Specifics and post-processing of HIFI mapping observation data

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Outline

• Reminder of the HIFI spectral mapping observing modes characteristics
• What are the HIFI spectral mapping data products
• What are their science readiness and what specific caveats still apply to these data
• Correction measures to these artifacts
• Further recipes for regridded cubes: OFF spectra, multiple map merging
The HIFI observing modes - reminder

1 – Position Switch
- Mode I – 1
  - Point-PositionSwitch

2 – Dual Beam Switch
- Mode I – 2
  - DBS
  - FastChop-DBS

Optional continuum optimisation

3 – Frequency Switch
- Mode I – 3
  - FSwitch
  - FSwitch-NoReference

Optional sky ref measurement

4 – Load Chop
- Mode I – 4
  - LoadChop
  - LoadChop-NoReference

Optional sky ref measurement

AOT I
- Single Point Observations

Mode I – 1
- Point-PositionSwitch

Mode I – 2
- DBS
- FastChop-DBS

Mode I – 3
- FSwitch
- FSwitch-NoReference

Mode I – 4
- LoadChop
- LoadChop-NoReference

AOT II
- Mapping Observations

Mode II – 1
- OTF

Mode II – 2
- DBS-Raster
- FastChop-DBS-Raster
- DBS-Cross
- FastChop-DBS-Cross

Mode II – 3
- OTF-FSwitch
- OTF-FSwitch-NoReference

Mode II – 4
- OTF-LoadChop
- OTF-LoadChop-NoReference

AOT III
- Spectral Scan

Mode III – 2
- SScan-DBS
- SScan-FastChop-DBS

Mode III – 3
- SScan-FSwitch
- SScan-FSwitch-NoReference

Mode III – 4
- SScan-LoadChop
- SScan-LoadChop-NoReference

The HIFI spectral mapping data
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The HIFI mapping observing mode

DBS raster map

**Sampling:**
- Fixed: 10, 20, 40”
- Half-beam
- Nyquist

On-the-fly Mapping

**Sampling:**
- Fixed: 10, 20, 40”
- Half-beam
- Nyquist

In combination with the following referencing schemes:

Position

Telescope slewing

Load Chop

REF (optional)

Internal Load COLD

Frequency Switch

ON₁-ON₂

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Spectral Mapping data in the archive

• **Stand-alone browse products:**
  – Level 2.5 products: 1 spectral cube per spectrometer (WBS/HRS), polarisation (H/V), sideband (USB/LSB) and sub-band if non-stitched (HRS)

• **Full observation contexts:**
  – Science data are contained in so-called Level0, Level1, Level 2 and Level 2.5
    – *Level0 are un-calibrated data of little interest to the general user*
    – *Level1 data are still in DSB intensity and on an Intermediate frequency scale, but contain all individual science spectra*
    – *Level2 data are averaged spectra of all individual level1 data, per sideband, per polarisation, per spectrometer*
    – *Level2.5 data are regridded cubes of the level 2 spectra at individual positions for each spectrometer*
  – Additional calibration data can be useful for further diagnostic, e.g. spectra from the OFF positions
The browse product, or postcard, offers a visual summary of the observation content and quality. In mapping observation the postcard contains both integrated intensity maps and collapsed spectra over the whole maps for each WBS sub-band in H and V polarisations from cubes, in both LSB and USB frequency scales.

First assessment of possible data characteristics and artefacts – here combination of optical and electric standing waves.

Observation summary

Spectrometers available in the data

AOR name

Cal-HifiMappingProc-OrionBar-CII-Normal_cycle_72 (1342249579)

Observing Mode = HifiMappingProcOTF
Spectrometer = WBS-H WBS-V
Source = Orion Bar peak-1
Requested RA = 5h 35m 20.90s
Requested Dec. = 5° 25’ 4.800”
Top level products from Spectral Mapping are the outcome of the re-gridding into cubes of the level 2 data from the pipeline. This means that any artifacts, esp. spurs or standing waves still present there, will be *propagated* in the final products, usually in the form of added noise or stripping structures along the mapping scans.
Data readiness in Mapping mode (2)

- The cubes are re-gridded onto regular spectral and spatial grids
  - The size of the re-gridded pixel is derived from the structure of the data acquisition during the coverage
  - In general this provides slightly better noise than was requested at the time of observation submission, so in practice pixel size typically 1.5x smaller than the default could be afforded (make sure you are Nyquist-sampled!)
Data Readiness in Mapping mode (3)

• **How can I further improve my Spectral Mapping data**
  – **Option 1**: Work from the final regridded cubes
    – The standard baseline cleaning tasks (e.g. *FitHifiFringe* or *FitBaseline*)
      can work on the individual spectra of spectral cubes in the same fashion
      as on isolated spectra from the Single Point mode
    – This option is the most straight-forward one in case you are happy with
      the spatial grid assumed in the stand-alone browse products
  – **Option 2**: Work from the level 2 individual positions and perform the re-
    gridding yourself on the cleaned spectra
    – This provides the largest margin towards both input spectra cleaning and
      control of the gridding parameters (e.g. pixel size, kernel, etc)
    – The approach is the same as for the Single Point mode data (see
      dedicated talk in this workshop) applied to the collection of level 2 spectra
      forming the survey
    – Besides it allows to perform combination of multiple sets of spectra (e.g.
      H and V, or other coverages/obsids) in one go
  – The re-gridding is done through the HIPE *doGridding* task
Mapping observation: Cube generation

• The doGridding task

  – This is the same task as the one used in the pipeline
  – Allows very versatile reprocessing of the cube
  – Any parameter that is not informed will use a default value optimised for the particular observation
  – There can be several reasons for re-gridding your data, e.g.:
    – Re-define the grid dimensions (pixel size, convolution kernel, etc)
    – Level2 data need baseline/fringe/spur correction
    – H/V average can be done as a re-gridding of the combination of both data-sets – it is the most accurate way to combine H and V since they don’t strictly cover the same positions on the sky

• **Information from the OFF positions**
  
  – A synthetic spectrum of the data acquired on the reference positions is also provided within the observation context *(note: it will eventually be served stand-alone as an HPDP but this will not be before HIPE 14)*
  
  – In the observation context it can be accessed at `obs > calibration > pipeline-out > ReferenceSpectra`
    
    – For DBS raster maps there is one OFF spectrum per ON spectrum so in principle one could also build a cube of the OFF spectra
    
    – For the other mapping modes, there’s only one single OFF position applying to a map
    
    – Beware that these synthetic spectra have noticeably poorer baseline quality, esp. strong standing wave residual or spurious responses (not automatically flagged)
    
  – See more information in the cookbook:

  http://herschel.esac.esa.int/hcss-doc-13.0/load/hifi_um/html/hrdg_cook_map.html
The HIFI spectral scan data

Background: MSX 8 µm

Overlay: HIFI mapping footprint

OMC 1

OFF position

CO 8-7

Antenna Temperature (K)

Upper sideband frequency (GHz)

[CI]  

Antenna Temperature (K)

Upper sideband frequency (GHz)

OFF contamination
Map and/or polarisation merging

- **It is possible to create cubes based on the combined level 2 information from either several polarisations and/or different obsids**
  - This work needs to be done using the level 2 data from each product you want to combine (to be extracted from the observation context)
  - A task `mergeHtps` exists than merges the products into one unique and large set of spectra, that can then be sent to `doGridding` to build the merged cube
Possible further steps towards data analysis

- Unit and scale transformations: Frequency scale conversion, or intensity conversion into main beam antenna temperature or flux density
- A dedicated cube spectral toolbox also allows to generate further products (integrated maps, moment maps, etc), or crop/export cube onto different WCS, etc

Please refer to the workshop talk dedicated to Data analysis and flux extraction for more details