The Sub-arcsecond FIR Space Observatory: the TALC concept

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The future of far-infrared observations rests on our capacity to reach sub-arcsecond angular resolution around 100 µm, in order to achieve a significant advance with respect to our current capabilities. Furthermore, by reaching this angular resolution we can bridge the gap between capacities offered by the JWST in the near infrared and those allowed by ALMA in the submillimeter, and thus benefit from similar resolving capacities over the whole wavelength range where interstellar dust radiates and where key atomic and molecular transitions are found.

We present a concept of a deployable annular telescope, named TALC for Thinned Aperture Light Collector, reaching 20m in diameter. Being annular, this telescope features a main beam width equivalent to that of a 27m telescope, i.e. an angular resolution of 0.92" at 100 µm. The principle is to remove the central part of the prime mirror dish, cut the remaining ring into 24 sectors and store them on top of one-another. With this approach we have shown that we can store a ring-telescope of outer diameter 20m and ring thickness 3m in an Ariane 6 fairing. The general structure is one of a bicycle wheel, where the inner side of the segments in compression to each other plays the role of the rim. The segments are linked to each other using a pantograph scissor system that let the segments extend from a pile of mirrors to a parabolic ring keeping high stiffness at all time during the deployment. The inner corners of the segments are linked to a central axis using spikes as in a bicycle wheel. The secondary mirror and the instrument box are built as a solid unit fixed at the extremity of the main axis. The tensegrity analysis of this structure shows a very high stiffness to mass ratio, resulting into 3 Hz Eigen frequency. The segments will consist of two skins and honeycomb CFRP structure build by replica processes.

The principal science cases of TALC revolve around its imaging capacities, and are conceived as follow-ups on the Herschel Space Observatory's main advances. They involve resolving the Kuiper belt in extra-solar planetary systems, or the filamentary scale in star forming clouds all the way to the Galactic Center, or the Narrow Line Region in Active Galactic Nuclei of the Local Group, or break the confusion limit to resolve the Cosmic Infrared Background. Equipping this telescope with detectors capable of imaging polarimetry offers as well the extremely interesting perspective to study the influence of the magnetic field in structuring the interstellar medium.

We will also present simulations of the optical performance of such a telescope. The main feature of an annular telescope is the small amount of energy contained in the main beam, around 30% for the studied configuration, and the presence of bright diffraction rings. Using simulated point spread functions for realistic broad-band filters, we study the observing performance of TALC in two typical situations, a field of point sources, and a field with emission power at every physical scales, taken to represent an extragalactic deep field observation and an interstellar medium observation. We investigate different inversion techniques to try and recover the information present in the input field. We show that techniques combining a forward modeling of the observation process and a reconstruction algorithm exploiting the concept of sparsity (i.e. related to the more general field of compressed sensing) allow reaching the angular resolution promised by the main beam of TALC.