The SAFARI Imaging Spectrometer for the SPICA space observatory

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***Abstract*— The Japanese SPace Infrared telescope for Cosmology and Astrophysics, SPICA, will provide astronomers with a long awaited new window on the universe. Having a large cold telescope cooled to only 6K above absolute zero, SPICA will provide a unique environment where instruments are limited only by the cosmic background itself. A consortium of European and Canadian institutes has been established to design and implement the SpicA FAR infrared Instrument SAFARI, an imaging spectrometer designed to fully exploit this extremely low far infrared background environment provided by the SPICA observatory.**

SAFARI, is an imaging Fourier Transform Spectrometer (FTS) designed to provide continuous coverage in photometry and spectroscopy from 34 to 210 µm, with a field of view of 2'×2' and various spectral resolution modes up to R = 2000 (at 100 µm). Like the SPIRE instrument on Herschel, SAFARI utilizes a Mach-Zehnder interferometer as a means to obtain spectral information. In such an interferometer the incoming beam is split over two optical branches which each contain moveable mirrors. The two beams are recombined and the combined beam is subsequently forwarded to the detectors. By moving the mirrors in the beams the path length along the two branches differs and the resulting combined signal yields an interferogram as function of the Optical Path length Delay (OPD). This interferogram corresponds to the Fourier transform of the incoming spectrum. By employing a detector array instead of a single pixel in the image plane, interferograms can be obtained simultaneously for a large on-sky area. By subsequently applying a Fourier transform to all interferograms, spectra are obtained simultaneously for all ~4000 pixels covering the instrument field of view. Observations obtained by scanning the mirror of the FTS (along the magnetic bearings) over the full stroke yield spectra with a resolution of R~2000 in the middle of the wavelength band. For lower resolution (SED mode) spectra a shorter scan is taken. Additionally the instrument can operate in a photometric mode in which the FTS is fixed at one end of its stroke.

To cover the full 34 to 210 µm wavelength range the SAFARI detector system utilizes three large-format detector arrays. As the telescope spatial resolution decreases towards longer wavelengths, fewer detectors are required to have full spatial sampling of the 2’×2’ field of view in the longer wavelength bands. The detector system elements are divided over the following main units: 3 “Focal Plane Arrays”, each containing one detector array, its multiplexed SQUID amplifier readout electronics, and shielding and filtering needed to operate these components within the SPICA environment, a 136 K Low-Noise Amplifier that amplifies the weak outputs from the cryogenic electronics, and the Detector Control Unit (DCU) containing control and readout electronics both at room temperature.

SAFARI’s large instantaneous field of view combined with the extremely sensitive Transition Edge Sensing detectors will allow astronomers to very efficiently map large areas of the sky in the far infrared – in a square degree survey within a 1000 hours many thousands of faint sources will be detected. A large fraction of these sources will be fully spectroscopically characterised by the instrument. Efficiently obtaining such a large number of complete spectra will be essential to address several fundamental questions in current astrophysics: how do galaxies form and evolve over cosmic time?, what is the true nature of our own Milky Way?, and why and where do planets like those in our own solar system come into being?