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the Cool Image of the Kuiper Belt Analogue q[1] Eri

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Abstract. About two dozen exo-solar debris systems have been spatially resolved. These debris discs commonly display a variety of structural features such as clumps, rings, belts, excentric distributions and spiral patterns. In most cases, these features are believed to be formed, shaped and maintained by the dynamical influence of planets orbiting the host stars. In very few cases has the presence of the dynamically important planet(s) been inferred from direct observation.

The solar-type star q[1] Eri is known to be surrounded by debris, extended on scales of up to some 30''. The star is also known to host at least one planet, albeit on an orbit far too small to make it responsible for structures at distances of tens to hundreds of AU. The aim of the present investigation is twofold: to determine the optical and material properties of the debris and to infer the spatial distribution of the dust, which may hint at the presence of additional planets.

The photodetector array camera and spectrometer (PACS) aboard the Herschel Space Observatory allows imaging observations in the far infrared at unprecedented resolution, i.e. at better than 6'' to 12'' over the wavelength range of 60 m to 210 m. Together with the results from ground-based observations, these spatially resolved data can be modelled to determine the nature of the debris and its evolution more reliably than what would be possible from unresolved data alone.

For the first time has the q1 Eri disc been resolved at far infrared wavelengths. The PACS observations at 70 m, 100 m and 160 m reveal an oval image showing a disc-like structure in all bands, the size of which increases with wavelength. Assuming a circular shape yields the inclination of its equatorial plane with respect to that of the sky, $i > 53°$. The results of image de-convolution indicate that i likely is larger than 63°, where 90° corresponds to an edge-on disc.

The observed emission is thermal and optically thin. The resolved data are consistent with debris at temperatures below 30 K at radii larger than 120 AU (7''). From image deconvolution, we find that q[1] Eri is surrounded by an about 40 AU wide ring at the radial distance of about 85 AU. **This is the first real Edgeworth-Kuiper Belt analogue ever observed.**

Keywords. Stars: q[1]Eri (HD 10647, HR 506, HIP 7978) -- planetary systems: planetary discs -- circumstellar matter -- formation

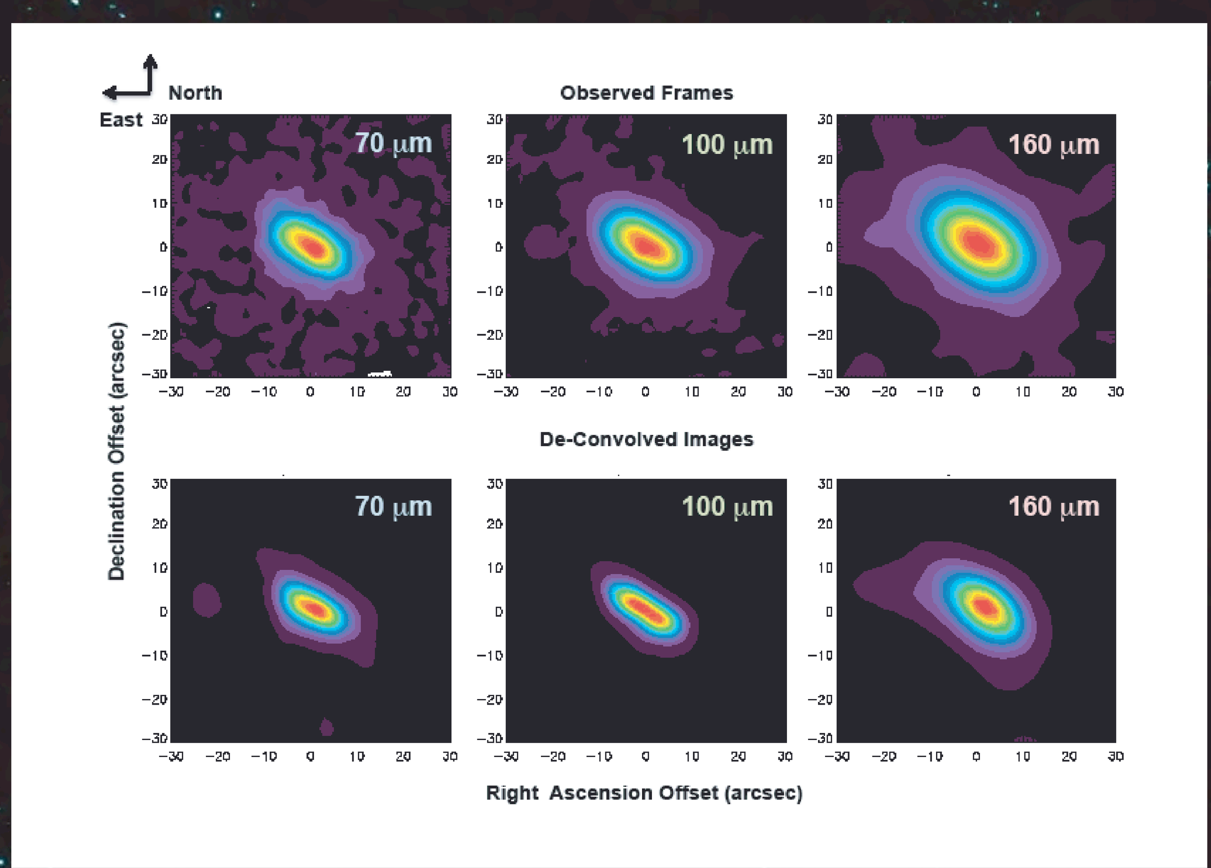

Figure Caption: PACS photometric imaging of q[1] Eri at, from left to right, 70 m (blue), 100 m (green) and 160 m (red). The 70 m image was taken in chop-nod mode, whereas the other two in scan-map mode. The upper panels display the reduced observations. Below, deconvolved images are shown, using observations of α Boo for the definition of the PSF. Displayed are the results for ten iterations of a MEM algorithm (Hollis et al. 1992, ApJ 386, 293). The star defines the origin of the frames, i.e. offset coordinates (0, 0). Within the positional accuracy (2'' rms), the stellar position and the centre of the elliptical brightness distributions coincide and offsets are in seconds of arc. The lowest contours are at 5% of the maximum values and consecutive steps are also by this amount. At the distance of the star, 20'' corresponds to 350 AU.

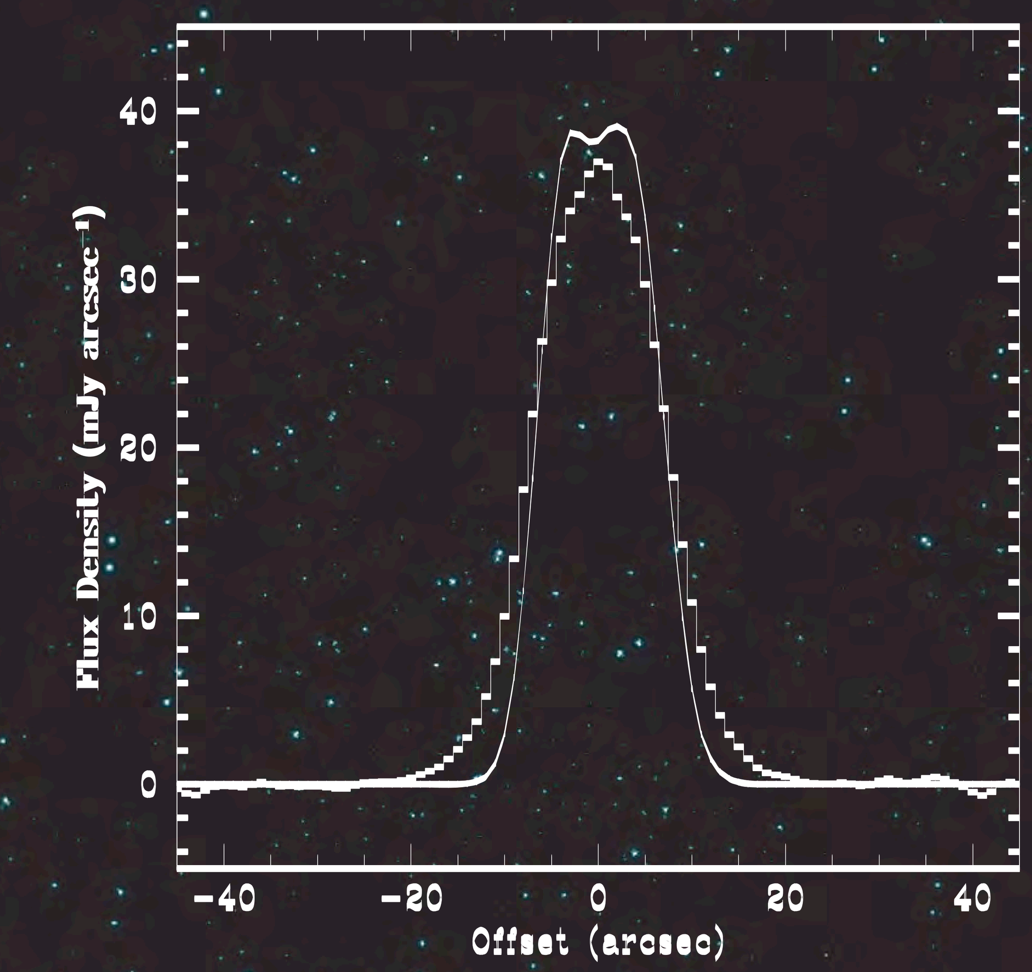

Figure Caption: One-dimensional cuts (averages of 5 pxl wide strips), along the major axis, through the 100 m scan map image, from which the stellar source (8 mJy) has been subtracted prior to the deconvolution. The histogram depicts the observed data, whereas the smooth line shows the result of the deconvolution, revealing the ring structure around the star q[1] Eri.This ring or belt is situated 85 AU from the star and has a width of 45 AU. Read the whole story in the Special Issue of A&A on Herschel.

Conclusions: Based on imaging observations with PACS in three photometric bands at 70 m, 100 m and 160 m we find that

- the debris around the solar-type star q[1] Eri has an oval-shaped brightness distribution, the size of which increases with the wavelength.
- the high S/N of the 100 m scan map is adequate to MEM the image, revealing a ring-like structure with max surface density at about 85 AU
- with a width of about 35 to 45 AU, this ring/belt around the some billion year old F9 V star q[1] Eri is similar to the Edgeworth-Kuiper belt around the Sun. This may hint at the presence of another planet, q[1] Eri c.