Semi-extended sources with SPIRE FTS

24 April 2014

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Identifying partially extended sources

- The spectrum shows kinks and discontinuities where the beam size changes
Does the spectrum need correcting?

1) Extended background (or telescope residual)
   - Check off-axis dets
   - Check dark sky

2) Faint source: calibration problem
   - Special pipeline (ask helpdesk)
   - Jump in opposite direction

3) Pointing offset
   - Use SECT

4) Partially extended
   - Use SECT

A pointing offset can be included in the source model for SECT

see SPIRE DRG

- Uses the \textit{forward coupling efficiency}:

\[ \eta_f(\nu, \Omega_{\text{source}}) = \frac{\int P_{\nu}(\Psi - \Omega_0) D_{\nu}(\Psi) d\Psi}{\int 2\pi P_{\nu}(\Psi) d\Psi} \]

- Start from point-source calibrated spectrum:

\[ F_s = F_{\text{point}} \eta_c(\nu, \Omega_{\text{source}}) \frac{\Omega_{\text{source}}}{\eta_f(\nu, \Omega_{\text{source}}) \Omega_{\text{beam}}(\nu)} \]

- Step 2: \textbf{normalise} the spectrum to a \textit{Gaussian reference beam}
  - Gives spectrum in Jy as if observed by the reference beam

Beam size of the FTS varies with frequency
Correction efficiency, $\eta_c$

- The correction efficiency deals with additional effects not taken into account by $\eta_f$
  1. Efficiency with which reconstructed beam couples to source (diffraction losses in optics and response of feedhorn/bolometer)
  2. Uncertainty in the source model
  3. Lack of measurement of the FTS beam far from the axis

For a point source $\eta_c = 1$

For a true extended source $\eta_c = 0.3 – 0.5$

- The HIPE tool assumes that $\eta_c = 1$ (OK for Saturn 17")
Source brightness model

- Three standard models:
  - Top hat
  - Gaussian
  - Sersic

- Or, input an image (e.g. PACS map)
  - Must have 257×257 1” pixels to match beam map

- Model should be normalised to have area of 1.0

- Some errors due to pixelisation for small models (although corrections are made for top hat and Gaussian)
Understanding the reference beam

- Reference beam is used to normalise the correction
- The aim is to obtain flux density that would be measured if the SPIRE FTS had a frequency independent Gaussian beam

Assumption: source distribution is independent of frequency

If the reference beam is made larger, the flux density increases until the whole source distribution is included inside the reference beam
Semi-extended correction tool
**Coupling threshold**

- The coupling measures the overlap between source and beam.
- Low coupling implies a very weak signal in the original data:
  - *The tool multiplies the original data by a correction factor.*
  - *Errors increase for low coupling.*
  - *The correction tends to infinity when coupling is zero.*
- The **coupling threshold** sets the value below which the tool does not produce output for that detector.

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*Source falls between detectors – no output spectra produced.*

*Output only contains centre detectors.*
Lines vs. Continuum

• The tool assumes the source distribution is **constant in frequency**

• This may not be true:
  – Spectral lines may have a different distribution to the continuum
  – Different parts of the source may have different temperatures
  – The distribution may change for lines of different energies

• The tool allows simple optimisation of the source model diameter
  – Minimises the overlap between bands
  – May not be good for spectral lines or complicated sources
    • Use scripting
Serpens MM1 (1342216893)

Corrected SERPENS_MM1 spectrum

- Optimised overlap
- Discontinuity where beam changes
- No change at freqs equivalent to 40" reference beam
- Wiggles remain – due to small scale beam changes?
- This line could be matched instead of continuum level
Summary

• Theory is described in Wu et al., A&A, 556, 116 (2013)

• Units of output spectrum are Jy in the reference beam
  – The reference beam is constant in frequency
  – Assumes source model is independent of frequency
  – Assumes that the source is small enough that $\eta_c = 1$

• Be careful to distinguish source model shape for continuum and lines

• SECT is not needed for fully sampled mapping observations – as all the information about source shape is in the map