# HStrayWG mtg#3 - MOM

**Herschel/HSC/MOM/1344**

**Göran Pilbratt, 8 February 2009**

The third meeting of the Herschel Straylight Characterisation Working Group (HStrayWG#3) took place in MPE, Garching on 23 Jan 2009 with two participants a video and telephone link, respectively. The meeting started at 09:15 hours and finished at 16:00 hours. The draft minutes were circulated on 30 Jan 2009, comments from JF, UK, and a few improvements were incorporated in the final minutes issued on 8 Feb 2009.

**Attendance**

Bruno Altieri (BA)
Dominic Doyle (DD) - by phone
Marc Ferlet (MF)
Jackie Fischer (JF) - by video
Ulrich Klaas (UK)
Koryo Okumura (KO)
Göran Pilbratt (GLP)
Norbert Geis (NG)
Philippe Martin (PM) - by phone, part of point 4 only

## 1. Welcome and Agenda

- GLP asked for additional comments on the circulated draft agenda *(attached as Appendix 1)*. No further comments, the agenda was adopted for the meeting.

## 2. Review of actions

HStrayWG2-Action#

1. Update and reissue the HStrayWG TOR. Actionee: GLP. Deadline: 22 Dec 2008.

CLOSED. Updated and circulated by email on 30 Dec 2008.

2. Clarify to what extent separate photometer and spectrometer observations for the characterisation of straylight paths outside instrument FOVs but inside the telescope FOV would be necessary/provide important added value. Actionees: UK/MF. Deadline: 16 Jan 2009.

No input received. For PACS UK reported: Straylight characterisation inside telescope FOV has highest priority for the photometer.

Should significant straylight spots be detected, then it makes also sense to characterize the straylight appearance with the spectrometer. The PACS spectrometer is a small IFU and the reflection of the straylight by the image slicer and its final distribution on the detector area are important to characterize. Also, if the straylight source has spectral features, one could "lock" the spectrometer wavelength on one of these features providing additional evidence for the straylight origin.

The mapping with the photometer should help to optimize the spectrometer maps by providing relative offset and angles w.r.t. the spectrometer FOV.

NG added that ghost tests for outside but near instrument FOV were only planned to be performed using the photometer, but not for the spectrometer; the sensitivity of the spectrometer for outside FOV sources is at least an order of magnitude lower than for the photometer, to perform such tests with the spectrometer would be prohibitively difficult.

For SPIRE MF reported: For SPIRE the optics are very similar for imaging and spectroscopy. It is felt that for SPIRE performing these tests with the photometer only will be sufficient for outside the instrument FOVs. This is not in contradiction with the PACS situation, but is a result of the different instrument optical designs. The SPIRE FTS is basically 'a photometer' from an imaging point of view.

CLOSED with reference to the discussion minuted above.

3. Interact with PM and try to extract and provide procedures for running the existing ASAP model. Actionee: DD. Deadline: 16 Jan 2009.

DD has not reached PM, but will continue addressing this action. In the discussion under agenda point 4 below when PM was available on the phone he verified that he has no written material aiding in the running the model, that the model is the best available model, but that one limitation is that the diffraction in the hexapod legs are not included. In PM's assessment this model should be suitable for re-generating the type of plots.

CLOSED with reference to the discussion minuted above.

4. Review the list of actions in the draft MOM. Actionee: all. Deadline: 7 Jan 2008.

CLOSED. Final minutes issued on 20 Jan 2009.

5. Clarify usefulness and procedure of using serendipitous observations for characterization of straylight from outside telescope FOV. Actionee: JF. Deadline: 16 Jan 2009.

CLOSED. Will be addressed under the relevant point on the agenda (point 4).

### 3. Inside FOV of the telescope

- PACS. Cf. the MOMs of HStrayWG#1 and #2. Near-field photometer and spectrometer straylight characterisation will be performed by using a bright source - a planet - and executing scanmaps around the source.
- For the photometer PACS a 2x2 deg scanmap around a several hundred Jy source will be done to characterise straylight properties at the level of tens to a hundred mJy.
- Last meeting we discussed doing this in parallel mode, covering PACS and SPIRE at the same time. KO argued that the distance between successive scan in the 'standard' parallel mode may be too large. In the current 'PACS only' observation in the PACS PV plan the separation between successive scans is 70 arcsec, in parallel mode it is 155 arcsec. Action on PACS/KO to clarify whether the 'standard parallel mode' setup is adequate for this straylight characterisation observation. *(Action_3-1 on KO)*
- MF stated for SPIRE the parallel mode setup is fine. A size of 2x2 deg is larger than strictly foreseen for SPIRE, but of course is OK. When a such a strong source is falling inside the SPIRE FOV it could saturate the detectors but there are no latency effects and all other data will be fine.
- The conclusion is that we hope that it will be adequate to perform a large SPIRE/PACS parallel mode map, supplanted by PACS, but no SPIRE, spectrometer observations.

### 4. Outside the telescope FOV

- The ASEF (2002, Doc#30) analysis used the actual telescope at the time and an 'assumption' of the cryostat at the time. The ASED (2004, Doc#20) analysis used the actual cryostat at the time with an 'assumption' of the telescope at the time.
- Having established contact with PM by phone it was clarified that the 'rings' that can be seen in the Doc#30 report (PM's presentation in HStrayWG#2-App#2 VG#6 and NG's representation of it in HStrayWG#1-App#5 VG#7 the 'thick green ring') are caused by reflections in the scattercone in the centre of M2.
- After the interaction with PM on the phone it was decided that MF will rerun the ASAP model. MF will not attempt to modify the model, but he feels confident to run it 'as is'. MF believes that he will

be able to present his first results on a timescale of two weeks. The idea is to perform calculations for two points in the FOV (the PACS and SPIRE photometer line of sights), rather than at the centre of the telescope FOV. *(Action_3-2 on MF)*

- GLP initiated a discussion re whether the problem is limited to the Moon as a source in a 'sore/bright spot', or whether we have a multitude of potential sources (for sources in range 'hundreds of Jy' the number is in the hundreds, in particular in the galactic plane) that could cause straylight problems, this would of course be a much more intractable situation.
- MF pointed out that it will be necessary to calibrate/scale the model predictions by observations, the model predictions only provide relative attenuations, for absolute numbers we will absolutely need real measurements.
- In HStrayWG#2 the possibility of using serendipitous observations for straylight characterisation was raised by JF who took an action to address this issue and has provided input *(attached as Appendix 2)* which was presented. The suggestion was to define a set of deep observations from various programs that can be split and observed during two epochs, when relative telescope / bright sources are in two different configurations.
  - For Herschel, at least for the SPIRE bands as pointed out by MF, there is unlikely to be good comparison material from other observatories, but with Herschel by observing at different epochs straylight features should appear in different places in the focal plane.
  - KO pointed out that a part of the characterisation should be to observe with a strong source in a 'sore spot', and with this source in a 'dark area' in both cases pointing at same point in the sky - this could be performed with a moving source (a SSO), or by waiting long enough so that the PA has changed.
  - The end result could be that certain Herschel observations should be split up and performed at different epochs in order to be able to identify potential straylight features.
- Regarding the kapton coating the hexapod legs, its Al coating has a thickness of 100 nm which in units of the skin depth $\delta$ is $3\delta$ at 500 μm, which is close to bulk material. NG pointed out that Al properties deviates from a simple skin depth analysis and in practice has lower reflectivity. MF provided the JWST/MIRI experience *(attached as Appendix 3)* which generated some discussion. It was agreed that to assume 95% reflectivity for the hexapod legs was reasonable.

## 5. Self-emission

- UK stated as part of the CoP it is planned to make a medium resolution spectrum of the telescope background shortly after telescope opening using the PACS spectrometer. He cautioned that at this point we will not have the proper bias settings and calibration. However, it is felt that even with these caveats, using the internal calibrators, the power of the optical background (telescope plus straylight) can be measured with an accuracy of 10-20%.
- There is also photometer FOV measurement planned for the CoP to be repeated later in the PV phase, which also might provide information re the telescope background. The current plan for this measurement - which is there to assess ghosts - may benefit from optimization from a self-emission perspective. This should be reviewed, and the observation optimised if/as appropriate. *(Action_3-3 on KO)*
- GLP stated we must ask ourselves what we gain by putting a in special effort to characterise the optical background and disentangling its contributors. After all, the detectors need to be biassed to cope with the total load no matter its origin. Is this purely an academic exercise?
- MF pointed out that for the SPIRE spectrometer we want to null the background signal and therefore we want to have a good characterisation of it; this is not just an academic exercise.
- MF confirmed that with SPIRE we only want to perform background measurements when the telescope temperature is within 10 K of the expected final stationary temperature. However, he also pointed out that there is no single magic test to disentangle the various contributors to the total background power signal, the result will have to be distilled out of analysis of the total set of measurements.
- One 'existing' SPIRE observation is to characterise pixel FOV be making small scans, this might also be helpful in characterising the background. This should be reviewed, and the observation optimised if/as appropriate. *(Action_3-4 on MF)*
- JF pointed out that we should ensure that the temperatures of the various self-emitters should be recorded during such characterization and could be entered into ASAP model.

- In this context, it was realised and agreed that there is a need to systematically assess/review all the current CPV phase observations in order to:
  - determine whether we can get the information we need from ‘planned ‘existing’ observations, possibly processed in a different way,
  - determine whether we can get the information we need by modifying ‘existing’ observations, without detracting from the original purpose, possibly processed in different way,
  - finally if needed, design and create ‘new’ observations specifically designed for the needs of the HStrayWG not fulfilled by existing or ‘modified existing’ observations.
- This extends the already placed actions 3-3 and 3-4 to systematically review all planned CPV observations for the PACS photometer *(Action_3-3 on KO)*, for SPIRE *(Action_3-4 on MF)*, and introduces the action for the PACS spectrometer *(Action_3-5 on UK)*.These actions are not limited to self-emission but extended to cover all straylight characterisation needs.
- JF suggested to make measurements of a sample of the kapton used to cover the hexapod legs. DD explained there are three different types of ‘kapton’: kapton SLI for the backside of the M1, kapton SLI for the barrel structure, VDA tape for hexapod legs. DD will summarise the properties of these materials in a written note *(Action_3-6 on DD)* and the HStrayWG takes note of the offer of JF to perform measurements on anything supplied to her.

### 6. Preliminary output from HStrayWG ‘end Jan 2009’

- GLP to report to the SciOPsWG on 28 Jan 2009 (and to the HSGSSG on 29 Jan 2009).
- GLP to circulate a presentation by Monday evening, all members of HStrayWG to provide feedback on Tuesday, preferably morning.
- GLP also brought up the issue of the final reporting of the HStrayWG; it will consist of a report and the AOR from this group. The AOR will have to be designed and constructed by the respective PACS and SPIRE ICCs. The report TOC will be proposed by GLP *(Action_3-7 on GLP)* with assignments for the writing to be agreed in the next meeting, the idea is to construct a concise report.

### 7. Next meeting

- The main tasks in our next meeting will be:
  - review the results of action 3-2 performing additional ASEP modelling
  - review the results of the actions 3-3,4,5 re existing/modified/new CPV observations
  - review of proposed report outline and agree writing assignments
- HStrayWG#4 will take place in ESTEC on Fri 27 Feb 2009, starting at 09:15 hours and finishing at 16:00 hours. GLP will look into possibility of videocon in ESTEC.

### 8. Action review

- To be performed by commenting on the draft MOM. *(Action_3-8 on all)*

### 9. AOB

- None.

GLP thanked everyone, especially Jackie given her local time of the day, for participating in the meeting and closed it.

## List of Actions - HStrayWG#3-Action#

1. Clarify whether the standard SPIRE/PACS parallel mode is adequate for PACS straylight characterisation (cf. Sec.3). Actionee: KO. Deadline: 10 Feb 2009.
2. Perform ASAP calculations for PACS and SPIRE photometer FOVs (cf. Sec.4). Actionee: MF. Deadline: 10 Feb 2009.
3. Systematically review all the existing CPV observations, modify, and identify additional observations as required in the context of straylight characterisation for the PACS photometer (cf. Sec.5). Actionee: KO. Deadline: 25 Feb Jan 2009.
4. Systematically review all the existing CPV observations, modify, and identify additional observations as required in the context of straylight characterisation for SPIRE (cf. Sec.5). Actionee: MF. Deadline: 25 Feb Jan 2009.
5. Systematically review all the existing CPV observations, modify, and identify additional observations as required in the context of straylight characterisation for the PACS spectrometer (cf. Sec.5). Actionee: UK. Deadline: 25 Feb Jan 2009.
6. Summarise the properties of the three different kapton materials employed in a written note (cf. Sec.5). Actionee: DD. Deadline: 10 Feb 2009.
7. Suggest final report TOC. Actionee: GLP. Deadline: 25 Feb 2009.
8. Review the list of actions in the draft MOM. Actionee: all. Deadline: 4 Feb 2009.

## List of Appendices - HStrayWG#3-Appendix#

1. Draft agenda
2. Characterisation of outside telescope FOV straylight by JF
3. JWST/MIRI MLI experience by MF

**Appendix 1**

## DRAFT agenda for HStrayWG#3

PACS 'Opera', MPE, Garching; 23 Jan 2009, 09:15-16:00 hours

1. Welcome and agenda - GLP

2. Actions review - GLP
- HStrayWG#2 actions closure

3. Inside/near (instrument) FOV straylight - all
- confirm covered by instrument tests
- what tests?
- what is covered?
- complete?
- do we need to come back to this one?
- document for the HStrayWG final report

4. Outside (instrument) FOV straylight - all
- predictions of relevant "areas on the sky"
- software tools - available to us?
- fidelity of predictions discussion
- what else needed to design observations?
- dependency with mission planning
- conclusions?
- open issues?

5. Self-emission - all
- what exactly do we want to characterise, cont'd from HStrayWG#1 & #2
- how could this be done? ("in theory")
- how can it be done? ("in practice")
- dependency with telescope cooldown and sky availability
- conclusions?
- open issues?

6. Preliminary output from group "end Jan 2009" - GLP

7. Next meetings - GLP

8. Action review - GLP
- open old ones (should be none!)
- new actions

9. AOB - all

# Characterization of straylight from outside the Herschel FOV

## Motivation:

Although full characterization is of course impossible, some characterization may be possible using serendipitous observations or some modification of existing observations.

In practice, straylight is important if it produces detectable sources or structure.

Extended emission will tend not to be detected due to chopping.

Photon noise is expected to be dominated by “self emission” (either telescope surfaces or other observatory surfaces) rather than straylight from astronomical sources.

## How can we verify that we have detected straylight?

- by comparison (in shared bands) with Spitzer, IRAS, AKARI, or other survey observations
- by comparing observations carried out in different telescope / bright source configurations

## Observational scenarios for consideration:

- Observe around predicted peaks in straylight models and compare observations from different telescope / bright source configurations
- Observe a sample of faint sources in different telescope configurations

# On the limitations of MLI at low T (or equivalently at longwave), from JWST/MIRI experience

Marc Ferlet (STFC-RAL/SSTD, 19/01/09)

Science & Technology Facilities Council

# Initial assessment of the MIRI MLI issues…

-----Original Message-----

**From:** Ferlet, MJ (Marc)

**Sent:** 01 December 2005 17:02

**To:** Elder, SC (Sam); Eccleston, P (Paul); Smith, DL (Dave)

**Subject:** MIRI questions

Following our discussions:

I used a wavelength-dependent model to estimate the skin depth in Al. The skin depth is a measure of how far an EM wave will penetrate in a material before being reduced to 1/e in amplitude.

Starting with the room-T case with BB curve at en equivalent ~18um (not at the peak at 10um, if you integrate the BB curve because of the slowly decreasing RJ region at longer wavelength). Taking room-T elec conductivity of pure Al + modulating it to match some measure data (optical constant and dielectric function) on Al thin film (ref. Optical constants of solids vol I, E Palik Eds), one can find the skin depth to be delta~250A. In practice, due to inhomogeneity, non-uniformity and non purity of the Al coating it is likely that the dynamical effective conductivity is ~4x lower which will raise by ~2 the value of delta. This would mean that <2% of the incoming radiation is going through the 1000A first layer. The Mylar, although 50.8um thin, has quite some absorption features in the range 5-20um which tends to indicate that the fraction transmitted is mostly trapped and absorbed and a very negligible fraction (<<0.01%) would eventually "tunnel" through the second Al layer. So that a single blanket Al-Mylar-Al would have in this approach an emissivity ~2-3% (with ~1-2% additional uncertainty) which is close (TBC by you) to the room-T perf expectations.

At 54K, the single wavelength equivalent to the BB is ~98.7um (~ 3.9mil by the way). With an increase of conductivity of the Al due to low T, one ends up with delta~800A and the transmission through the first Al side of the top layer would be ~exp(-2*1000/800)~8.2+/-3%. The Mylar is less absorbing at this wavelengths. This would mean that ~0.5% would go through the first Al dual sided layer and almost nothing further into the blanket. A (very approximate version of mean-field homogenisation/effective medium theory) model taking into account the dielectric function of the Al and Mylar would lead to an effective reflectivity for the dual-sided Al front layer ~80-90%. From the ~10% max transmitted through the front side of the layer only a small fraction (~0.5-1.5%) can make through back so that the absorption would be ~1-(average R+second order reflected) as the transmitted is again trapped in the first 1 or 2 layers of the blanket and will act as effectively absorbed. By Kirchoff law, this gives eps~14% (probably +/-6.5%).

NB: in order to be as efficient as in the first case (room-T) the Al coating thickness would then need to be typically ~2500A min (5000A for margin to be on safe side).

This is a bit crude but has the advantage of giving an insight on the mechanism compared to a pure numerical simulation (doable by implementing the complete blanket geometry).

Marc

## …leading to estimated emissivity of ~14% (compared to a few % nominal expected)…

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… and estimates from model well in agreement with thermal model correlation

Table E
MLI Blanket Performance Parameters for Optimal Thermal Model Correlation

| Sample Number | Outer Layer Emissivity | Inter-Layer Degradation Factor | Inner Layer Coupling to Plate (W/m.K) |
|---|---|---|---|
| 1 | 0.1314 | 1 | 0.00047 |
| 2 | 0.066 | 0.81 | 0.003 |
| 3 | 0.072 | 0.75 | 0.006 |
| 4 | 0.05 [1] | N/A | N/A |

[1] Assumed value used in correlation out of non-radiation parasitic loads (gas conduction, harness conduction)

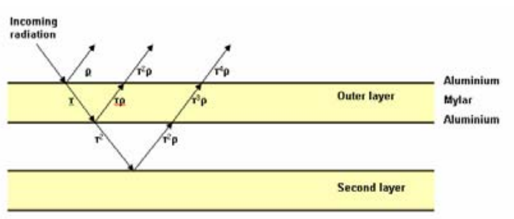


Table A
Sample MLI Blankets

| Sample ID | Description | Build Standard |
|---|---|---|
| 1 | MIRI STM Blanket sample | Un-perforated 50.8um Mylar, coated both sides with ~1000 Angstroms Aluminium for outer and inner layers<br>Perforated 12.7um Mylar, coated both sides with ~1000 Angstroms Aluminium for each of 6 core layers<br>Three layers of Dacron in between all shields<br>Two Tyvek particulate filter patches on outer layer, 20cm x 20 cm |
| 2 | 8 layers of aluminised polyester of 9um each side | 0.009mm Al/0.023mm Polyester/0.009mm Al.<br>Un-perforated outer and inner layers<br>Perforated 6 core layer<br>Three layers of Dacron in between all shields<br>Two Tyvek particulate filter patches on outer layer, 20cm x 20 cm |
| 3 | 8 layers of 18um aluminium foil | Un-perforated outer and inner layers<br>Perforated 6 core layer<br>Three layers of Dacron in between all shields<br>Two Tyvek particulate filter patches on outer layer, 20cm x 20 cm |
| 4 | Gold plated aluminium plate | Conforms to standard MIL-G-45204 Type 1 Class 1 (coating thickness 1.25um, purity 99.7%). |

**NB:** …and MIRI outer MLI is Al+Mylar+Al so potentially a better shield than VDA Kapton of Herschel SLI…

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Table G
Effective Median Wavelength of Emitted Blackbody Radiation for Various Environment Temperatures

| Temperature (K) | Effective Wavelength (micron) |
|---|---|
| 6 | 851 |
| 10 | 514 |
| 20 | 260 |
| 22 | 238 |
| 30 | 180 |
| 32 | 170 |
| 40 | 137 |
| 50 | 108 |
| 54 | 100 |
| 100 | 55 |
| 300 | 19 |

**NB:** …remembering that radiative exchange at low T occurs dominantly in the FIR/submm part of the spectrum…

Table H
Transmission Through Aluminium Layers as a Function of Incident Radiation Temperature and Aluminium Layer Thickness

| Temperature (K) | Skin Depth (Angstrom) | Transmission through 1000Å Al Layer (%) | Transmission through 5000Å Al Layer (%) |
|---|---|---|---|
| 6 | 2260 | 41.28 | 1.20 |
| 10 | 1729 | 31.45 | 0.31 |
| 20 | 1230 | 19.67 | 0.03 |
| 22 | 1182 | 18.41 | 0.02 |
| 30 | 1043 | 14.69 | 0.01 |
| 32 | 1017 | 14.00 | 0.01 |
| 40 | 931 | 11.66 | 0.00 |
| 50 | 850 | 9.52 | 0.00 |
| 54 | 826 | 8.87 | 0.00 |
| 100 | 684 | 5.38 | 0.00 |
| 300 | 545 | 2.55 | 0.00 |

**Conclusion from study for JWST/MIRI:**

500nm Al thickness appears necessary to avoid partial transmission through outer layer and acting effectively as low emissivity shield

Table I
Transmissivity, Bulk Reflectivity and Effective Emissivity of Outer Layers of MLI (both 1000 and 5000 Angstrom Thicknesses) for various incident radiation temperatures

| Environment Temperature (K) | 1000Å Al Layer Transmission (%) | 1000Å Al Layer Bulk Reflectivity (%) | 1000Å Al Layer Effective Emissivity (%) | 5000Å Al layer Transmission (%) | 5000Å Al layer Bulk Reflectivity (%) | 5000Å Al layer Effective Emissivity (%) |
|---|---|---|---|---|---|---|
| 6 | 41.28 | 55.7 | 25.3 | 1.20 | 95.8 | 4.2 |
| 10 | 31.45 | 65.6 | 23.8 | 0.31 | 96.7 | 3.3 |
| 20 | 19.67 | 77.3 | 18.7 | 0.03 | 97.0 | 3.0 |
| 22 | 18.41 | 78.6 | 17.9 | 0.02 | 97.0 | 3.0 |
| 30 | 14.69 | 82.3 | 15.5 | 0.01 | 97.0 | 3.0 |
| 32 | 14.00 | 83.0 | 15.0 | 0.01 | 97.0 | 3.0 |
| 40 | 11.66 | 85.3 | 13.3 | 0.00 | 97.0 | 3.0 |
| 50 | 9.52 | 87.5 | 11.6 | 0.00 | 97.0 | 3.0 |
| 54 | 8.87 | 88.1 | 11.1 | 0.00 | 97.0 | 3.0 |
| 100 | 5.38 | 91.6 | 8.1 | 0.00 | 97.0 | 3.0 |
| 300 | 2.55 | 94.5 | 5.5 | 0.00 | 97.0 | 3.0 |

Nominal perf (but at ambient/MIR) for standard 100nm thick Al layer

Low T (equivalent longwave) behaviour: typically x(3+/-1) higher emissivity

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