From:	Dr. P.R. Roelfsema on behalf of the SAFARI Heads of Nation	5 June 2016
Re:	ESA M5 call Letter of Intent: The SPICA Infrared Cryogenic Space Telescope	

1 The SPICA Infrared Cryogenic Space Telescope

A joint European-Japanese project is proposed to implement a cryogenically cooled infrared space telescope for launch and operations at the end of the next decade. This mission will build on the heritage of earlier infrared missions both in Europe and Japan, and profit fully from the advances in modern detector technologies. When combined with an extremely low background, cold telescope this new generation of detectors will yield a world class observatory with unprecedented sensitivity in the mid- and far- infrared. The observatory will enable astronomers to address a wide range of topics, from studying the earliest galaxies and their evolution to investigations of the nearby Universe including the process of planet formation in proto-planetary discs and the characterization of many of the small Trans-Neptunian Objects in our own solar system

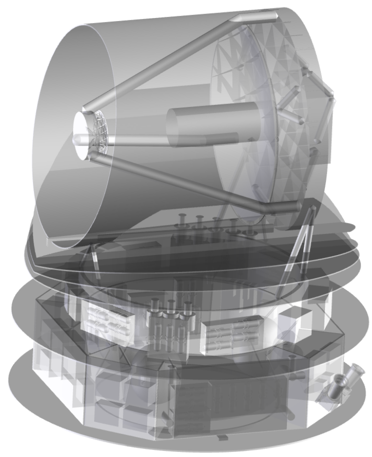

Figure 1 the SPICA satellite

2 Project contact details

The project will be proposed by a European consortium led by SRON Netherlands Institute for Space Research. The prime contact for the proposal will be:

Dr. P.R. Roelfsema
SRON Netherlands Institute for Space Research
Postbus 800, 9700 AV, Groningen, The Netherlands
email: P.R.Roelfsema@sron.nl
Tel. +31-50-3634043/4074 / Mob.+31-6-23461742 / Fax. +31-50-3634033

Core team members

Name	Institute	Role
Dr. P.R. Roelfsema	NL/SRON	SPICA/Europe lead/SAFARI Principal Investigator
SAFARI Heads of Nation	various	Representing national agencies/institutes
Prof. Dr. H. Shibai	Jp/Osaka U.	SPICA/J Principal Investigator
Prof. Dr. T. Onaka	Jp/U. Tokyo	SPICA/J Project Scientist
Prof. Dr. H. Kaneda	Jp/Nagoya U.	SMI Principal Investigator
Prof. Dr. T.Nakagawa	ISAS/JAXA	SPICA/J ISAS representative
Dr. L. Spinoglio, Dr. L. Armus		SPICA science team leads – galaxy evolution
Prof. Dr. F. van der Tak, Dr. S. Madden		SPICA science team leads – nearby galaxies
Dr. I. Kamp, Dr. M. Audard		SPICA science team leads – proto planetary disks
Prof. Dr. H. Shibai Prof. Dr. T. Onaka, Prof. Dr. H. Kaneda, Prof. Dr. T. Yamada		SPICA science team
Dr. C.K. Wafelbakker	NL/SRON	SAFARI Project Manager
Dr. Ir. W. Jellema	NL/SRON	SAFARI Instrument Scientist
J. Evers	NL/SRON	SAFARI Engineering Manager
Dr. Ir. P. Dieleman	NL/SRON	SAFARI AIV manager
Dr. C. Pastor-Santos	Sp/CAB-INTA	SAFARI lead optical engineer
J. Torres-Redondo/ Ing. M. Eggens	Sp/CAB-INTA/ NL/SRON	SAFARI lead structural engineers
Dr. I. Charles	Fr/CEA	SAFARI lead thermal engineer
Ir. D. van Loon	NL/SRON	SAFARI lead electrical engineer

3 Scientific objectives

There are many fields of astronomy that can and will be addressed with the SPICA mission, from nearby to very distant objects and from small to very large scales. Below are some of the core objectives that are being used to scope the mission capabilities and requirements.

The formation and evolution of galaxies

It has been well established that the bulk of star formation and supermassive black hole accretion in the Universe occurred from redshift z~1 to z~3. To understand galaxy evolution, we need to measure the rate at which stars are forming and the rate at which BH accrete matter over cosmic time. These two primary processes are intimately related through gas accretion and energetic feedback and regulate the fate of both galactic hosts and their nuclei. This co-evolution results in the BH–galactic stellar mass correlation we see in the local Universe. SPICA spectroscopy can uniquely quantify the fractional contribution of buried AGN and hot, young stars to the overall energy budget of even the most dust obscured galaxies. This is because the mid- to far-IR domain encompasses a suite of atomic and molecular lines and features covering a wide range of excitation and tracing the physical conditions (excitation, density, ionization, hardness of the radiation field, metallicity, dust composition) in galaxies. Additionally the interactions between the BH and its host galaxy need to be understood: feeding of the AGN through gas inflow, and feedback driven by the AGN into the host galaxy. Both phenomena can be investigated in moderate luminosity galaxies ($L \sim 2\times10^{12} L_{\odot}$) up to redshift of z~2 by using SAFARI, SPICA's far-infrared instrument, to obtain high spectral resolution profiles of molecular and atomic lines (e.g. OH and [OI]). To fully trace galaxy evolution, the evolution of the metal enrichment over cosmic time can be determined through mid- to far-IR ionic fine-structure lines. These do not suffer the strong effects of dust extinction, which do hamper metallicity determinations from optical lines. Only an observatory like SPICA can carry out high sensitivity spectroscopy of large and complete samples of galaxies over the wide range of redshift needed to obtain the detailed physical information that gives insight into how galaxy evolution proceeded over 90% of the age of the Universe.

The lifecycle of gas and dust in galaxies near and far

By mapping nearby galaxies in diagnostic lines and features, SPICA will give us the unique opportunity to characterize the local conditions of dust and gas – temperature, density and radiation field – in unprecedented spatial and spectral detail. This will give insight into a major driver of the evolution of galaxies; the relation between local conditions and the cycling of gas between stars and the interstellar medium. The rate of star formation is found to vary by orders of magnitude within galaxies, and even more between galaxies of different types. PDR and photoionization models will be used to derive the physical parameters from the far-infrared spectra, an approach which to date, due to limited sensitivity, was feasible only for parts of a few of the very brightest nearby galaxies. By comparing the estimated local star formation rates measured using SPICA with the local ISM conditions - magnetic field, neutral gas, CO, stellar distribution - derived from observations with other facilities (SKA, LMT and EUCLID etc.), it will be possible to further unravel the origin of variations in the star formation rate, and thus the stellar mass distribution. By spectrally surveying this large number of nearby spatially-resolved galaxies the chemical and physical conditions where dust grains are formed, processed, and destroyed can be characterized in unprecedented detail.

Tracing the gas, ice and dust evolution in planet-forming systems

Research into protoplanetary disks aims to provide the missing link between planet formation models and extrasolar planetary systems. Young stars have flat rotating disks of gas and dust in which planets form over timescales ranging from a few Myr (gas giants) to 100 Myr (terrestrial planets). The Kepler mission shows that planet formation must be very efficient, but it is still unclear how protoplanetary disks evolve into planetary systems and whether there exist multiple pathways to planetary systems. With SPICA our understanding of these systems will improve enormously, as measurements of the strong cooling lines in the 12 − 210 μm domain will provide a complete view of the gas, dust, and ice involved in planet formation processes, and allow us to probe the physical conditions throughout the inner and outer regions of the disk. SPICA will also be the only observatory which can study the relation between ices and dust mineralogy, and between disk structure and the presence of ices for stars similar to our Sun.

The role of magnetic fields in galactic dust filaments

Herschel imaging surveys have established the ubiquity of interstellar filaments on almost all length scales (~ 0.1 to ~100 pc) in galactic molecular clouds, and that this filamentary structure likely plays a key role in the star formation process. Lower 5' resolution Planck data show well organised magnetic fields on 1-10 pc scales. With SPICA's Far-IR polarimeter we will measure the polarization of the thermal dust emission, providing the connection between the magnetic field at larger scale and at the scale of the filaments themselves, to help clarify the role of magnetic fields in shaping the interstellar web of filaments within which most pre-stellar cores and protostars are forming.

4 Mission description

The proposed mission will have a 2.5-meter class Ritchey-Chrétien telescope, cooled to a temperature in the 6-8 K range. The mission is to operate nominally for 3 years, with a goal of 5 years. The mission configuration (see *Figure 1*) is based on the results of the recent ESA *Next Generation Cryogenic Infra-Red* telescope study and subsequent further analysis by JAXA/ISAS. The telescope is mounted on the service module with its axis perpendicular to the satellite axis. The payload will be cooled using mechanical coolers in combination with V-groove radiators as was done for the *Planck* satellite. Solar panels to provide electrical power are mounted on the bottom of the service module, which always faces the Sun. The satellite will be launched using a Japanese HIII Launcher into an L2 halo orbit. At any one time this will give access to a 360˚ annulus with a width of about 20˚ on the sky, providing full sky access over half a year. The satellite will operate autonomously over a 24-hour cycle. In each daily contact period new 24-hr schedules will be uploaded and instrument and satellite data stored in mass memory will be downloaded. The science program will be a mix of guaranteed time, held by the parties contributing to the mission, and open time which can be applied for by the general astronomical community. All proposals for observations will go through an evaluation process; an international Time Allocation Committee will provide advice on the proposal's scientific merits, and whether observing time should be awarded.

Two payload instruments are currently planned; a mid-IR imager-spectrometer, SMI, and a far-IR grating spectrometer, SAFARI. Together these provide continuous spectroscopic coverage over the full 20 to 230 μm range, with a wavelength resolution R between a few hundred and a thousand. SAFARI can also be used to obtain high resolution spectra (R~11000 at 35 μm to R~1500 at 230 μm) by routing the beam through a Martin-Puplett interferometer before entering the grating modules, allowing much more detailed line profile studies. Additionally, SMI will provide a high resolution (R~25.000) capability in the 12 to 18 μm window. In the 20 to 34 μm domain a camera will provide a high sensitivity mapping capability to survey large areas. For the far-IR currently a small field of view multiband polarimetric imaging capability is also currently foreseen.

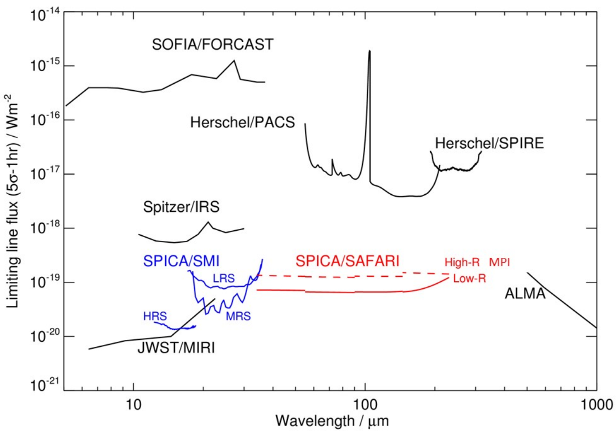

Figure 2 projected spectroscopic sensitivity of the SPICA instruments as compared to other facilities

The spectroscopic sensitivity of the instrument suite (see Figure 2) will provide a spectacular improvement – at least two orders of magnitude – over what has been attained to date leading to a truly enormous increase in observing speed. Such an exceptional leap in performance is bound to produce many scientific advances. Some of these are predictable today and form the core science case for the mission, but others are impossible to predict - there will undoubtedly be much discovery science with SPICA.

5 Payload funding scheme/consortium

The mid-infrared imager/spectrometer SMI is to be developed by JAXA with a Japanese university consortium. Funding for this instrument falls under the JAXA Strategic L-class mission budget for the SPICA mission as a whole.

The far-infrared instrument SAFARI is to be provided by a consortium of European, Canadian and US institutes. The basis for the SAFARI consortium has been in place for several years. The Consortium is led by SRON for the Netherlands, with Spain and France as major partners, and further significant contributions from Italy, Belgium, Canada, Germany, the UK, Austria, Switzerland, Sweden and the US. Funding for the instrument would be provided by the participating institutes as well as by national agencies. For some years the consortium has been actively carrying out research and development to develop key technologies and establish an instrument design. In parallel with this process a distribution of responsibilities over the participating nations and institutes, commensurate with their (technical) capabilities and (funding) possibilities, has been established.

6 International partnership

The mission will be proposed as an ESA-led mission with a major JAXA participation. Within the Japanese space agency selection process for future missions, SPICA has been proposed as a candidate for a JAXA Strategic L-class mission allocation, with an implementation schedule foreseeing launch by the late 2020s. On November 18, 2015, Dr. Saku Tsuneta, Director General of ISAS, JAXA, issued a letter to the astronomical community, reporting that SPICA, with the re-designed configuration, successfully passed its Mission Definition Review at ISAS, JAXA. The letter declared that ISAS is ready to support international efforts along the direction of making SPICA happen.

An initial rough division of responsibilities, proposed by the SPICA team, foresees ESA to take the project lead role, provide the telescope assembly, the fine attitude sensor and the service module, and be responsible for satellite level integration and test. JAXA would provide the launcher, the payload cryogenic system (including coolers, V-grooves), and SMI.

Dr. P.R. Roelfsema

The SAFARI Heads of Nation
Dr. Peter Roelfsema (SAFARI PI)

Dr. Francisco Najarro (Co-PI) – Spain	Dr. Martin Giard (Co-PI) - France
Dr. Frank Helmich – The Netherlands	Dr. Luigi Spinoglio – Italy
Dr. Matt Bradford – USA	Prof.Dr. David Naylor - Canada
Dr. Bart Vandenbussche – Belgium	Dr. Oliver Krause - Germany
Prof. Matt Griffin – UK	Dr. Marc Audard - Switzerland
Prof.Dr. Franz Kerschbaum – Austria	Prof.Dr. Yasuo Doi – Japan
Dr. Bengt Larsson – Sweden	