

Looking Deep into the Cat's Eye - Official "First Light" with PACS on the Herschel Space Observatory

After the surprising success of the earlier "sneak preview" of the PACS photometer – a spectacular far-infrared colour image of the Whirlpool Galaxy M51, with unprecedented spatial resolution – the first light observation of the spectrometer part of the instrument was carried out on June 23. This part of the PACS instrument is capable of taking images of an object in the sky in individual spectral lines, at precisely defined wavelengths, in contrast to the photometer, which takes images in broader wavelength bands. Both parts of the instrument are perfect complements to each other: the broad-band photometer is best at observing cool dust in the universe while the spectrometer sees the gas, which it can diagnose for physical properties and chemical composition. Both parts cover the wavelength range from about 60 microns to about 200 microns – roughly 200 times longer than visible light.

The first object the telescope was pointed at while the PACS spectrometer was operating was the planetary nebula NGC 6543 in the constellation of Draco, also known as the Cat's Eye Nebula, which was first discovered by William Herschel in 1786. A "planetary nebula" is an emission nebula consisting of a glowing shell of gas and plasma formed by certain types of stars when they die. The "Cat's Eye" is a very well studied object, perfectly suited for a first-light observation with a new observatory. ESA's Infrared Space Observatory (ISO) already performed spectroscopic observations in the far-infrared on it and found bright line emission. However, at these long wavelengths, ISO could not resolve any structure in, but the PACS spectrometer might.

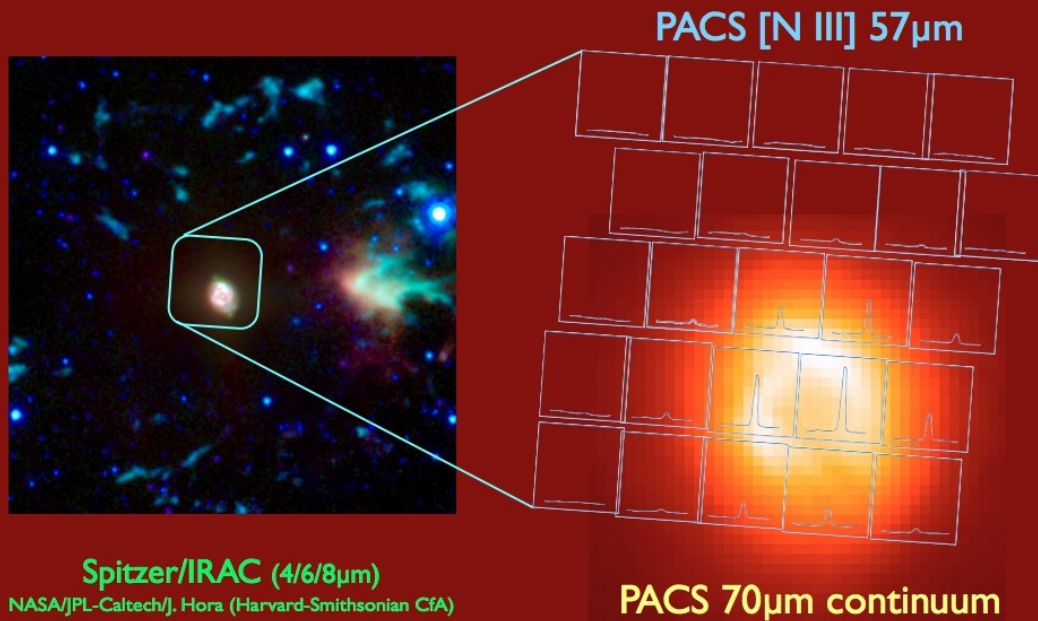
Christoffel Waelkens of the Catholic University in Leuven, Belgium, who is the PACS Co-Principal Investigator, explains: "Dying stars relegate a large fraction of their mass to the interstellar medium, shaping spectacular nebulae. For high-mass stars, this happens through a catastrophic supernova explosion, for objects more like our Sun the process is gentler, and a planetary nebula is formed. A major question is how initially spherical stars can shape nebulae that are so complex and diverse. To solve this question we need to look at the processes close to the star, where the matter is ejected."

"In the vicinity of the hot central star, matter is largely gaseous, and its density, motion, temperature and composition can be probed from atomic spectra. With PACS it is now possible for the first time to resolve the spectral lines on the sky, and hence to see how the wind from the star shapes the nebula in three dimensions."

PACS observed the nebula in two spectral lines, the fine structure line of doubly-ionised nitrogen at 57 microns and the fine structure line of neutral oxygen at 63 microns. For better orientation the PACS photometer took a small map of NGC 6543 in its 70 micron band, showing the structure of a dust ring with an opening on one side.

The panel below shows an overlay of individual spectra of the nitrogen line, all taken simultaneously with the PACS spectrometer, on the dust continuum as observed with the PACS photometer. A near-infrared image taken by the Spitzer Space Observatory illustrates the inner region of the nebula that was covered by the PACS measurements. The PACS Principal investigator, Albrecht Poglitsch of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany, points out that while these spectra are excellent on a qualitative level, the registration of the individual spectra on the continuum image still needs to be verified, and the line intensities are non-quantitative. All this is work that lies ahead of us in the upcoming "Performance Verification Phase" of the observatory.

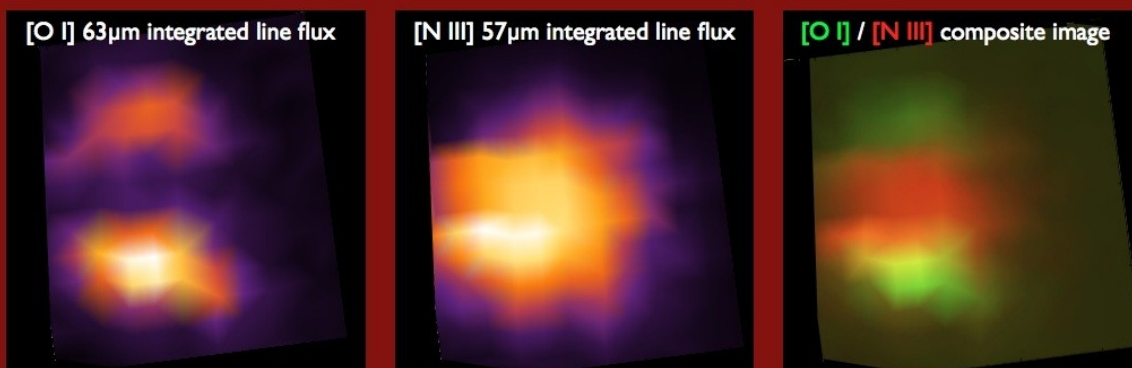
Planetary Nebula NGC 6543 ("Cat's Eye")



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The second panel shows a comparison of the spatial distribution of two different spectral lines: ionized nitrogen and neutral oxygen. The spectral intensity distributions were reconstructed from a mosaic of 9 snapshots as in the figure above, spatially slightly displaced with respect to each other. The two lines obviously originate from different components within the object - where the ionised nitrogen emission is brightest, there is a "hole" in the neutral oxygen. This is seen most clearly in the 2-colour composite image (neutral oxygen is shown in green, ionized nitrogen in red).

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Already, these very first data fulfil our expectations at this point and are of unprecedented sensitivity, accurately tracing the physical conditions in cold and warmer gas. The next step is to supplement these first results with data from other atomic species and confront them with the morphology of the gaseous and dusty structures farther out.

The first spectra with PACS indicate that our high hopes for the PACS spectrometer performance were justified, that the effort that particularly went into the development of detectors and their readout payed off, and that a lot of excitement is ahead of us.

PACS was built by a consortium of institutes and university departments from across Europe, including the Max Planck Institute for Astronomy, Heidelberg, under the leadership of Principal Investigator Albrecht Poglitsch located at the Max-Planck-Institute for Extraterrestrial Physics, Garching. Consortium members are: Austria: UVIE; Belgium: IMEC, KUL, CSL; France: CEA, OAMP; Germany: MPE, MPIA; Italy: IFSI, OAP/OAT, OAA/CAISMI, LENS, SISSA; Spain: IAC; Hungary: Konkoly Observatory; USA: NHS.

More information on the first light results from Herschel can be found on the ESA-website: <http://herschel.esac.esa.int/FirstLight.shtml>