Angewandte Physik und Messtechnik, LRT 2
Sektion biomedizinische Strahlenphysik
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PhD- Thesis

Numerical information field theory to surpass the limit of optical resolution

Numerical Information Field Theory (NIFTy) is a powerful tool in the analysis and modeling of large-scale, high-dimensional data sets. NIFTy is based on mathematical concepts of signal processing, probability theory, and information theory, and enables efficient processing and extraction of relevant information from complex data.

NIFTy provides a flexible framework for analyzing information in the form of fields, such as images, volume data, or maps. It enables probabilistic modeling of fields and estimation of parameters from the data. In addition, NIFTy provides methods for estimating uncertainties and predicting fields based on existing observations.

A prominent feature of NIFTy is its ability to handle high-dimensional data. It allows scaling to data with millions or even billions of dimensions while still providing efficient and accurate calculations. This is particularly relevant for processing data in fields such as cosmology, neurobiology, or materials science, where high-dimensional data is common.

NIFTy provides a variety of tools and algorithms for field analysis, including filtering, smoothing, deconvolution, compression, and uncertainty modeling. These tools allow the extraction of relevant information, characterization of structures and patterns, and prediction of fields with high accuracy.

By combining mathematical modeling, statistical methods, and efficient numerical computation, NIFTy enables detailed and accurate analysis of complex data. It finds application in various scientific disciplines where processing large data sets and extracting information from high-dimensional fields play a central role.

In this project the goal is to use NIFTy on fluorescence microscopy data to get a relsoution well beyond the Abbé limit. This increased resolution will be used to get deeper knowledge on the cellular reactions to radiation.

This thesis will be performed in the ERUM-Data joint project ERUM-IFT (Figure 1) in a consortium of theoretical physicists, astrophysicists and astroparticle physicists.

It will give insights into NIFTy, Radiobiology and radiation physics and optics and microscopy.

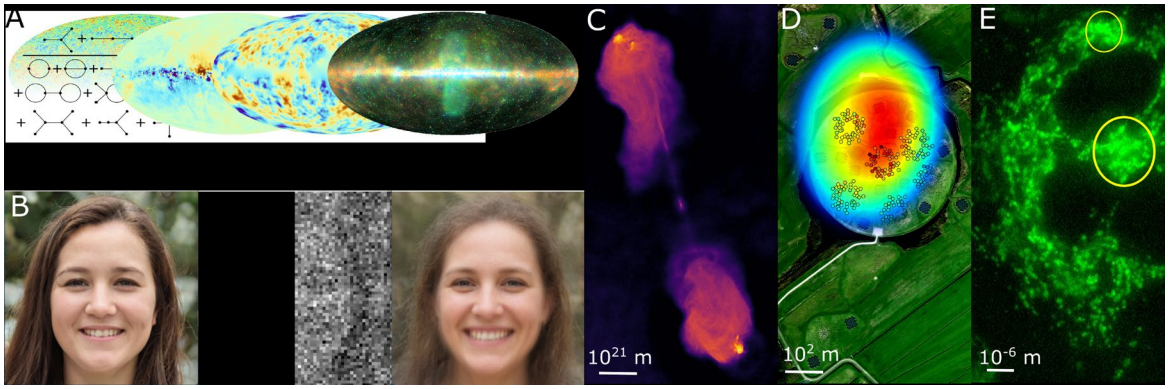

Figure 1: Existing (AD) and planned (BE) IFT applications: A) Feynmand diagrams for analysis of the cosmic microwave background (far left) and celestial views of galactic magnetic fields (left), primordial gravitational fields (right), and cosmic gamma rays (far right) B) Integration of deep NN as information carriers in NIFTy-based applications, here for facial reconstruction (original, data, reconstruction) C) radio imaging. (e.g. radio galaxy Cyg A) D) Air showers measured with LOFAR E) Local induction (yellow circles) of damaging cytotoxins in mitochondria of human cells by ion radiation.

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