IRTG Multiscale Imaging Spring Lecture Series 2025

Multiscale Imaging Centre (MIC) | Röntgenstraße 16 | 48149 Münster

Tuesday 20 May 2025 – Optics

Afternoon session: Principles of optics and introduction to different optical imaging modalities

13:15 – 14:00 Thomas Huser

14:00 – 14:45 Friedemann Kiefer

14:45 – 15:30 Sven Herman

The lectures cover an introduction to the basic principles of geometrical optics and microscopy: we will discuss some basics of geometrical optics, e.g. basic optical aberrations and their corrections, as well as refraction and diffraction - all in the context of high end imaging applications. The lecture will then move on to cover specialized topics, such as telecentric lenses and the basic optical design of optical projection tomography systems, confocal scanning systems (angle scanning in the pupil plane, 4f optics), as well as the generation of light sheets by cylindrical lenses or scanned Bessel beams.

The second part, we will introduce the micro and mesoscopic imaging modalities including light sheet, confocal and multiphoton microscopy in biomedical imaging, and discuss their specific application range. We will address animal models systems and introduce sample generation ranging from transgenic models to whole-mount staining. The overview will include tissue clearing and volume imaging.

In the third part, optoacoustic (OA) imaging will be introduced: we will focus on OA's basic principles, major implementations and tomographic OA imaging, as well as imaging contrasts. The lecture will provide an overview of preclinical & clinical applications of OA imaging, and furthermore, will cover specialized topics, such as the evaluation of novel OA labels and tracers *in vivo*.

15:30 Coffee break

Open discussion of current research topics (application examples with relevance to the CRC)

16:00 – 17:30 Thomas Huser / Friedemann Kiefer

In this open discussion round with all lecturers, methods and applications for achieving super-resolution optical microscopy, intravital and mesoscopic microscopy will be discussed. Inquiries for specific use cases derived from ongoing projects are strongly encouraged. Examples of successful applications will include: structured illumination in live-cell fluorescence imaging with approx. 100 nm spatial resolution, surface receptor stimulation by high affinity ligand versus receptor clustering and the visualization of the vascular bed of entire tumors.

17:30 Get-together

inSight
CRC 1450

Wednesday 21 May 2025 – Nuclear imaging

Morning session: Basics of magnetic resonance and mass-spectrometric imaging

9:00 – 9:45 Cornelius Faber

9:45 – 10:30 Verena Hörr

10:30 – 11:15 Uwe Karst

The first and second lecture will cover the physical and technical basics of Magnetic Resonance Imaging: Questions entertained include, what is the physical origin of the detected signal and which physico-chemical information is contained in the MR signal? How does the signal relate to anatomical and physiological parameters and which technical devices (components of an MR scanner) are required to measure the signal? What is MR relaxation, how does relaxation reveal biochemical and physiological processes? What is an MR sequence, which parameters can we choose to assess biological questions with MR, what are MR contrast agents good for and how do they work? Finally, how can MR encode motion?

Mass spectrometric imaging comprises a group of analytical methods, which provide chemical information about the composition of a sample. Typically, tissue slices, which are prepared by a microtome or a cryotome, will be investigated, so that only ex-vivo samples can be analysed. In the third presentation, two MSI methods are presented, which can be used to obtain spatially resolved molecular and elemental information, respectively. Using matrix-assisted laser desorption/ionization mass spectrometry imaging (MALDI-MSI), low molecular weight analytes, including lipids, metabolites or peptides, are detected and can be correlated with features obtained by light microscopy or immunohistochemistry. Laser ablation-inductively coupled plasma-mass spectrometry imaging (LA-ICP-MSI) is a complementary method, which provides precise information about the distribution and concentration of the chemical elements in a biological sample.

11:15 Coffee break

Open discussion of current research topics (application examples with relevance to the CRC)

11:45 – 13:00 Cornelius Faber / Verena Hörr

In this open discussion around the lecturers, we address the use of MRI to assess flow in the cardiovascular system; Chemical Exchange Saturation Transfer MRI to study metabolism; contrast agents for cell tracking; time-resolved tracking of single cells; combining MRI and MSI for specific cell tracking.

13:00 Lunch break

Afternoon session: Basics and principles of imaging with radioactivity

14:00 – 14:45 Michael Schäfers

14:45 – 15:30 Klaus Schäfers

The lectures will provide an introduction to nuclear medicine. We will discuss basic imaging principles of nuclear imaging, such as single photon emission tomography (SPECT) and positron emission tomography (PET) in conjunction with their preclinical and clinical applications. A particular focus will be on the quantitative properties of SPECT and PET that allow insight into physiological and pathophysiological processes *in vivo*.

15:30 Coffee break

Open discussion of current research topics (application examples with relevance to the CRC)

16:00 – 17:00 Klaus Schäfers / Michael Schäfers / Sven Hermann

In this open discussion round, new methods for dynamic whole-body PET imaging using large-scale super-sensitive scanners will be presented and upcoming strategies allowing to enter a fascinating new world of nuclear imaging will be explored together with the audience.