The Interplay among Black Holes, Stars and ISM in Galactic Nuclei
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The Herschel submm space observatory

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Abstract. The "Herschel Space Observatory" is an ESA mission to perform imaging photometry and spectroscopy in the far-IR & submm 57−670 μm range. It carries a 3.5 m diameter radiatively cooled telescope. The scientific instruments – two cameras/medium resolution spectrometers (PACS and SPIRE) and a very high resolution heterodyne spectrometer (HIFI) – are housed in a superfluid helium cryostat. Herschel will be placed in orbit around the Earth-Sun L2 point in 2007 and will operate for a minimum of 3 years. Roughly 2/3 of the observing time is open to the general astronomical community through a competitive proposal procedure.

1. The Herschel spacecraft and its payload

The Herschel spacecraft has a modular design, consisting of the "extended payload module" (EPLM) and the "service module" (SVM). The EPLM consists of a superfluid helium cryostat – based on the proven succesful ISO technology – housing the Herschel optical bench with the instrument Focal Plane Units, and supporting the telescope, the sunshield/shade, and payload associated equipment. The SVM houses 'warm' payload electronics, and provides the necessary infrastructure for the satellite such as power, attitude and orbit control, the onboard data handling and command execution, communications, and safety.

The telescope is a classical Cassegrain with a 3.5 m diameter aluminium coated SiC primary mirror. Its emissivity is extremely low and it is optimised for straylight rejection. The telescope is passively cooled to $\sim$ 80 K and diffraction limited at about 90 μm. There are three focal plane instruments, housed in a superfluid helium cryostat. These instruments are developed by consortia led by Principal Investigators (PIs) who get guaranteed observing time in return.

The Photodetector Array Camera & Spectrometer (PACS) instrument can be operated either as an imaging photometer, or as an integral field line medium resolution spectrometer up to $\sim$210 μm. It employs 4 detector arrays, 2 bolometer arrays and 2 stressed Ge:Ga photoconductor arrays. The bolometer arrays are dedicated for photometry, while the photoconductor arrays are to be used exclusively for spectroscopy. The 2 bolometer arrays both fully sample the same $1'.75\times3'.5$ field of view on the sky, and provide a point source detection limit of $\sim$3 mJy (5σ, 1 hr). An internal ^{3}He sorption cooler provides the 300 mK environment needed by the bolometers. For spectroscopy, PACS covers 57−210 μm in three contiguous bands, providing a velocity resolution in the range 150−200 km s^{-1} and an instantaneous coverage of $\sim$1500 km s^{-1}. The point source detection limit is $\sim3\times10^{-18}$ Wm^{-2} (5σ, 1 hr) over most of the band. The Spectral and Photometric Imaging REceiver (SPIRE) instrument is a camera and low to medium resolution spectrometer for $\lambda \geqslant 200$ μm. It comprises an imaging photometer and a Fourier Transform Spectrometer (FTS), both of which use bolometer detector arrays. There are a total of five arrays, three dedicated for photometry and two for spectroscopy. All employ 'spider-web' bolometers with NTD Ge temperature sensors, with each pixel being fed by a single-mode 2Fλ feedhorn, and JFET readout electronics. The bolometers

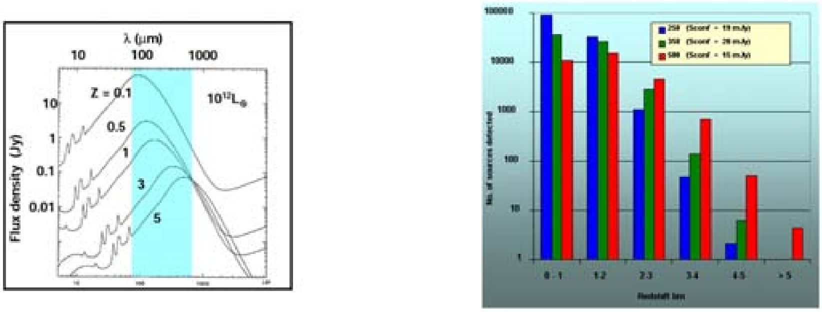

Figure 1. At left, the Herschel frequency coverage is overlaid on the spectral energy distribution of a "typical" star-forming galaxy at redshifts in the range $0.1 - 5$. The right diagram shows the number of galaxies which will be detected by Herschel per redshift interval in a 100 square degree survey to the SPIRE confusion limit of $15 - 20$ mJy, for 3 different galaxy formation models.

are cooled to 300 mK by an internal ^{3}He sorption cooler. In its broad-band ($R \sim 3$) photometry mode, SPIRE simultaneously images a $4\farcm \times 8\farcm$ field on the sky in three colours centred on 250, 363, and 517 μm. The point source sensitivity is in the range $7-9$ mJy (5σ, 1 hr). SPIRE will be able to map ~ 0.5 square degree on the sky per day to its $10-20$ mJy confusion limit. The SPIRE spectrometer is based on a Mach-Zender configuration. Its spectral resolution varies in the range $R \sim 100-1000$ and its field of view is $\sim 2\farcm 6$.

The Heterodyne Instrument for the Far Infrared (HIFI) is an heterodyne spectrometer offering a very high resolution in the range $0.3-300$ km s^{-1}, combined with low noise detection. It uses superconductor-insulator-superconductor (SIS) and hot electron bolometer (HEB) mixers. HIFI is not an imaging instrument, it provides a single pixel on the sky. The focal plane unit (FPU) houses seven mixer assemblies, each one equipped with two orthogonally polarised mixers. Bands $1-5$ utilise SIS mixers that together cover approximately $500-1250$ GHz without any gaps in the frequency coverage. Bands 6L(ow) and 6H(igh) utilise HEB mixers, and together target the $1410-1910$ GHz band.

2. The Herschel observing programme

Herschel will be launched in 2007 and put in a Lissajous orbit around the second Sun-Earth Lagrangian L2 point. From this thermally stable environment, Herschel will carry-out observations for a minimum duration of 3 years. Two thirds of the time will be opened to the scientific community via the usual call for proposals and peer review process. The first call will take place in 2006 and will be followed by additional calls after launch.

Herschel is the only observatory dedicated to the $57-670$ μm range. Its major strength is its photometric mapping capability for performing unbiased surveys related to galaxy formation. Star forming galaxies will have the maximum of their emission in the Herschel band-pass for z up to 5 (see Fig. 1 left). Moreover, as z increases, this maximum moves further inside the Herschel bandpass, thereby increasing the source brightness and partially offsetting the dimming due to increasing distance. This "negative K correction", together with an excellent sensitivity means that Herschel will be efficient at detecting galaxies up to large redshift, as illustrated in Fig. 1 (right). More information is available at http://www.rssd.esa.int/SA-general/Projects/Herschel/