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## Appendix A: Calibration uncertainties

The HB approach is one of the only methods allowing a rigorous treatment of the photometric calibration uncertainties. These uncertainties are indeed systematic effects, with both spectral and spatial correlations. Some studies account for their spectral correlations, but ignore their spatial correlations (e.g., [Gordon et al. 2014](#)). In the present paper, following [G18](#), we assume that calibration uncertainties are perfectly correlated between sources, and partially correlated between wavelengths. In this section, we discuss the values of these uncertainties and of their correlation coefficients.

The DustPedia photometric fluxes, given in the archive<sup>25</sup>,  $F_\nu(\lambda_0)$  at wavelength  $\lambda_0$ , are accompanied with a total uncertainty being the quadratic sum of noise and calibration errors:

$$\sigma_\nu^{\text{C18}}(\lambda_0) = \sqrt{(\sigma_\nu^{\text{noise}}(\lambda_0))^2 + (\delta_{\text{cal}}^{\text{C18}}(\lambda_0) \times F_\nu(\lambda_0))^2}, \quad (\text{A.1})$$

where  $\delta_{\text{cal}}^{\text{C18}}(\lambda_0)$  is the calibration uncertainty (Table 1 of [C18](#)). HerBIE treats the noise and calibration uncertainties separately. Therefore, we keep the noise uncertainty,  $\sigma_\nu^{\text{noise}}(\lambda_0)$ , but we build a covariance matrix of the absolute calibration uncertainties,  $V_{\text{cal}}$ , to replace the  $\delta_{\text{cal}}^{\text{C18}}$  coefficients.

### A.1. The full covariance matrix

Using the separation strategy ([Barnard et al. 2000](#)), we decompose the covariance matrix of the absolute calibration uncertainties as:

$$V_{\text{cal}} = S_{\text{cal}} R_{\text{cal}} S_{\text{cal}}, \quad (\text{A.2})$$

where  $S_{\text{cal}}$  is the diagonal matrix of standard-deviations and  $R_{\text{cal}}$  the correlation matrix. The nontrivial elements of  $S_{\text{cal}}$  and  $R_{\text{cal}}$  are given in Tables [A.1](#) and [A.2](#). We describe, in the following Appendices [A.2–A.8](#), how we obtained these values from the literature.

### A.2. Spitzer/IRAC

The calibration of IRAC data is presented by [Reach et al. \(2005\)](#). It is performed using a subsample of the stellar catalog of [Cohen et al. \(2003\)](#). The components entering in the uncertainty on the absolute calibration are given by Eq. (13) of [Reach et al. \(2005\)](#) and the corresponding values in their Table 7. The first term is the correlated uncertainty,  $\sigma_{\text{abs}} = 1.5\%$ , corresponding to the uncertainty in the predicted fluxes of Vega and Sirius. The second term is the uncorrelated uncertainty on the calibrator fluxes:  $\sqrt{(\sigma_{\text{ground}}^2 - \sigma_{\text{abs}}^2)/n} = 0.87\%$ , with  $\sigma_{\text{ground}} = 2.3\%$  and  $n = 4$ . Finally, there is an uncorrelated term introduced by the dispersion of the IRAC observations of the calibrators:  $\sigma_{\text{rms}}/\sqrt{n}$ , where  $\sigma_{\text{rms}} = 2.0\%$ ,  $1.9\%$ ,  $2.1\%$  and  $2.1\%$  for IRAC1, IRAC2, IRAC3, and IRAC4, respectively.

In addition, one must multiply the point source calibrated fluxes by aperture correction factors. According to the IRAC instrument handbook<sup>26</sup> (Sect. 4.11), these factors have a 10% uncertainty. We include this extra source of uncertainty, assuming it is uncorrelated. These correction factors have been applied by [C18](#) for all the DustPedia galaxies and by [Rémy-Ruyer et al.](#)

<sup>25</sup> <http://dustpedia.astro.noa.gr/Photometry>

<sup>26</sup> <https://irsa.ipac.caltech.edu/data/SPITZER/docs/irac/iracinstrumenthandbook/>

**Table A.1.** Absolute calibration uncertainties (diagonal of  $S_{\text{cal}}$ ; Eq. (A.2)).

Waveband label	Calibration uncertainty
IRAC1	10.2%
IRAC2	10.2%
IRAC3	10.2%
IRAC4	10.2%
MIPS1	4.0%
MIPS2	5.0%
MIPS3	11.6%
PACS1	5.4%
PACS2	5.4%
PACS3	5.4%
SPIRE1	5.9%
SPIRE2	5.9%
SPIRE3	5.9%
WISE1	3.2%
WISE2	3.5%
WISE3	5.0%
WISE4	7.0%
IRAS1	7.6%
IRAS2	11.0%
IRAS3	14.6%
IRAS4	20.2%
HFI1	4.3%
HFI2	4.2%
HFI3	0.90%

**Notes.** See Table 1 for waveband naming conventions.

(2015) for half of the DGS galaxies, the other half being nearly point sources. The IRAC calibration uncertainties will thus be overestimated for about 15 of our sources.

### A.3. Spitzer/MIPS

MIPS calibration has been independently performed for each of its three wavebands. The 24  $\mu\text{m}$  calibration is presented by [Engelbracht et al. \(2007\)](#). It is primarily based on observations of A stars. The authors recommend adopting a net calibration uncertainty of 4%. The 70  $\mu\text{m}$  calibration is presented by [Gordon et al. \(2007\)](#). It is primarily based on observations of B and M stars. The authors recommend using a calibration uncertainty of 5%, dominated by repeatability scatter. Finally, the 160  $\mu\text{m}$  calibration, presented by [Stansberry et al. \(2007\)](#) is performed on observations of asteroids, simultaneously in the three MIPS bands. This 160  $\mu\text{m}$  calibration uncertainty is therefore tied to 24 and 70  $\mu\text{m}$ . The authors estimate a 7% uncertainty tied to these bands, for a total uncertainty of 11.6%. To simplify, we assume that the calibration uncertainty is the quadratical sum of 4% correlated with MIPS1, 5% correlated with MIPS2, and the remaining 9.7% uncorrelated.

### A.4. Herschel/PACS

PACS calibration is performed on five stars, used as primary calibrators ([Balog et al. 2014](#)). The absolute calibration uncertainty for point sources appears to be dominated by the stellar model uncertainty of 5%, correlated between bands. In addition, there is a 2% repeatability uncertainty, uncorrelated between bands.