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Bayesian Imaging for Multi-Messenger Data with Information Field Theory

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Working with multi-messenger data comes with a variety of challenges. Ideally, one would like to take the prior information into account that the scientific object looks similar in neighbouring frequency channels. Moreover, data from radio telescopes has different statistical properties compared to data generated by gamma-ray telescopes: the former can be assumed to have Gaussian noise and the latter has Poissonian statistics. Finally, radio telescopes measure the Fourier transform of the sky. In contrast, gamma-ray telescopes measure single photons. Theoretically, all those aspects could be taken into account when performing a joint data analysis of e.g. radio and gamma-ray data resulting in one single spectral cube accompanied by its uncertainty.

Information field theory (IFT) provides a framework in which the above challenges can be addressed. IFT algorithms are nowadays computationally reasonably cheap and allow for a full Bayesian analysis of e.g. multi-messenger data. The IFT group led by Torsten Enßlin at the Max-Planck Institute for Astrophysics (Garching) maintains an open-source software package called NIFTy (Numerical Information Field Theory) which enables users to implement Bayesian algorithms relatively easily and may be used for a variety of applications related to Monitoring the Nonthermal Universe.

In the talk, the most recent developments in the area of multi-frequency radio imaging will be presented. Additionally, a proof of concept (with mock data) of multi-messenger reconstructions (Gaussian and Poissonian data combined) will be shown for the first time.

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