All observations by the aperture photometer (PHT-P) and the far-infrared (FIR) camera section (PHT-C) of ISOPHOT included reference measurements against stable internal fine calibration sources (FCS) to correct for temporal drifts in detector responsivities. The FCSs were absolutely calibrated in-orbit against stars, asteroids and planets, covering wavelengths from 3.2 to 240 µm. We present the calibration concept for point sources within a flux-range from 60 mJy up to 4500 Jy for staring and raster observations in standard configurations and discuss the requisite measurements and the uncertainties involved. In this process we correct for instrumental effects like nonlinearities, signal transients, time variable dark current, misalignments and diffraction effects. A set of formulae is developed that describes the calibration from signal level to flux densities. The scatter of 10 to 20% of the individual datapoints around the derived calibration relations is a measure of the consistency.

Introduction In its broadest meaning, we define calibration as transforming the specific, nowadays digital, output of a scientific instrument to physical units. In our case these are flux densities at given wavelengths and sky positions. This transformation generally varies with every change of the instrument set-up, hence the complexity of the calibration task increases with the number of instrument configurations used. Initially it is derived on the grounds of the known instrument geometry and the relevant optical and electrical properties, that as a whole we will refer to as the ideal instrument model. Subsequently this model is refined and becomes more empirical, in order to match the measured data.

The task of calibration can be divided into three parts: First, development of the instrument model and determination of the instrument parameters that are assumed to be unchanging and that can be measured in the laboratory, e.g. filter transmissions, aperture diameters, etc. Second, the determination of the open parameters of the ideal instrument model that can be determined only in-situ, i.e. with the instrument built into the satellite and in the real space-environment. And third, the determination of deviations from the ideal instrument model that cannot be removed by adjusting parameters, and require a new functional property. These modifications to the instrument model are found empirically, and generally originate in simplifications. Because open parameters and non-ideal instrumental effects are usually intertwined, an iterative process is required to separate and quantify all the contributing effects.

This paper presents the photometric calibration of staring mode- and simple raster mode observations. Excluding the AOT P32.0 point sources with the P- and C-sections of ISOPHOT (Lemke et al. lemke96), which is one of four scientific instruments on board ESA’s Infrared (IR) Space Observatory ISO (Kessler et al. kessler96). Unlike CCD devices, the detectors for the Mid-IR (MIR) and Far-IR (FIR) are far less stable and exhibit a continuously changing relation between signal and incident flux. Thus the two Fine Calibration Sources (FCS) built into ISOPHOT played a crucial role as stable references for the photometry and most of this paper will describe their empirical calibration.
The data collected for this task represent the largest part of all specific calibration observations during the mission. This resulted in a fairly homogeneous block of data. Its analysis and comparison to modeled spectral energy distributions (SEDs), of the observed celestial standard sources yielded most of the results presented here and drove several refinements to the ideal instrument model. An additional difficulty was the large number of possible instrument configurations, which was limited somewhat by considering only one standard aperture for each filter band of the aperture photometer (see Table wavtab). The set of instrument configurations and modes we treat herein defines a well-understood baseline within the large parameter space, where absolute calibration errors are expected to be minimal. The calibration of further configurations and modes, like chopped observations, extended source photometry, or non-standard apertures, is left to future publications.

We start with a brief review of the instrumental design with some emphasis on the internal reference sources (Sect. instrdes), followed by an outline of the calibration strategy (Sect. calstrat). Sect. (sigcond) continues with a description of the corrections applicable to the detector signal. Sect. (celcal) presents the celestial calibrators and Sect. (phitcor) describes those corrections imposed by photometric constraints. We derive the FCS calibration tables in Sect. (fcspow) and present the final flux calibration, with its mathematical description and a discussion on accuracy and reproducibility, in Sect. (fixcal). A summary constitutes Sect. (summar).

Instrument Design instrdes Optical System A schematic instrumental set-up is shown in Fig. fcsgra. A more detailed description can be found in Klaas et al. (klaas94) or Laureijs et al. (laureijs2001). The set-up design, diffraction-limited at 5 μm, with an entrance aperture 60 cm diameter and an

Instrument schematic from a calibrator’s point of view. The detector compares IR radiation directly from the sky and from the internal reference source. Stability of the detector is required only for the time interval of the two measurements. fcsgra