Beyond *Herschel*: Key Scientific Requirements for Future Far Infrared Facilities

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The THz spectral region is critical to the characterisation of the obscured Universe, in our own galaxy and also in nearby and distant galaxies. The *Herschel* Space Observatory, which operated between 2009 and 2013 has made many observational advances in this respect, and its results are setting the scene for ground-based facilities such as ALMA and for future THz space observatories.

I will focus on two particular *Herschel* science themes and their implications: characterisation of the ubiquitous filamentary structure which pervades the interstellar medium (ISM) and is clearly strongly associated with the formation and evolution of pre-stellar cores and protostars, and the spectroscopy of high-redshift galaxies revealing the mechanisms by which galaxies in the early Universe formed their stellar populations. Both of these have significant implications for our understanding of star formation on local and global scales and over cosmic time, and also raise questions that can only be addressed observationally by future facilities.

The picture of the star-formation process that emerges from *Herschel* is one in which ISM filaments form via the dissipation of kinetic energy in large-scale flows, followed by fragmentation of the densest filaments into prestellar cores through gravitational instability if the filament mass per unit length exceeds a critical value. But this scenario requires further observational study to establish the roles of turbulence and magnetic fields in the formation, growth and maintenance of filamentary structure, the condensation of dense cores and the formation of protostars within them. As well as kinematic observations with ALMA and other telescopes, this will requires characterisation of the magnetic fields through sensitive THz polarimetry on a variety of angular scales, covering the relevant ranges of mass and density from clouds to filaments and cores, and covering a significant sample of galactic regions to establish statistically significant results and to understand the influence of the local cloud environment on star formation. Both ground-based and spaceborne facilities will be needed. To date, no FIR space observatory has had the necessary polarimetric capability, and the development and implementation of a future space polarimeter is therefore important to pursue.

Herschel also allowed us to probe the interstellar medium by means of THz spectroscopy in our own and nearby galaxies, but, because its sensitivity was fundamentally limited by thermal emission from its passively-cooled 80-K telescope, it lacked (except in a few tantalising cases) the sensitivity to study the detailed physics and chemistry of the ISM in high-redshift (distant) galaxies. Future FIR satellite missions will be able to operate with actively cooled apertures and to take advantage of a new generation of superconducting detectors with sensitivity orders of magnitude better than those used on *Herschel*. Such missions are needed to investigate in spectral and spatial detail the material and processes involved in galaxy formation and evolution. SPICA is the next step, with a huge increase over *Herschel* in spectroscopic observing speed. Ultimately, a FIR space interferometer will allow us to study the high-redshift Universe with the same capabilities that we currently have for the local Universe.