Flux Calibration with "Normalization"

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When - in SpecDiffChop - "normalize" is activated, the RSRF is not used; instead, uncalibrated signals are used in the following way:

$$norm = 1/2\left[\underbrace{\frac{A-B}{(A+B)/2}}_{\text{Nod A}}+\underbrace{\frac{B'-A'}{(A'+B')/2}}_{\text{Nod B}}\right] \tag{1}$$

where A and B are the signals detected in the two chopper positions in Nod A and A' and B' are the signals detected in the two chopper positions in Nod B. Note that in the pipeline, the first and the second terms of this equation are executed in the task $specDiffChop$ with normalize=1. The combination of nods is not part of SpecDiffChop - presently, it's done "manually" (in HIPE).

The whole purpose of this exercise is the elimination of drifts with time in the system response (mostly detectors), which relates flux to measured ramp slope. Below, we express the observed signals as fluxes T_A and T_B from the telescope in the two chopper positions (assumed to be constant with time) and flux from the source s, all converted to ramp slopes by the gain factor g, assumed to be not necessarily constant with time, but at least constant for the duration of a complete chop cycle. Then we can rewrite the normalized result as:

$$norm = \frac{(T_A+s)*g-T_B*g}{(T_A+s+T_B)*g}+\frac{(T_B+s)*g'-T_A*g'}{(T_A+s+T_B)*g'} \tag{2}$$

$$= \frac{2s}{T_A+T_B+s} \tag{3}$$

$$= \frac{s}{(T_A+T_B+s)/2} \tag{4}$$

Thus, for signals $s << T_A + T_B$, this expresses the source flux as a fraction of the mean telescope flux (per pixel), and it eliminates any time evolution of the responsivity between nods (or even within nods, as it is done on individual chop cycles). Also, and implicitly contained in g, the system response variations as a function of wavelength are eliminated. But the main purpose really is to make the offset signals in Nod A and Nod B cancel each other even when there is a detector response drift.

However, if the source flux isn't negligible then what one really wants is

$$x = \frac{s}{(T_A + T_B)/2} \tag{5}$$

which is the source flux as a fraction of the telescope flux. Luckily, there is an analytic solution for this:

$$\begin{aligned} norm &= \frac{s}{(T_A + T_B + s)/2} && (6) \\ &= \frac{\frac{s}{(T_A+T_B)/2}}{1 + \frac{s/2}{(T_A+T_B)/2}} && (7) \\ &= \frac{x}{1 + x/2} && (8) \end{aligned}$$

thus:

$$\begin{aligned} norm + norm\frac{x}{2} &= x && (9) \\ x &= \frac{norm}{1 - norm/2} && (10) \end{aligned}$$

Of course, for signals $s >> T_A + T_B$, $norm$ approaches a constant value of 2, and the whole method doesn't make much sense, anyway.

So, after calculating *norm* - which is good for checking whether it doesn't exceed 1 - one should add the more useful quantity x, which, for a known telescope spectrum, can be easily converted in flux units.

In the current pipeline *norm* is the result of the combination of the nods IF $specDiffChop$ with normalize =1 has been used.