, Optical and Atomic Physics

– Prof Hermann Uys

- Weak measurements trapped single ions
- Investigation of quantum feedback processes
- Design and construction of sensitive magnetometers



High Resolution Laser Spectroscopy

Capabilities:

- Measure transmission in the UV and VUV (122-200 nm)
  - CW Deuterium lamp
- Measure transmission, fluorescence or scattering in the visible and near ultraviolet (220-360 nm and 430-660 nm).
  - Nanosecond pulsed lasers
- Selective laser ionization of element/isotope
- TOF mass spectroscopy
- We have expertise in the generation of laser pulses in the vacuum ultraviolet (140-160 nm)

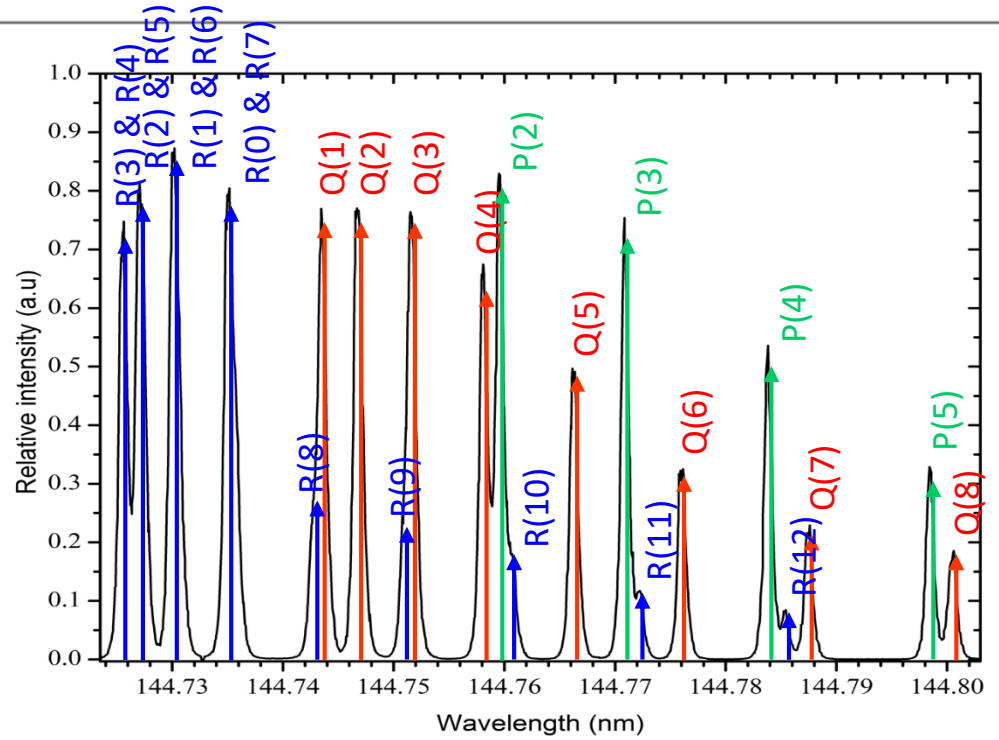
Contact person: Christine Steenkamp –

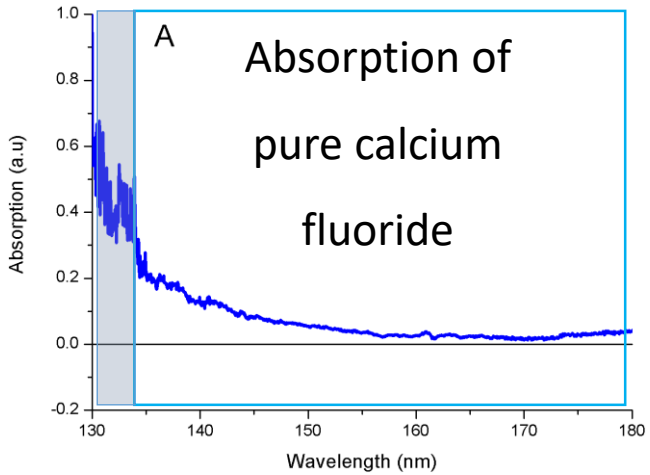
cmsteen@sun.ac.za

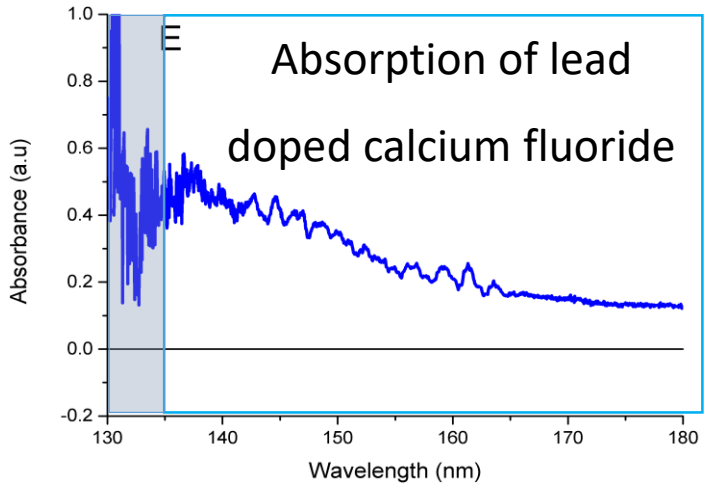
High Resolution Laser Spectroscopy

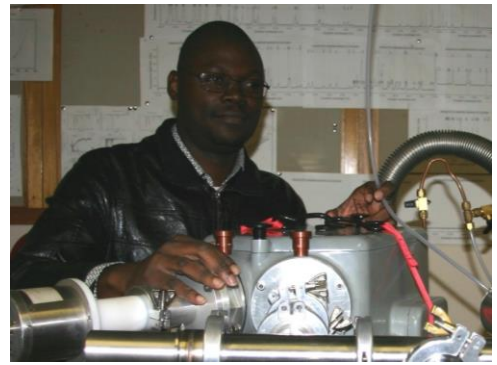
Examples of previous work

- Excitation of individual rotational energy levels of carbon monoxide molecules. Detection to parts per million level by measuring fluorescence.
- Measuring absorption of light in pure and doped calcium fluoride crystals.









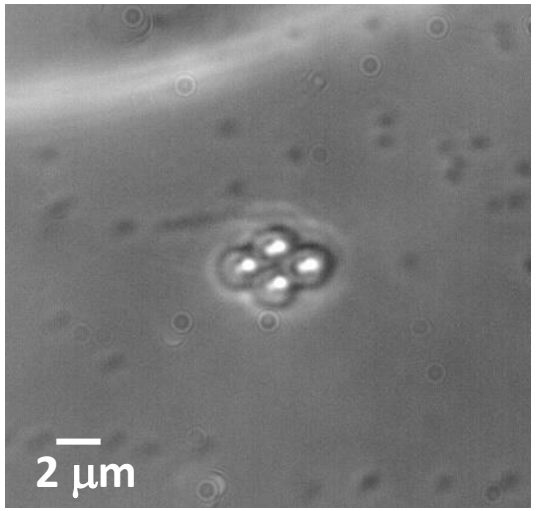
Contact person:
Christine Steenkamp
– cmsteen@sun.ac.za

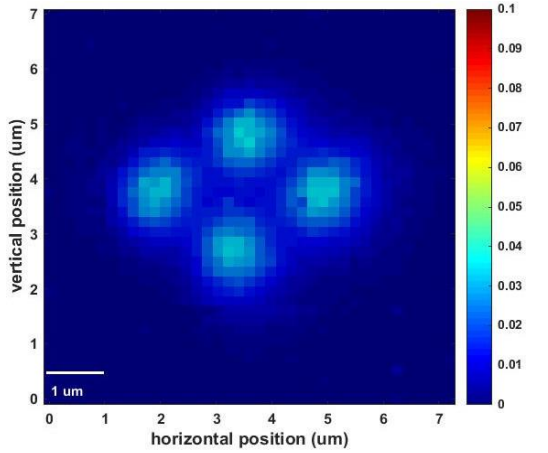
Microscopy

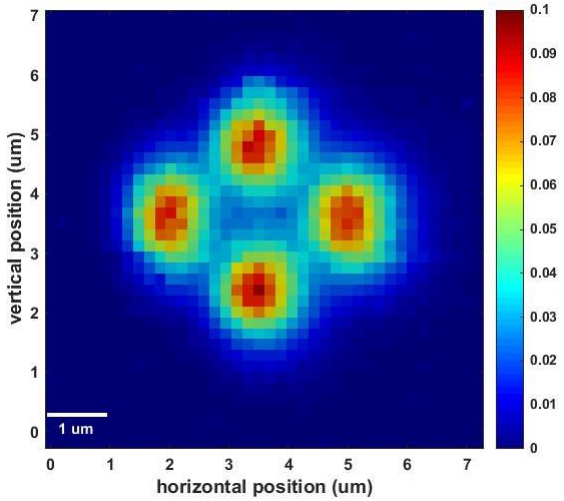
- Custom application specific microscopes
- Super resolution techniques (10 nm localization precision)
- Linear and nonlinear optical microscopies
- Confocal and wide-field geometries
- Chemical identification and distribution (CARS)
- Integrated optical tweezers (trapping of micron sized objects)

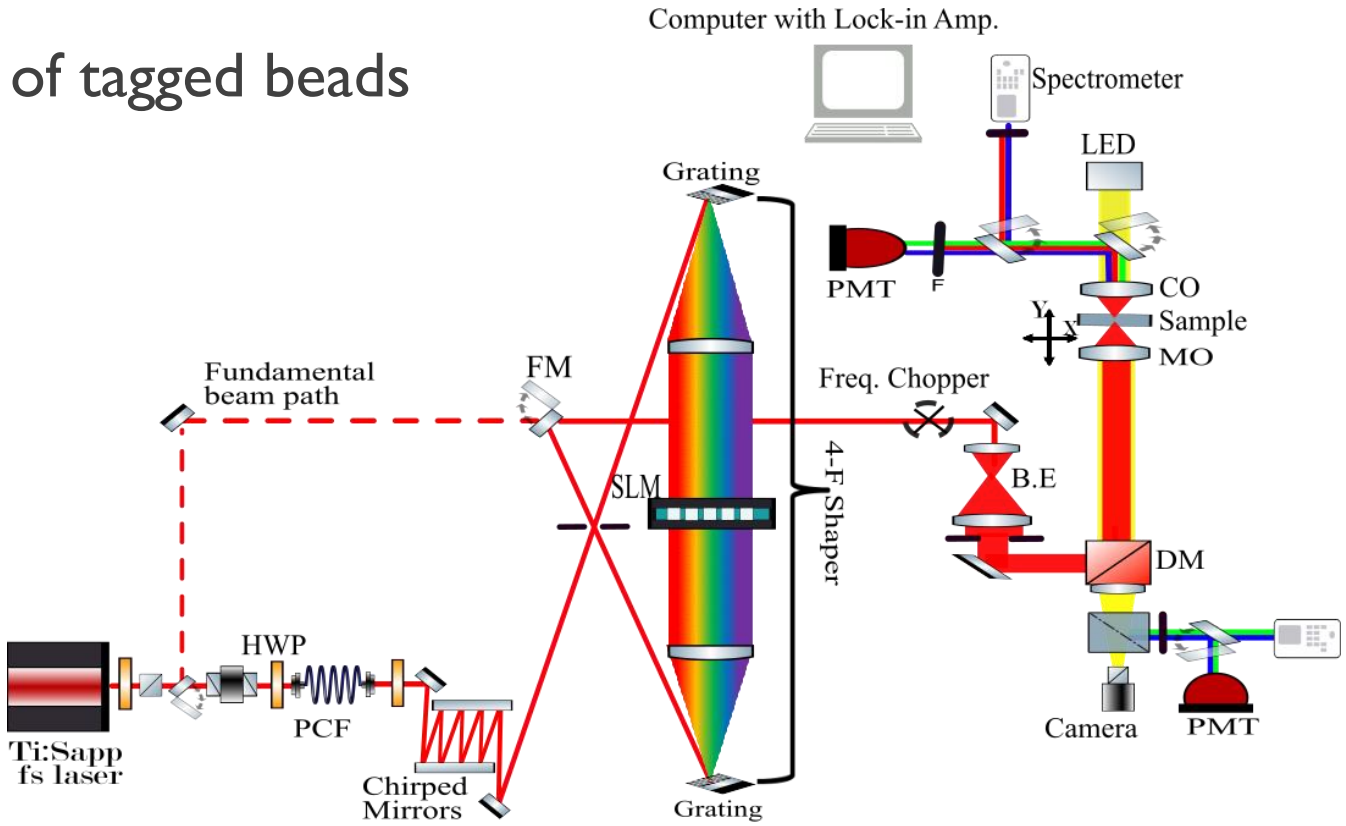
Microscopy

Setup and Two-photon fluorescence images of tagged beads



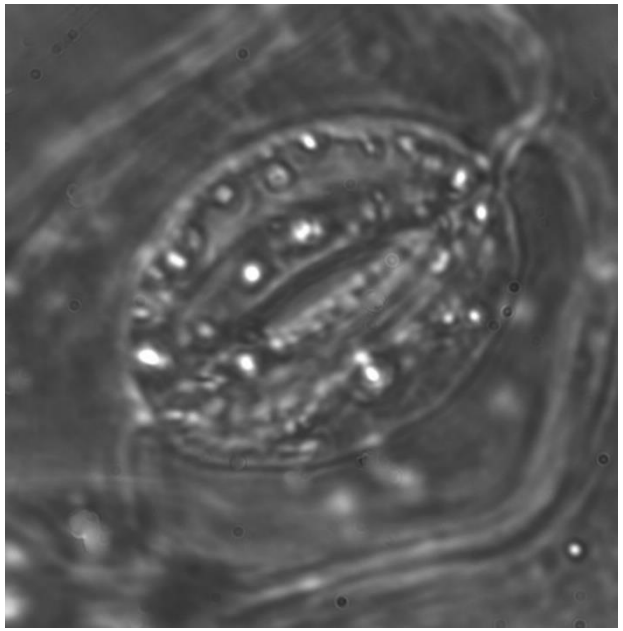




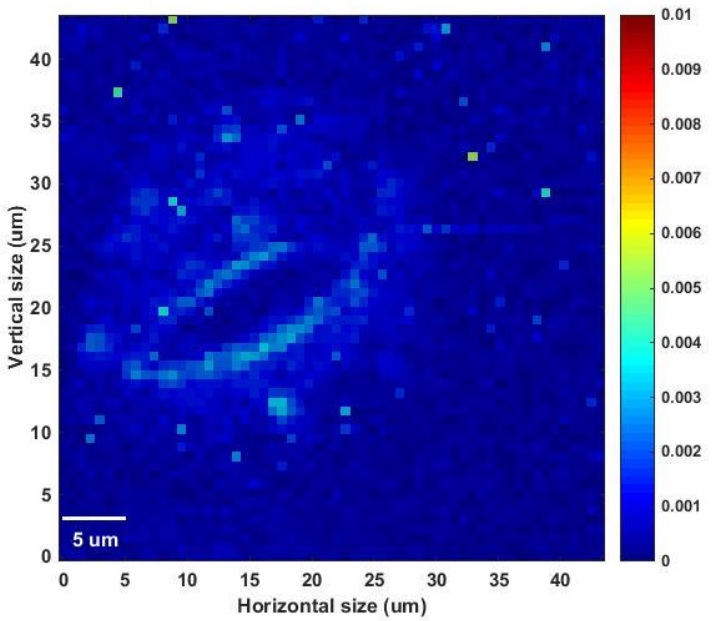


Microscopy

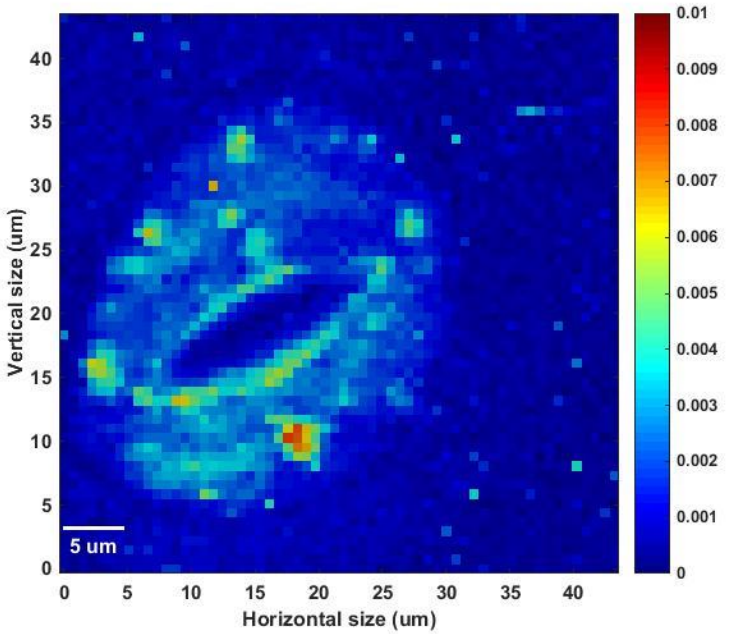
Second harmonic images



Without pulse compression



With pulse compression



Laser source development

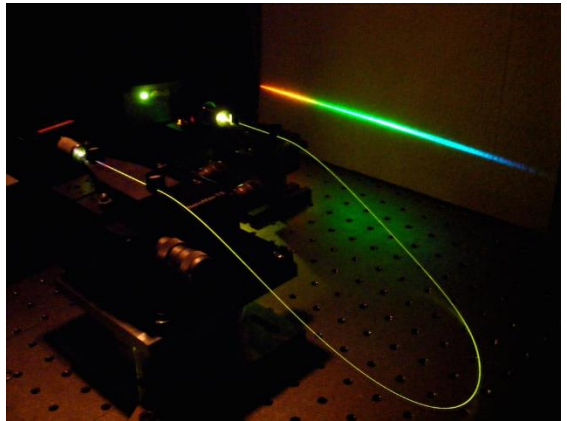
High power infrared fibre laser systems (pulsed and CW operation)

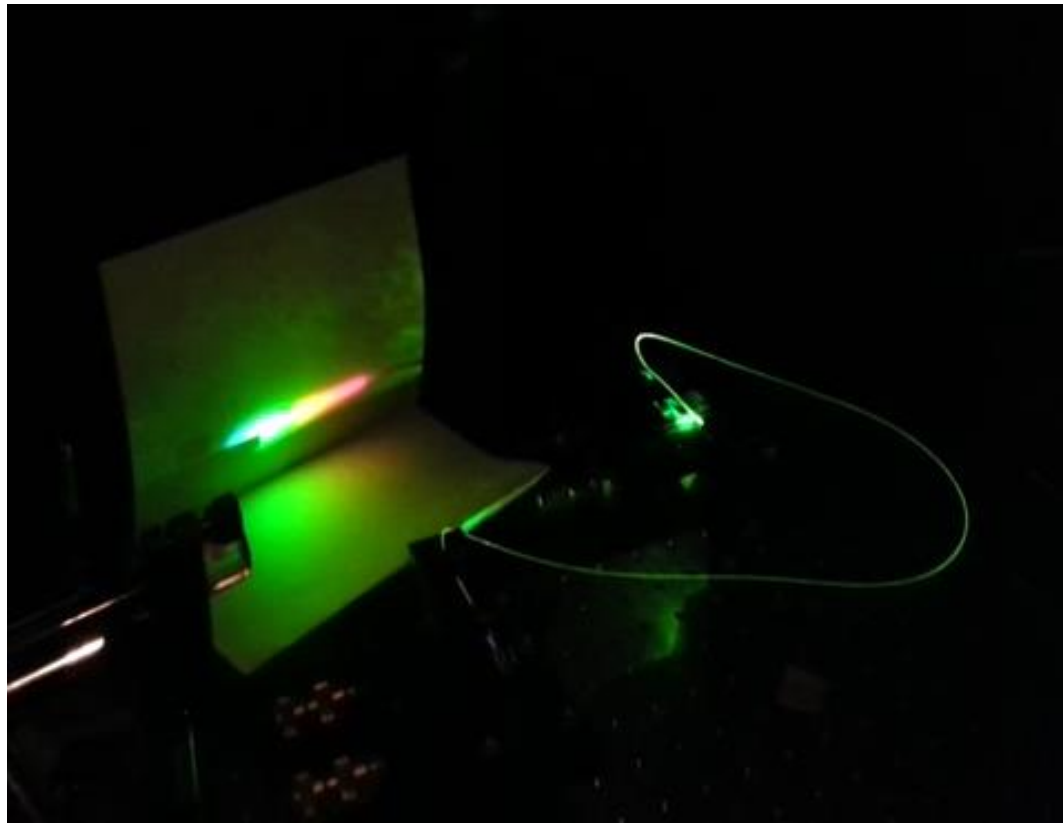
High power gas lasers and amplifiers (CO_2, N_2)

Phase and amplitude control of supercontinuum pulses (VIS-IR, 5 fs – 2ps)

Short pulsed radiation (100 fs) in the IR-MIR

Coherent radiation in the vacuum ultraviolet (140-160 nm)

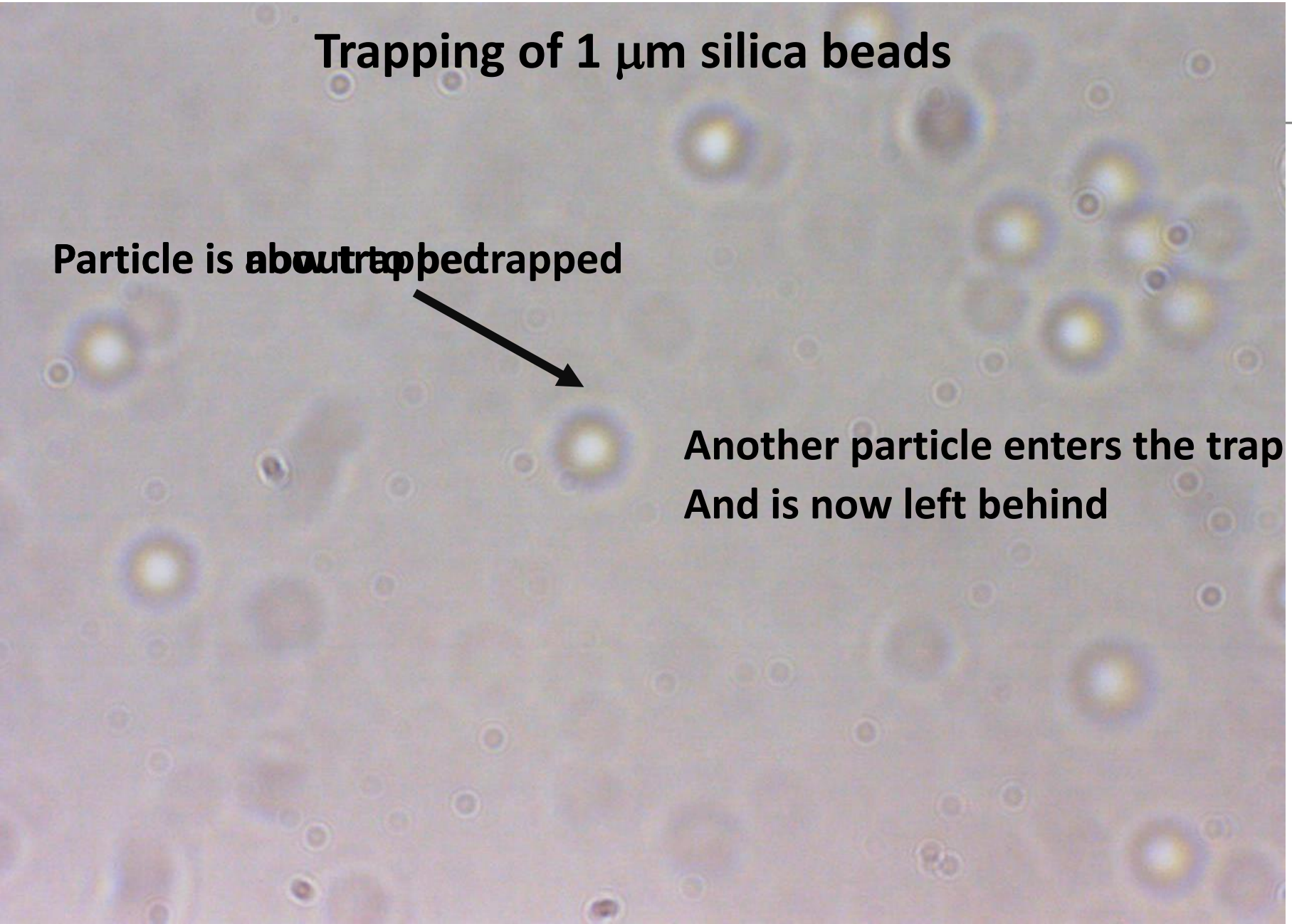




Custom setups

Recent completed applied projects

- Evaluation of laser-based paint stripping
- Insect monitoring using LIDAR
- Investigating charge transfer dynamics in organic solar cells on the fs/ps time scales
- Development of high power CO_2 lasers for industry
- Measurement of nonlinear optical properties of materials used as optical limiters
- Evaluation of thin film growth of semiconductor materials on a variety of substrates
- Monitoring of polymer crystallization in real time
- Construction of a time-domain THz ellipsometer
- Development of an optical tweezers setup
- Novel Raman spectroscopy setup



Optical tweezers in action

Nuclear Physics

Digital electronics for high resolution and high sampling rate

Data acquisition systems at iThemba LABS

- Pixie-4/Pixie16 XIA 500MHz, 16 bit
- Phasing out but supporting:
- VME (analogue electronics)
- CAMAC
- NetMCA/PalmtopMCA: single Multi Channel Analysers
- Using industrial standard big data tools: KAFKA
- Mutualised computing power plus data storage
- producer/consumer
- Data acquisition ported under Apache open source

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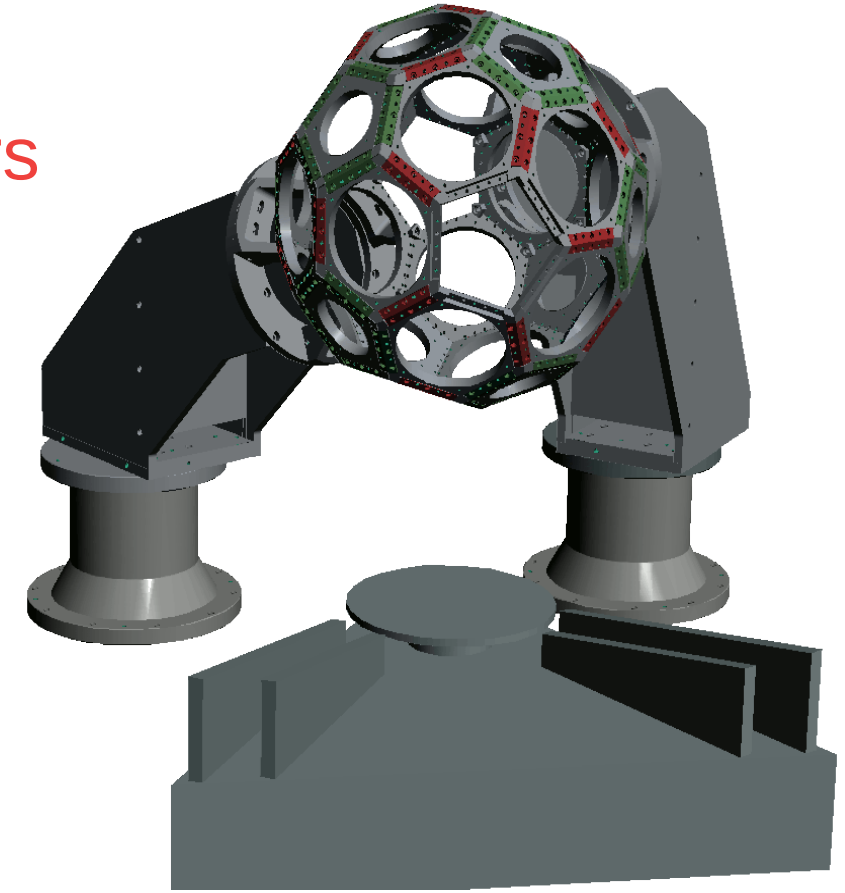
Nuclear Industry

- **Radiation detectors**
- High Purity Germanium and scintillator detectors
  - Spectroscopy
  - Diagnostics
  - Environmental studies
- Detector array
  - Application to Positron Emitter Tomography
  - Multiple detector array for coincidence measurement
- Gaseous detectors
  - Drift chambers



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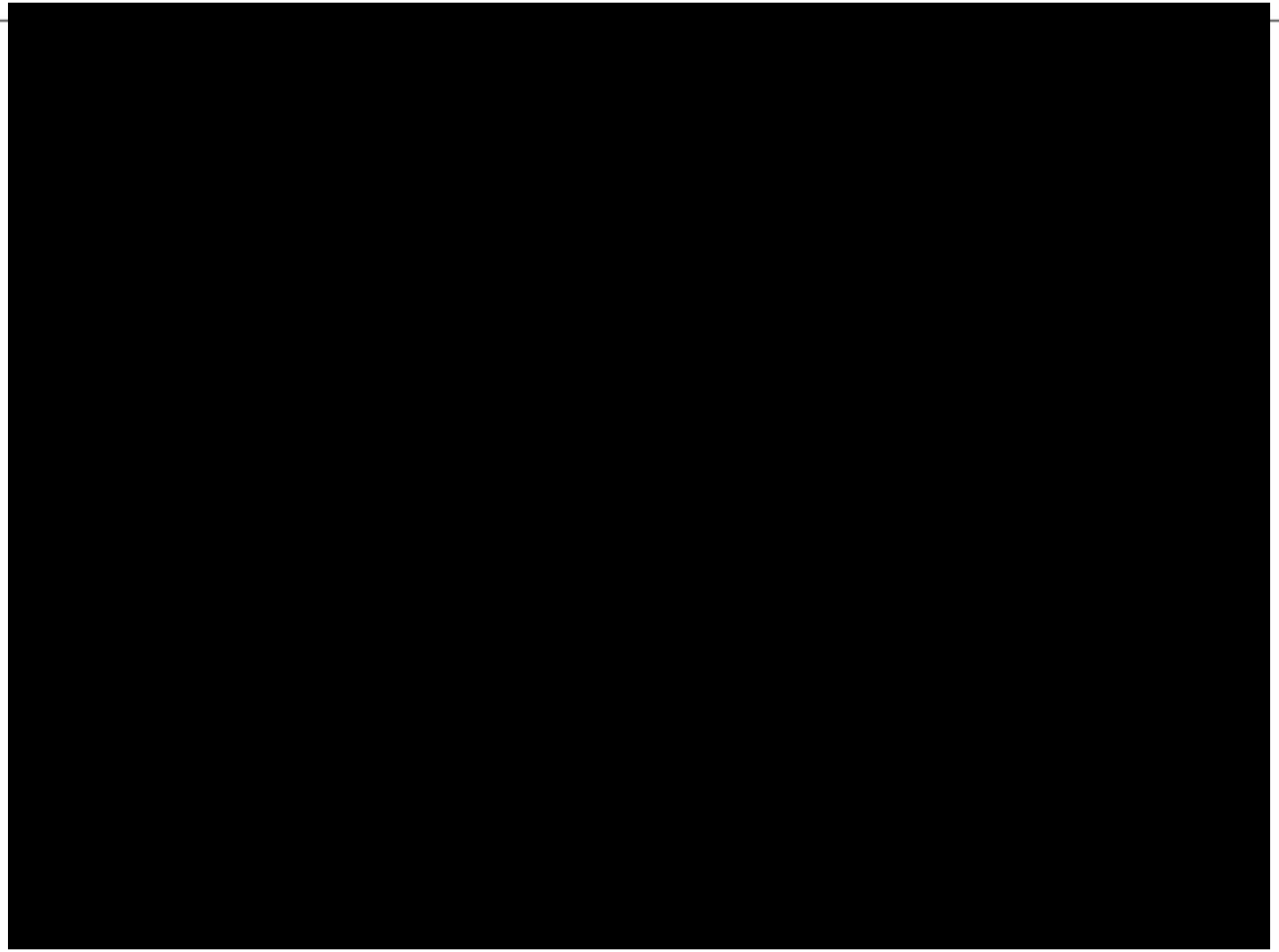
Nuclear

- Environmental radiation monitoring
- Radiation / nuclear safety
- Custom radiation detectors
- Custom particle detectors
- Elemental analysis – isotope identification

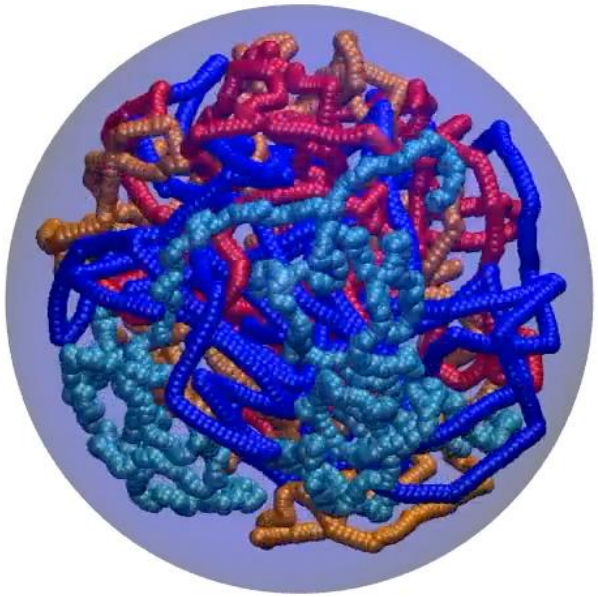
Modelling methods (1 of 2)

Modelling soft and biological matter

- Polymer networks
  Dynamics and equilibrium properties of networks, including self-healing gels, confined cytoskeleton
- Dynamics in noisy systems
  Self-propelled particles
- Membranes
  Tethering and fusion dynamics



Modelling methods (2 of 2)



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Modelling tools

- Analytical tools
- Image processing tools (e.g. extracting order parameters from microscopy images)
- Computer simulations:
  Molecular dynamics,
  Langevin dynamics

Training

Custom designed short courses

- Optics
- Lasers
- Imaging
- Image processing
- Light matter interaction
- Nuclear Safety

Can tailor the course to the clients need

Any questions

Contact Details

- Head of Department and numerical modeling: Prof Kristian Müller-Nedebock (kkmn@sun.ac.za)
- Research Chair – Ion Trapping: Prof Hermann Uys (hermann@sun.ac.za)
- Research Chair – Nanoplasmonics: Prof Mark Tame (mstame@sun.ac.za)
- High res spectroscopy: Dr Christine Steenkamp (cmsteen@sun.ac.za)
- Nonlinear microscopy and source development: Prof EG Rohwer (egr@sun.ac.za)
- Custom optical setups: Dr Pieter Neethling (pietern@sun.ac.za)
- Nuclear detectors: Prof Paul Papka (papka@sun.ac.za)
- Environmental radiation monitoring: Prof Richard Newman (rtnewman@sun.ac.za)