Notes about the Photometric Data Collection

1 Data Collection from Various Archives

The photometric data was retrieved by Pieter Degroote in an automated way, using query-scripts, to scan all data archives known to him (I am still missing an exact list of resources from Pieter here). The data comes in 85 `*.phot` and 85 `*.bib` files, one pair for each target, which can be found in the folders `diana@thuban4.st-and.ac.uk:TARGETS/*/photometry`. The important columns are

- `meas`: the measured flux value in original units, as pointed out in column `unit`
- `e_meas`: its error σ
- `photband`: the name of the photometric filter
- `source`: search term to find out more details
- `_r`: the mis-pointing offset [arcsec], i.e. the difference between nominal object position and instrument pointing position during the observation
- `cwave`: central filter wavelength [Å]
- `cmeas`: flux in [erg/s/cm^2/Å]
- `e_cmeas`: its error σ
- `bibcode`: bibcode according to entries in the respective `*.bib`-file
- `comments`: available comments in the catalog

The offset positions of the various observations are visualized in finndercharts to be found at `diana@thuban4.st-and.ac.uk:TARGETS/*/photometry/*_finderchart.png` which also contains information about the proper motion of the object, see example in Fig. 4. Pieter assumes 10% error if no information about σ is given (30% for some particularly unreliable filters), and 1% minimum error.

2 Light Version

There is an idl-tool in `diana@thuban4.st-and.ac.uk:TOOLS/extract_phot.pro`, which you can run yourself in the `TOOLS`-directory, which reads these data, visualizes the SED (including mean UV and Spitzer-IRS spectra where available) and saves the plot into a ps-file, see `diana@thuban4.st-and.ac.uk:TARGETS/*/photometry/SED*.ps`, and then produces an easy-to-read photometric output file with obvious entries in `diana@thuban4.st-and.ac.uk:TARGETS/*/photometry/SED*.dat` as

```
lam[mic] flux[Jy] sigma[Jy] rem filter    typ bibcode
0.352 3.6375E-03 3.8193E-04  ok SDSS.U    CCD 2011yCat.2306....0A
0.364 1.0267E-02 1.0267E-03  ?? JOHNSON.U CCD 2002yCat.2237....0D
...
101.9 1.0500E+01 1.0500E+00  ul IRAS.F100 BOL 1988IRASP.C......0J
```

The rem-entries mark the kind and quality of the data points: "ok" means good quality (as far as this is possible to tell from Pieter's entries), "??" means dodgy point for some reasons, see below, and "ul" means upper limit. In the latter case, only sigma[Jy] is relevant. Two examples SEDs are shown in Figs. 2 and 3, where dodgy points are plotted with open symbols without errorbars, and upper limits are shown as arrows from 3·sigma down to 1·sigma.

3 Filter transmission files, and comparison between photometric data and the models

The comparison between our models and the photometric data should involve the photometric filter transmission curves $t^{\,\rm filter}(\lambda)$. The primary measurement quantity is different for CCD detectors and bolometers, namely

$$\begin{aligned}
\text{CCD-detectors:} &\qquad F_\lambda^{\rm filter} = \frac{\int \lambda F_\lambda\, t^{\,\rm filter}(\lambda)\, d\lambda}{\int \lambda\, t^{\,\rm filter}(\lambda)\, d\lambda} \quad [\text{erg/cm}^2/\text{s/Å}] \\
\text{BOL-detectors:} &\qquad F_\lambda^{\rm filter} = \frac{\int F_\lambda\, t^{\,\rm filter}(\lambda)\, d\lambda}{\int t^{\,\rm filter}(\lambda)\, d\lambda} \quad [\text{erg/cm}^2/\text{s}/\mu\text{m}]\ . \qquad (1)
\end{aligned}$$

By means of suitably defined central filter wavelength $\langle\lambda\rangle$, these flux measurements have been converted to Jy-units in both the *.phot and *.dat files as

$$\begin{aligned}
\text{CCD-detectors:} &\qquad F_\nu^{\rm filter} = \frac{\langle\lambda\rangle^2}{c} F^{\,\rm filter} \quad [\text{Jy}] \\
\text{BOL-detectors:} &\qquad F_\nu^{\rm filter} = \frac{\langle\lambda\rangle^2}{c} F_\lambda^{\rm filter} \quad [\text{Jy}]\ . \qquad (2)
\end{aligned}$$

This implies that we should compare the models to the photometric data as follows

$$\begin{aligned}
\text{CCD-detectors:} &\qquad F_\nu^{\rm filter} = \frac{\int \frac{1}{\lambda} F_\nu\, t^{\,\rm filter}(\lambda)\, d\lambda}{\int \frac{1}{\lambda} t^{\,\rm filter}(\lambda)\, d\lambda} \\
\text{BOL-detectors:} &\qquad F_\nu^{\rm filter} = \frac{\int \frac{1}{\lambda^2}\, F_\nu\, t^{\,\rm filter}(\lambda)\, d\lambda}{\int \frac{1}{\lambda^2}\, t^{\,\rm filter}(\lambda)\, d\lambda} \qquad (3)
\end{aligned}$$

with the central filter wavelength $\langle\lambda\rangle$ being defined as

$$\begin{aligned}
\text{CCD-detectors:} &\qquad \langle\lambda\rangle^2 = \frac{\int \lambda\, t^{\,\rm filter}(\lambda)\, d\lambda}{\int \frac{1}{\lambda}\, t^{\,\rm filter}(\lambda)\, d\lambda} \\
\text{BOL-detectors:} &\qquad \langle\lambda\rangle^2 = \frac{\int t^{\,\rm filter}(\lambda)\, d\lambda}{\int \frac{1}{\lambda^2}\, t^{\,\rm filter}(\lambda)\, d\lambda}\ . \qquad (4)
\end{aligned}$$

This means that we should compare the models to the observations by using Eq. (3) with $F_\nu = F_\nu^{\rm model}$. In an heroic effort, Pieter has collected electronic versions of more than 400 filter transmission curves, one example is shown in Fig. 1. These files are available at diana@thuban4.st-and.ac.uk:INSTRUMENT_DATA/Filters with the abbrevated names given in the *.phot and SED*.dat files. He also used these files, together with a high quality

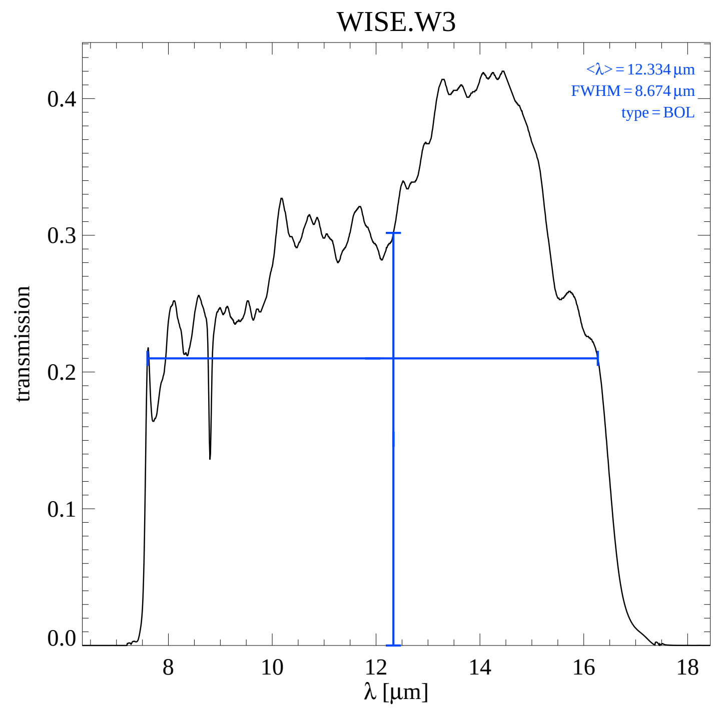

Figure 1: Transmission curve for WISE.W3. The blue bars show FWHM and centre wavelength. See `diana@thuban4.st-and.ac.uk:DOCUMENTS/Filter_all.ps` for more filters.

spectrum of Vega, to calculate the **zero-points** of many filters himself, to go from magnitudes to fluxes, in order to have the fluxes on a consistent basis. More details will need to go into a paper, I guess. The integration according to Eq. (3) makes the central wavelengths $\langle\lambda\rangle = \texttt{lam[mic]} = \texttt{cwave}$ actually obsolete, they should only be used for plotting purposes.

4 Data Issues

Not all of the photometric data is actually useful, and we will have to carefully select the good data for the modelling. When looking at all 85 SEDs `diana@thuban4.st-and.ac.uk:DOCUMENTS/SED_all.ps` it is quite obvious that there are certain re-occurring flaws with certain intruments, for example

1. SDSS data often unusable
2. DENIS data often unusable
3. USNO-B1 data often unusable
4. IRAS fluxes often too high (well, we knew that before)
5. WISE.W2 often too high

Some of these issues are due to mis-pointings, see e.g. Fig. 4, but others are actaully not so clear. Here is some feedback from Pieter ...

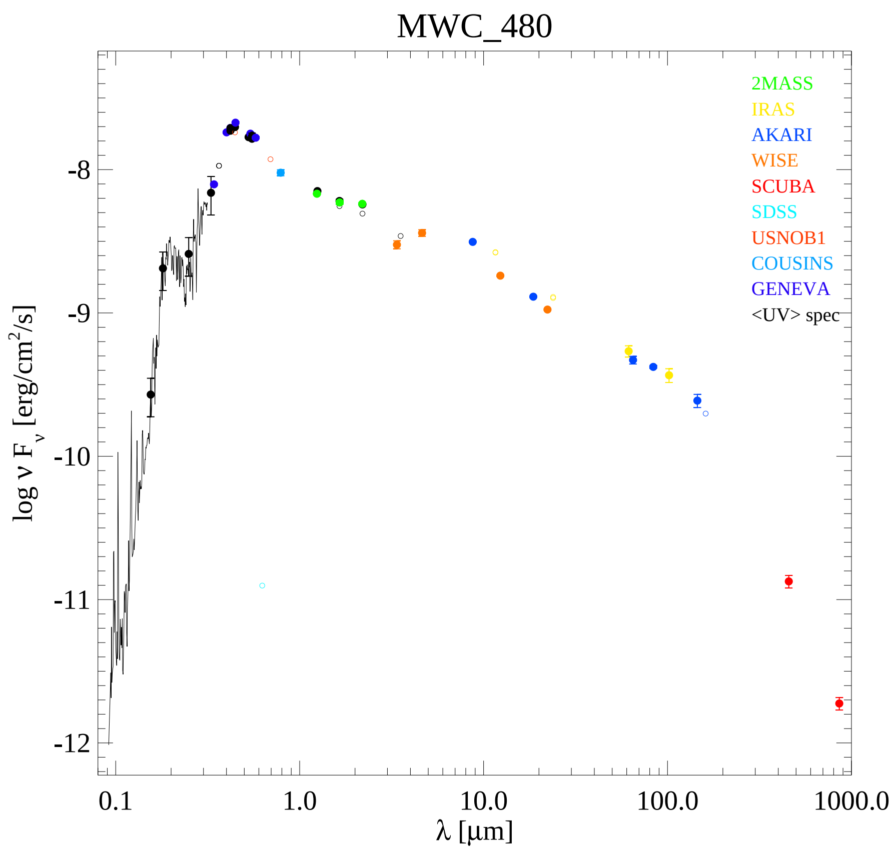

Figure 2: Photometric data for MWC 480, with overplotted mean UV spectrum. There is one obviously very erroneous SDSS data point.

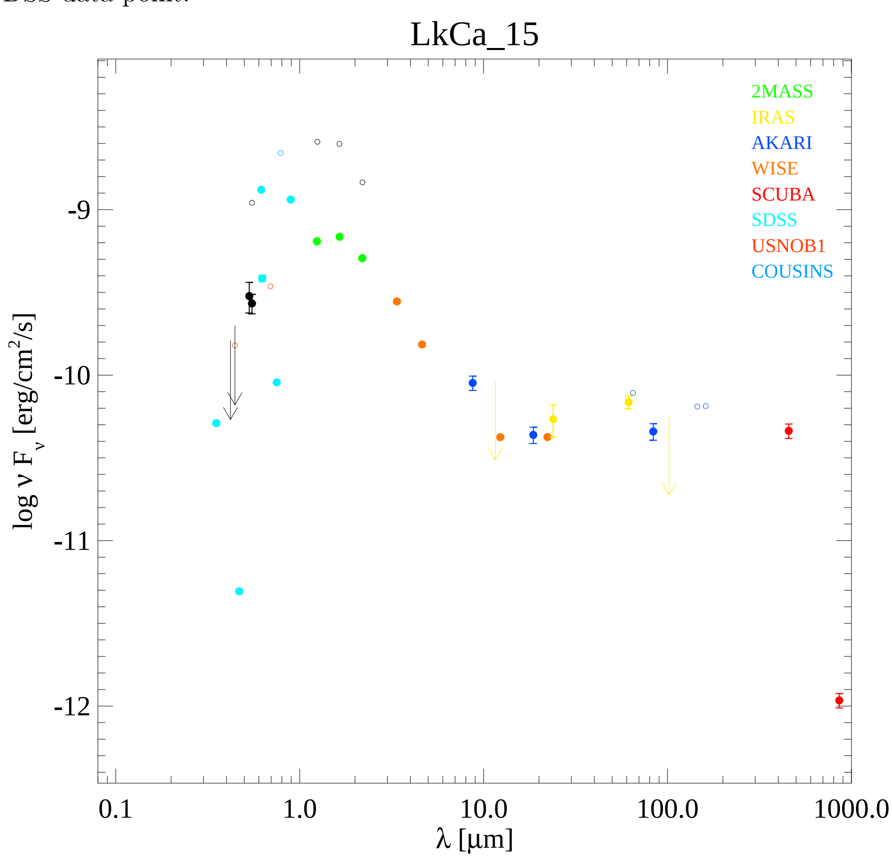

Figure 3: Photometric data for LkCa 15 with many issues. Dodgy points are plotted with open symbols without errorbars, and upper limits are shown as arrows from 3·`sigma` down to 1·`sigma`

1. *“SDSS easily picks up background sources. They are easily detectable though. I will improve on that. I have several sources were I get the SDSS from, and the problem lies always with the same catalog. Perhaps I will remove it.”*

2. *“DENIS data: there should be a ”flag” column in the .phot files. DENIS data for bright (saturated) sources is always unreliable. And I have noticed that it is sometimes unreliable for other sources also. Most of the time, I don’t use DENIS, and 2MASS is very complete anyway.”*

3. *“USNO-B1 data: I only use USNO-B1 when there is absolute nothing else available, and even then I use it with caution. The photometric filters are not well defined, and they are highly variable over the entire survey (or so I read in the paper describing the survey). They claim it is ’approximated’ by the JOHNSON filters, but the error can be as high as 50%, with a 30% error ’more realisic’. Nothing useful, I’d say. A similar remark, though not as severe, can be made for the Hipparcos and Tycho fluxes.”*

4. *“for the IRAS fluxes, upper limits can be given. They are also marked in the ”flag” column (see the Vizier site of the catalog for the meaning of the flags, I can’t remember them by heart)”*

5. *“I’ve also found inconsistencies with the WISE.W2 (and WISE.W3) data points. I should try to derive the zeropoints myself using a large set of sources. I’ve ’hired’ a master student for next academy year to do this kind of work, but perhaps I should get to it sooner.”*

6. *“my zeropoint for the COUSINS filter seem to be off. I got a very recent (2006) filter*

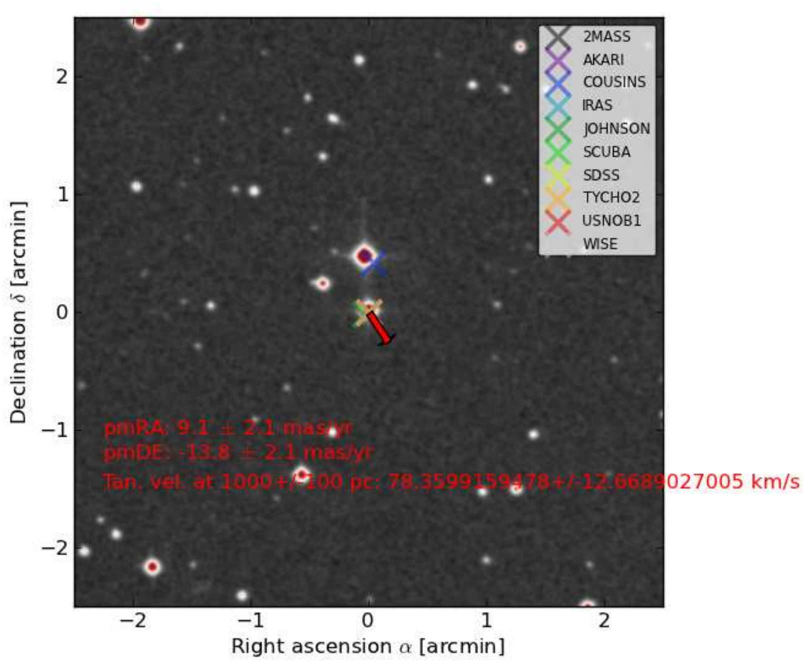

Figure 4: Visualisation of observational offset positions and proper motion for LkCa 15.

transmission profile and zeropoint, but it seems to be wrong. I also should try to derive the zeropoint myself here."

"So the data I gave you is the first extremely raw selection, including everything I could find. I will try to improve on them, and perhaps put them in comprehensive table with unified flags and comments."

Based on this discussion with Pieter, and the study of the 85 SEDs, I flagged possibly dodgy points as `rem=??` in `*.dat` if

- data has comment `source_is_saturated`
- data has comment `unreliable_zeropoint_and_transmission_profile`
- IRAS data has comment `moderate_quality`
- AKARI data has comment `the_source_is_not_confirmed`
- magnitude data is given without error, i.e `e_cmeas = NaN`
- pointing offset is larger than 10 arcsec and $\lambda > 25\,\mu$m

This is the default pre-flagging of the data. For one particular object, you are highly encouraged to study the data and alter these judgements.

5 How to find out more about a specific data point?

- go to `http://vizier.u-strasbg.fr`
- leave "any catalog" in the first box, put the `source`-entry from the `*.phot` file into the 2nd box, for example "`II/306/sdss8`" to search for the SDSS data, and press "search"
- select data set (probably the one with smallest `_r` on "Full", to get the dat of the observatiopn, or the field of view of the instrument, or try "Plot of II/306/sdss8 in this region with Aladin-Java"

The Aladin-tool applied to the LkCa 15, for example, shows 3 different measurements within 1 arcsec with different results ...

6 Missing Data

At the moment we miss the Spitzer photometric data from the IRAC (3.6, 4.5, 5.8, and $8.0\,\mu$m) and MIPS (24, 70, and $160\,\mu$m) instruments. There seems to be no data archive that simply states the point-like photometric fluxes. Instead, you can download maps, and reduce the photometric fluxes yourself.

I have asked Ilaria Pascucci about it, and she advises us to simply look at papers ... *"Most of the IRAC/MIPS photometry on disks I think has been published already, this would make your life much simpler. If you have Taurus and/or Chamaeleon, just search for publications from Luhman, K. et al. and Rebull, L. et al. If you are interested in Lupus, you should* *search for Merin et al. In general, the co called c2d did many star-forming regions, their site is at:* `http://irsa.ipac.caltech.edu/data/SPITZER/C2D/`*. They should have an updated list of sources/publications. For Upper Sco you can look at work from Carpenter et al. For etaCha Aurora Sicilia-Aguilar and so on, I believe most of the photometry is public."*

We are also missing photometric ISO and Herschel data so far.