Calibration instructions

Note 1: By convention the first column in a data file is 'column 0', the second is 'column 1', etc
Note 2: The star name in 'star_data.txt' should appear as it does in the 'filenames.txt' file eg: 'HIP_73765'
Note 3: The scripts used are already on analysis, but they can also be found on github should you need to re-upload them again. An example of '**star_names.txt**' has also been uploaded into the calibration directory with the name '**star_names_example.txt**'

Theory

Currently contrast (or '5sig') is measured as: $5sig(old) = \frac{F_m}{F_{psf}}$
Where F_m is the minimum measureable flux (per unit time) at a particular radial point in an image and F_{psf} is the measured flux of the psf.fits calibration image, which is an image of BD+45_598. However, F_{psf} should actually be F_{star}, the flux of the host star to get the true 5sig contrast. It is possible to get the true 5sig using: $5sig(true) = \frac{F_m}{F_{psf}}\frac{F_{psf}}{F_{star}} = \frac{5sig(old)}{f}$

Where f is **calibration factor 1** and is found using: $f = \frac{F_{star}}{F_{psf}} = 10^{-\frac{m_{star}-m_{psf}}{2.5}}$

Where m_{star} is the apparent magnitude of the star and m_{psf} apparent magnitude of the psf.

This however, is not enough as F_m required a calibration too (**calibration factor 2**): $F_m = \frac{k\,\sigma_R}{T_R}$

Where k is a factor (5 in this case, for 5sig contrast), σ_R is the standard deviation or noise of the flux and T_R is the throughput or signal attenuation (dimensionless). In total:
$5sig(true) = 5sig(old)\frac{1}{f} = \frac{F_m}{F_{psf}}\frac{1}{f} = \frac{k\sigma_R}{T_R F_{psf}}\frac{1}{f}$

σ_R is measured using a parameter Starphot (S):
$S = F_{psf}\tau_{cube}$

Where τ_{cube} is the exposure time of one image in the cube, inserting into5sig: $5sig(true) = \frac{k\sigma_R\tau_{cube}}{T_R S}\frac{1}{f} = \frac{k\Delta C_R}{T_R S}\frac{1}{f}$

Where ΔC_R is the standard deviation of the counts. Starphot should differ for each star (because they have different exposure times), but the RDI script assumed it to be constant with $\tau_{cube} = 5s$. Therefore to actually find S requires an additional correction: $S = S(RDI)\frac{\tau_{cube}}{5}$

Where S(RDI) is the constant value of S used in the script, applying this to the equation for 5sig above (note $\sigma_R(old) = \frac{\Delta C_m}{5}$):
$5sig(true) = \frac{5k\Delta C_R}{T_R S(RDI)\tau_{cube}}\frac{1}{f} = \frac{5k\Delta C_R}{5T_R F_{psf}\tau_{cube}}\frac{1}{f} = \frac{5}{\tau_{cube}f}\frac{k\sigma_R(old)}{T_R F_{psf}} = \frac{5}{\tau_{cube}f}\frac{F_m(old)}{F_{psf}}$

The total required correction (1 and 2) is then:

$$5sig(true) = \frac{5}{\tau_{cube}f}5sig(\text{original})$$

Procedure

1. Access analysis:
   ssh -XY abc123@analysis.astro.ex.ac.uk
   typing in your password when prompted. Navigate to the calibration folder:
   cd ../../data/shinkley/Keck_Data/completed_stars/calibration
2. Produce a file called **star_names.txt** file with four columns:
   star name star epoch K-band abs magnitude psf abs magnitude (always 7.051)
   corresponding to all your champion stars, if the star has more than one epoch, have 2 lines for the different epochs with the same star name. Star name should appear as it does in the 'filenames.txt' file. For GJ4185 this appears just as 'GJ4185', for 'HIP' stars, they have an _
3. You can find the K-band magnitudes for your stars on Simbad. Click on **Vizier,** in 'mission' select **WISE,** click '**Find catalogs**', click '**II/311**'. Create a txt file list of all your champion stars (with or without '_'). Click **List of Targets**, click **choose file** and select the file with the names of your stars. Select **single table.** On **Target dimensions** type **5** and select **arcsec.** On the left, change **HTML table** to **tab separated variables** and change **50** above that to **100**. For the constraints, de-select all and only select **Kmag.** Click **submit.** A file of the magnitudes will be produced that can be inserted into star_names.txt.
4. Run **cpm1.py** using:
   python cpm1.py
   It will produce a file: **star_data.txt** containing 3 columns of (f being calibration factor 1):
   Star name star epoch f
   eg: HIP_59608 2011feb06 12.37086307
5. Run the script **cpm2.py:**
   python cpm2.py
   The script will find the value of correction 2 for each epoch of each star and combine with correction 1 to get the total calibration required. It will output this in a file called: **stars_calibration.txt**, which contains 3 columns of:
   Star name star epoch calibration
6. Run the script **cal3.py:**
   python cal3.py
   This will apply the calibration to all the contrast curve txt files (RDI, ADI etc.) regardless of percentages and will create new txt files in each RDI directory for each star with the same name as the previous files but beginning with '**calibrated**' and missing the word '**curve**'
7. It will also produce a new plot for all the txt files with the same name, but beginning with '**calibrated**' and ending in '**.png**' rather than '**.txt**'
8. These new files can be downloaded from analysis; navigate (not on analysis) to the directory where you want the new files to be and use:
   scp abc123@analysis.astro.ex.ac.uk:/data/shinkley/Keck_Data/completed_stars/DangerZone/HIP***/RDI/{filename}.png .**
   The decimal ('.') is needed. Type in your password when prompted.