FISICA: efforts to support FIR Interferometry from the space

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The success of mid- and far-infrared instruments in the last decade has widened our understanding of many astrophysical processes both in the local galactic neighbourhood and in the far extra-galactic distant objects. SPIRE Fourier Transform Spectrometer on board the Herschel Space Observatory has provided high quality spectral data for a large variety of objects from solar system bodies [1],[2], star forming regions[3],[4] and extra-galactic distant sources [5]. In many cases, such spectra have detected the presence of unexpected molecular signatures as well as providing insight in the temperature at which these elements were found. It is without a doubt though that the most extreme and radical change of paradigm in understanding in astrophysics comes with spatial detail. The recent imaging in the nearinfrared by the Subaru telescope of a dusty ring with dip inherently pointing at the presence of a planet orbiting a young star [6], the recent ALMA image of planet formation in the Fomalhaut system[7]. This detail is lacking in the Far Infrared region inaccessible from the ground from the lack of an instrument which cannot reach spatial resolution on scales comparable to those which have been available to the community for more than half a century in the visible or in radio astronomy. In order to fill this gap which at present is represented by the veteran HST in the visible, soon to be matched in spatial detail by the JWST at the end of this decade and strongly challenged

As the activity of the Herschel Space Telescope comes to an end and the data taken is in the process of being mined, a successor mission study is well under way. At the same time it cannot be helped to ask oneself "what comes next". The elephant in the room of the inaccessible portion of the Far Infrared background from the ground is angular resolution. It is a well known fact that this portion of the spectrum lags behind the visible due to the diffraction limits imposed by the size of a rocket fairing (JWST will be the first astrophysical telescope to exceed that with a deployable structure). Similarly radio wavelengths benefit from interferometry from the ground and it is this well known technique which could, with non trivial progress, be "exported" from our planet to the second lagrangian point to increase the spatial detail of our FIR observations ten fold (or more).

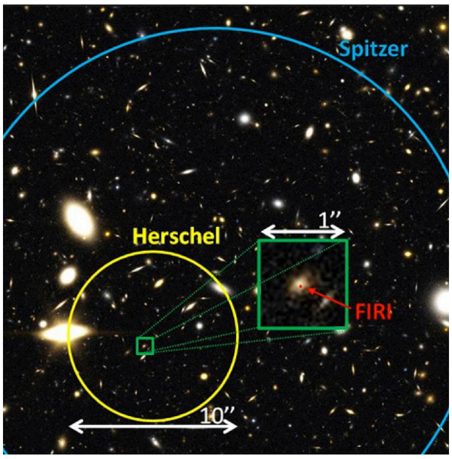

Fig.1 Adapted from Helmich & Ivison(07), this figure shows the drastic increase of resolution to be gained with a large baseline interferometer compared to existing FIR satellites.

The resilience to this step is understood as the technical difficulties are substantial and other ambitious studies have been proposed (TPF, Darwin) which have emphasized the gains, but at the same time highlighting the difficulties in achieving said gains.

This 3-year Framework Programme 7 project "Far Infrared Space Interferometry Critical Assessment" (FISICA) attempts (in its first step) to translate the desired goals of the astrophysical community into actual data requirements which in turn point to specific instrument parameters for a space-based interferometer. Two parallel technology development activities (Work Packages – WP) subsequently address satellite and payload aspects involved in achieving such requirements.

This talk will address one particular technique which has been identified from the start as being promising for its potential application on board a hub satellite receiving optical beams from two or three satellites. This technique known as "Double Fourier Modulation" (Mariotti&Ridgeway88) or spatial-spectral interferometry performs simultaneous phase modulation imposed by a controlled delay stage and by the moving baseline(s) involved. We outline how the project aims to further the achieved demonstrations at mm- and submm-wavelengths by extending them at the shorter wavelengths of interest while attempting to characterize and control the systematic effects of temperature and instrument non-idealities.

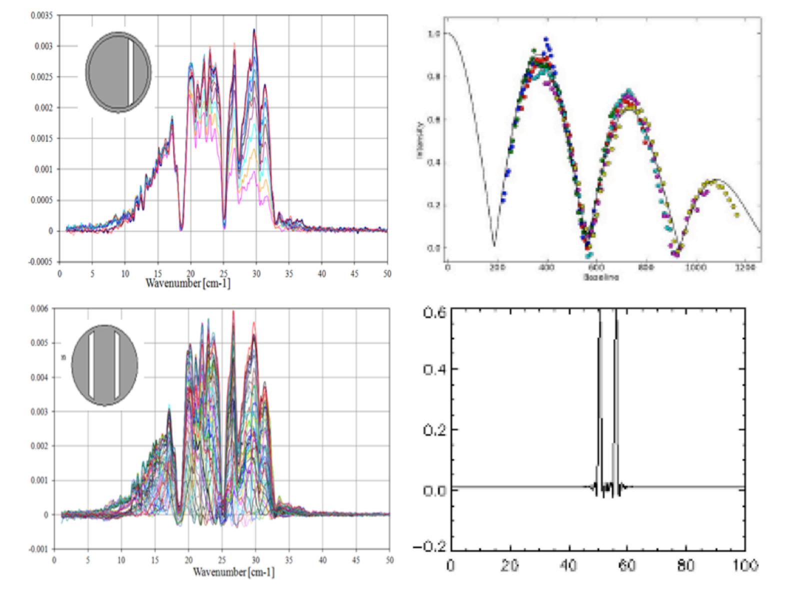

Fig.2 TL:Specta with varying baselines of unresolved source (placed at focus of collimator).BL: Spatial modulation resulting from source resolution with varying baselines. TR: integrated power as a function of baseline in unit wavelength (coloured per spectral bin). BR: Cosine transform of average of spatial modulation resolving separate spatial sources.

The build of an end-to-end Instrument Simulator which will ingest simulated astrophysical data-cubes (2Dspatialx1Dspectral) to produce data timelines expected and process these according to the best known current algorithms for Double Fourier data reduction is also a key activity of FISICA. The results of the latter will allow to emphasize the key difficulties involved in the build of a space interferometer while at the same time quantifying such parameters with possibly a direct relation to the quality of the data products.