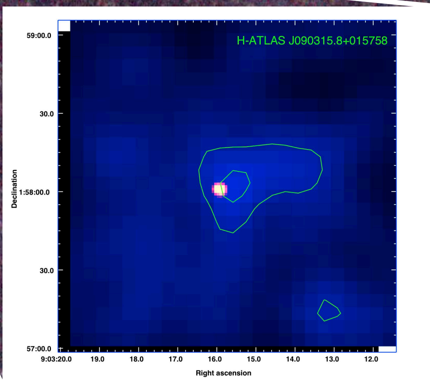
Galactic Highlights from the Herschel ATLAS

Nearby dust in the Milky Way

The Herschel ATLAS (H-ATLAS) is the largest Herschel Open Time Key Project, with an eventual survey area of 570 square degrees that will be covered at 5 wavelengths between 110 and 500 μm. The primary goal of the H-ATLAS is to study galaxy formation and evolution however the unrivalled sensitivity and wide-area coverage means that H-ATLAS can also reveal dust in a range of more local (i.e. within the Milky Way) environments. As the survey fields are all located at high Galactic latitude any Galactic emission that is detected must be no more than a few hundred parsecs distant.

In its Science Demonstration Phase the Herschel ATLAS observed a 16 square degree field along the Celestial Equator (the GAMA 9 hour field). Here we present some of the Milky Way discoveries that the Herschel ATLAS team have made so far.



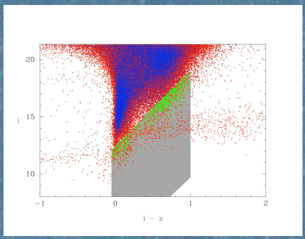
Three colour image (red 2MASS J, green 2MASS Ks, blue SPIRE 250 μm) of a candidate debris disk associated with a K0 main sequence star (spectral type determined from the *g-i* colour, Covey et al 2007). A fit to SPIRE fluxes & PACS upper limits indicates a dust mass of 0.1 Earth masses and a temperature ~ 60 K. This mass is similar to the well known disk β Pictoris.

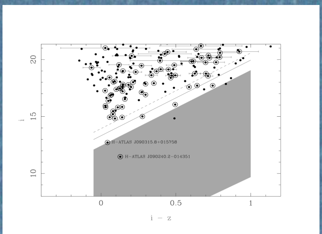
Candidate debris disks

The H-ATLAS survey fields have high-quality supporting optical and near-infrared data from SDSS DR7and the UKIDSS Large Area Survey, with forthcoming deeper INT and VST KIDS optical data, and VISTA VIKING in the near-infrared. The full H-ATLAS survey will contain on the order of 100,000 stars within a photometric distance of 200 pc (Thompson et al 2010), at which distance the sensitivity of H-ATLAS is sufficient to detect known debris disks such as Beta Pictoris or Fomalhaut. H-ATLAS is thus a shallower but much wider tier to the more targeted debris disk studies with Herschel (e.g. DEBRIS, DUNES & GASPS), and as the deepest and widest unbiased survey since IRAS has the potential to discover rarities in the debris disk population.

We have selected main sequence stars in the H-ATLAS Demonstration field using the *ugriz* colours of SDSS point sources and the 4-dimensional colour locus of Kimball et al (2009). H-ATLAS sources are identified with these objects using a Bayesian Likelihood Ratio approach (Smith et al 2010). The combination of the two indicates a potential debris disks as the typical photospheric flux of a main sequence stars is a few μJy at 250 μm compared to our H-ATLAS detection threshold of 33 mJy at this wavelength. We select out likely dust-obscured QSOs and unresolved galaxies whose colours fall into the main sequence locus by a photometric distance cut and search for the presence of contaminating background galaxies via deep UKIDSS LAS images.

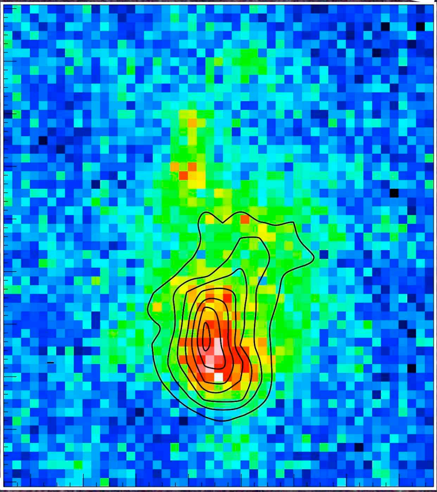
In total we find 78 H-ATLAS sources identified with SDSS point sources on the main sequence locus. Two of these objects (H-ATLAS J090315.8 and H-ATLAS J090240.2) lie within a photometric distance of 200 pc and are our most probable debris disk candidates. We show that their properties are similar to those of known debris disks in the diagrams to the right. We have also identified a further 7 objects within a photometric distance of 400 pc that may be brighter or more massive debris disks. Spectroscopic confirmation of the host stars and deeper PACS imaging are required to confirm these candidates as debris disks.





Left: An *i vs i-z* colour-magnitude diagram of the 180,000 point sources in the H-ATLAS Science Demonstration field. Objects on the main sequence locus are shown in blue and the general population in red. The grey polygon indicates the colour-magnitude space occupied by stars at a photometric distance of 4–200 pc. Green dots are point sources on the main-sequence locus with a photometric distance <200 pc. In the 16 square degree field there are 851 point sources on the main sequence locus within a photometric distance of 200 pc. This forms our search sample for debris disks.

R*ight:* An An *i vs i-z* colour-magnitude diagram of the 204 H-ATLAS sources that are high reliability (> 80%) matches to SDSS point sources. Objects on the main sequence locus are identified by circles and the grey polygon represents the same photometric distance range as in the left-hand figure. Solid and dashed lines show photometric distances of 300 and 400 pc respectively. Faint objects are more likely to be dust obscured QSOs or galaxies, whereas the two brightest objects are within our likely debris disk search range and are thus the most likely debris disk candidates..



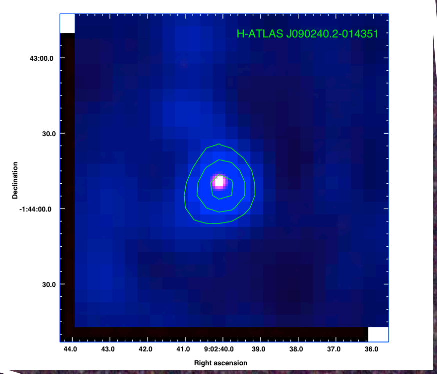
SPIRE 250 μm colourscale overlaid with JCMT CO 2-1 contours of the isolated molecular cloud. Note that the centrally condensed and cometary morphology is similar to many known Bok Globules. A fit to the SED suggests a dust temperature of ~15 K and a mass of 0.01 $M_{\odot}$, if at a distance of 170 pc.

An unusual isolated molecular cloud

In addition to the candidate debris disks we have also discovered an unusual extended optically dark and sub-mm bright object. Follow-up molecular imaging with the JCMT reveals that this object is a molecular cloud with close to rest frame CO 2-1 emission (V_{LSR} ~ -21 km/s). The morphology and appearance of the cloud are similar to those of Bok globules (e.g. Launhardt et al 2010), however unlike most Bok globules this cloud is isolated from any other known molecular complex, lying over 20 degrees away from the nearest known molecular cloud (Dame et al 2001, 2004).

The distance to the cloud is currently uncertain, but if located within the Galactic disk the scale height of molecular gas implies that it is likely to be located within 170 parsecs of the Sun. Fits to the cloud's SED indicate a dust temperature of 15 K, a mass of 0.01 $M_{\odot}$ and a column density of $10^{4.5}$ cm^{-2}. The shape of the SED is consistent with a Class 0 protostellar core, although no molecular outflow has yet been detected. No embedded source is detected in UKIDSS Large Area Survey images, consistent with the Class 0 hypothesis.

At a distance of 170 pc the mass of the cloud determined from fits to the H-ATLAS SED is roughly a factor 50 smaller than that of a typical Bok globule and implies that if this cloud is "star-forming" then it is forming objects of substellar mass. However, to bring the cloud into the observed range of Bok Globule masses requires a distance of ~ 1.7 kpc, which would place the cloud at a distance from the Galactic plane some 10x greater than the scale height for molecular gas. Determining the distance of this cloud is currently a high priority for the H-ATLAS team so that we may distinguish between these two hypotheses.



Three colour image (red 2MASS J, green 2MASS Ks, blue SPIRE 250 μm) of a candidate debris disk associated with a likely G5 main sequence (again from its *g-i* colour). A fit to the SPIRE fluxes & PACS upper limits suggests a dust temperature of ~65 K and a disk mass of 1 Earth mass, similar to the known disk around HD 12167 (Sheret et al 2004).

References

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Launhardt et al 2010, ApJS accepted, arxiv:1004.0869
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Backdrop image: 3 colour SPIRE image of the H-ATLAS Science Demonstration Field