Preface

A large and growing number of astronomers recognize the importance of high spatial and spectral resolution observations in the far-infrared. Half of the energy emitted by stars and accreting objects comes to us in the far-infrared waveband and has yet to be explored in detail. On the one side, to study the far-infrared wavelength range there is a need for space observatories due to one main reason: the Earth's atmosphere. On the other side, to achieve high angular resolution there are two options: a very large aperture single dish telescope, or an array of smaller telescopes, that is, an interferometer. It is possible for ground-based systems to consist of very large apertures, but for space observatories there are launch requirements that limit both the size and the weight of the telescopes. Hence, to satisfy the community's sensitivity requirements in the far-infrared and in order to improve the existing resolution in space, a space-based interferometer is the most practical solution.

Far-infrared interferometer (FIRI) is a concept for a spatial and spectral space interferometer with an operating wavelength range 25–400 μm and sub-arcsecond angular resolution, and is based on the combination of two well-known techniques, stellar interferometry and Fourier transform spectroscopy, to achieve high spectral and spatial resolution in the far infrared. The resulting technique is called Double Fourier Spatio-Spectral Interferometry (Mariotti and Ridgway 1988) or Double Fourier Modulation. With an increased spatial and spectral resolution, a number of interesting science cases such as the formation and the evolution of active galactic nuclei and the characterization of gas, ice and dust in disks undergoing planetary formation, among others, can be investigated.

In Chap.1 I give an introduction to far-infrared astronomy and the science cases that could be studied with a double Fourier interferometer from space. An overview of past, current and future instruments is given and the scope of this thesis is presented. In Chap.2 the theoretical background needed to understand the principles of Double Fourier Modulation is presented. Starting with the basics of Fourier transform spectroscopy, where the generation and sampling of interferograms is shown, and stellar interferometry, with an emphasis on the *uv*-map generation, the link is made to explain analytically Double Fourier Modulation. The state-of-the-art data synthesis techniques are also summarized.

In this thesis I present two approaches to study the feasibility of a FIRI system:

(a) An experimental approach via the Cardiff University-UCL FIRI testbed, a laboratory prototype spectral-spatial interferometer to demonstrate the feasibility of the double Fourier technique at the far-infrared regime, including the Wide-Filed Imaging Interferometry Testbed at the Optical and Near-infrared regime located at NASA's Goddard Space Flight Center, both presented in Chap.3. My contribution has been to the characterization of the system, data analysis and forward modelling for the Cardiff–UCL FIRI testbed, and in the data analysis and verification for the WIIT. Both systems are operational and ongoing, and the current issues and next steps are shown.

(b) The Far-Infrared Interferometer Instrument Simulator (FIInS) to assess the performance of a space-based system. The main goal of this software is to simulate both the input and the output of such a system, which is the core of my research and is described in Chap.4. With a modular design, the different components of the software are explained, from the sky generator to the interferograms readout. The modules will allow future instrument artifacts to be added to the simulator. It is also capable of simulating different instrument configurations, i.e. boom-based or formation flying interferometers.

In Chap.5 the interferograms generated by FIInS are processed and synthesized to obtain the source information and to compare with the input sky map. In order to verify the performance of FIInS, the parameters are tuned to simulate the Cardiff-UCL FIRI testbed and the results obtained are shown.

FIInS is intended to be a tool available to the scientific community to test the performance of such an instrument for the different science cases. In Chap.6 a description and simulation of a selected science case, a circumstellar disk, is presented for both an ideal instrument (noise-free) and a more realistic instrument. Finally, in Chap.7 a summary of the conclusions of the work in this thesis is presented, as well as future work possibilities regarding the Cardiff-UCL FIRI testbed and the possible extensions of the instrument simulator FIInS.

The work described here is the result of my Ph.D. research, which was started in October 2010, defended in 2014. Dr. Giorgio Savini then suggested the nomination of this thesis for publication in the Springer Theses series, and thanks to the endorsement of Dr. David Leisawitz (NASA Goddard Space Flight Center) it was accepted by Springer in July 2015. I would like to thank both of them for their encouragement and support.

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