A Recalibration of the IRTF Bolometry

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1 introduction

In February/March 1992 M. Jourdain de Muizon and M.F. Kessler took N, 8.7 9.8 12.5 and Q bolometry of 23 stars on the IRTF (Hawaii). Subsequently this data was reduced by P. Bouchet and is presented in the original flux table. However, it was not clear on what the fluxes were based; ie wavelength, zero point and absolute calibration. Therefore I have attempted to recalibrate the photometry using the model SED's derived as part of the calibration programme. Further, as this is possible the most consistent 8 to 20 μm data set available it provides possibly the best test to date for the validity of the approach adopted for the ISO calibration.

The aim of this report is to explain how I have attempted to re-calibrate the IRTF data and what are the implications of the result to the ISO calibration programme. For the purpose of this report, and in order to be consistent with the original flux table, the 8.6 μm filter will be called N1, the 9.8 μm filter N2 and the 12.5 μm filter N3. These should not be confused with the ESO narrow band N filters as they are not the same.

2 Calculating the 'System Constant'

The requirements before proceeding are

- the table of fluxes produced by Patrice. I have then assumed that the fluxes are proportional to signal.
- The filter profiles.
- The atmospheric transmission above Mauna Kea.
- The detector response (not that important).
- The predicted SEDs for the stars
- the absolute photospheric Vega model

First the effective system response is calculated by multiplying the filter profiles, the atmospheric transmission and the detector response. Each SED is then multiplied by the system response function to calculate the in band flux for that filter, which is then divided by the in band flux from Vega and converted to a magnitude. This is the prediced magnitude, with the zero point being Vega.

In principle the system constant (SC) for each filter is then

$$SC = \frac{\sum pm_n + 2.5\log(flux_n)}{n} \tag{1}$$

Where
pm_n is the predicted flux for star n
$flux_n$ is the measured flux given in original flux table.

Figure 1 shows $pm_n + 2.5log(flux_n)$ against temperature for every measurement in the 5 filters. As can be seen whilst in general the scatter is small there are a few problems.

2.1 The SiO

The Kurucz model grids, which were used for constructing the SED's, do not contain the SiO absorption bands. These effect the region between about 7 and 11 microns (See the templates of M Cohen). These will badly effect the N1 and N filters and to a lesser extent the N2 and even N3 (although by this point it should be negligible). As can be seen in Figure 1 the SiO shows up very clearly. Fortunately, though, the SiO disappears hotter than about 4500 K. Therefore in order to get the system constant for N and N1 I have only used stars hotter than 4500K. For the other filters the effect is nowhere near as significant so I have used all of the sources.

2.2 Bad Points

There are a few odd bad points and these are normally very obvious so I have just deleted them. However, there are a couple of anomalies which are slightly strange.

In the Q filter there are a group of points with a system constant near 2.55, well away from the rest of the group. It turns out these are all of the points that were taken on the 26th Feb, except one. The exception was was a HR5340 point which I guess was used to calibrate the day. I have deleted HR5340 point and pulled the other down by 0.195 mags, which solves the problem.

In the N3 filter there are 7 points which are near 3.07. For two of them the star was remeasured and the value was the expected one. The other five were only measured once. The points come from different days but are close enough in value to be worrying. My guess is that on occasion the filter was not being place properly, but really I have no idea. As none of these points belong to HR5340 or HR1457 which were the main calibration sources, and as the magnitudes for these stars in the other filters are as expected, I have deleted the bad points from the N3 filter.

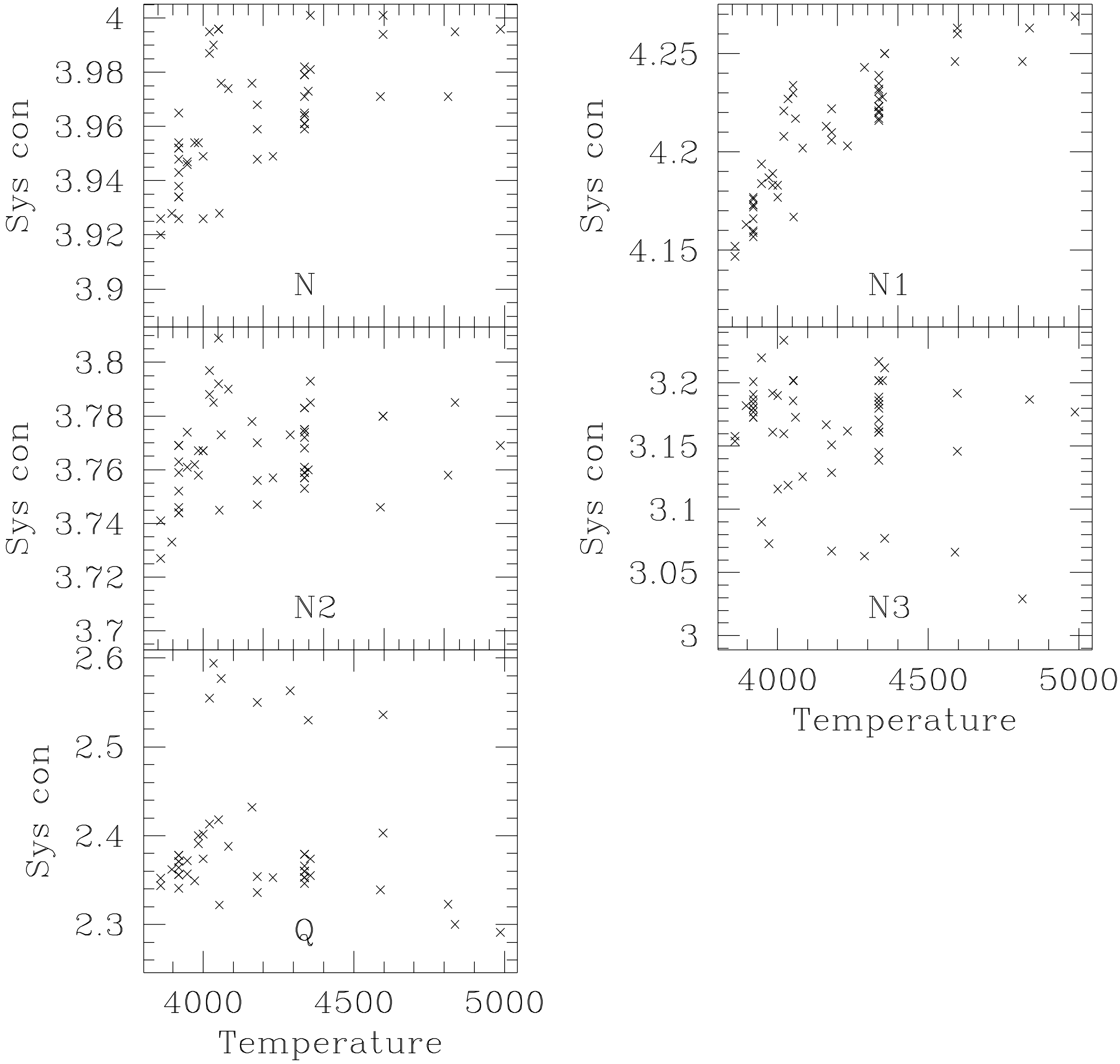

Figure 1: *The system constants in the 5 filters*

3 The Final Magnitudes

The magnitude (m) for each observation is calculated in the normal way ie:

$$m = SC_f - 2.5\log(flux) \tag{2}$$

When there are multiple observations of a star these have been averaged using a weighted mean. The error is then the standard error from the individual measurements. When there is only one measurement the error is that quoted in the original table.

4 Discussion

In the following figures are shown the difference between the predicted and measured magnitudes.

- The crosses show the difference between the model SED (extracted by me) predicted magnitudes and the measured magnitudes. However the three main calibration stars have been marked differently HR5340 is a solid triangle, HR1457 is a solid square and BS6705 is a solid hexagon.
- There are 6 stars in the list which are templated by Martin Cohen. I have generated predicted magnitudes in exactly the same way as for the the model SED's. The difference between the template predicted magnitudes and measured magnitudes are shown as open circles.
- In order to give an idea as to the stated errors (possibly underestimated when there is only one measurement) the error bars given in the magnitude file have been drawn around the difference between the model predicted magnitudes and the measured magnitudes (ie the crosses and solid shapes)

N is shown in In Figure 2 . The SiO shows clearly in the cool stars producing an 6 to 7% error for the coolest stars. If only the stars hotter than 4300K are considered the rms scatter is 0.013 mags.

N1 is shown in figure 3. This is at 8.6 micron so hits the deepest part of the SiO band heads. The models are some 12% off for the coolest stars.

N2 is shown in figure 4. 9.8 microns is still in the SiO but they are weaker and the maximum effect is of the order of 3%. Even using all of the stars and ignoring the effect of the SiO bands, the rms scatter in the difference is 0.018 mags. Clearly if the SiO were to be taken into account this scatter would be reduced.

N3 is shown in figure 5. This has had the 5 bad points removed. The rms scatter is 0.023 mags

Q is shown in Figure 6. It has had the mags for Feb 26th corrected. The rms scatter is 0.034 mags

Although there are only six stars with templates they do cover a wide temperature range. It is noticeable that the difference between the template magnitudes and the measured magnitudes shows little if any relationship with temperature, even in the N1 filter. It is also noticeable that the once the SiO is allowed for the template and the models are giving more or less the same flux levels. The only filter in which there is a significant difference is the N2 where the templates would put the zero point 2

5 Conclusions

I have attempted to re calibrate the IRTF bolometry using the model templates. Comparing the results that what would be achieved using templates suggests that the zero points are good to about 0.01 magnitude (with the possible exception of the N2 filter where the templates are lower.)

The actual scatter between the predicted and measured magnitudes is very low which indicates that the model SED's are getting the continuum fluxes correct and the templates are getting the actual fluxes correct at the 2% level over this wavelength range. The big problem that remains to be solved in this wavelnegth range is the lack of SiO in the models. The resultant error could be 12% or more for the coolest stars.

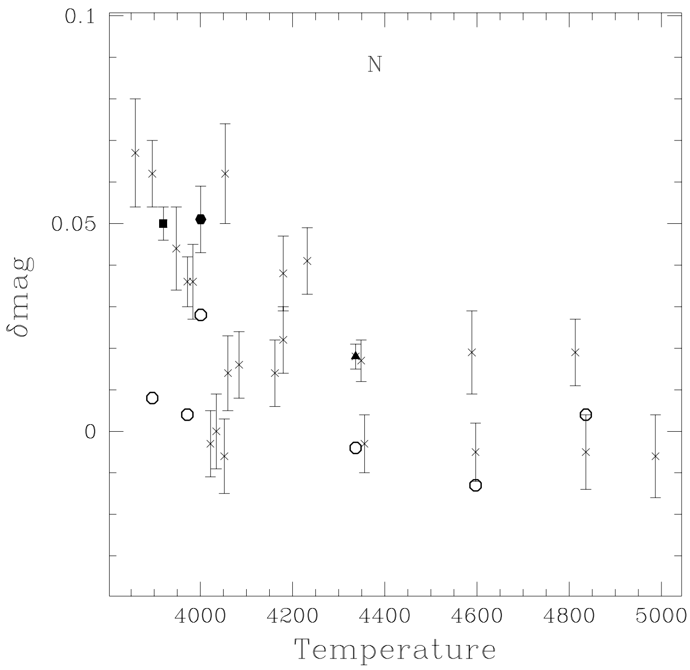

Figure 2: *The Magnitude difference in N*

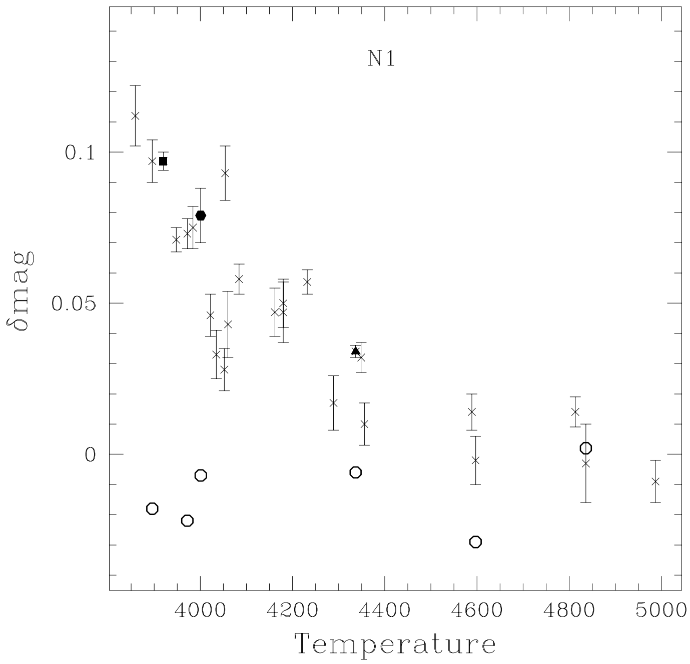

Figure 3: *The Magnitude difference in N1*

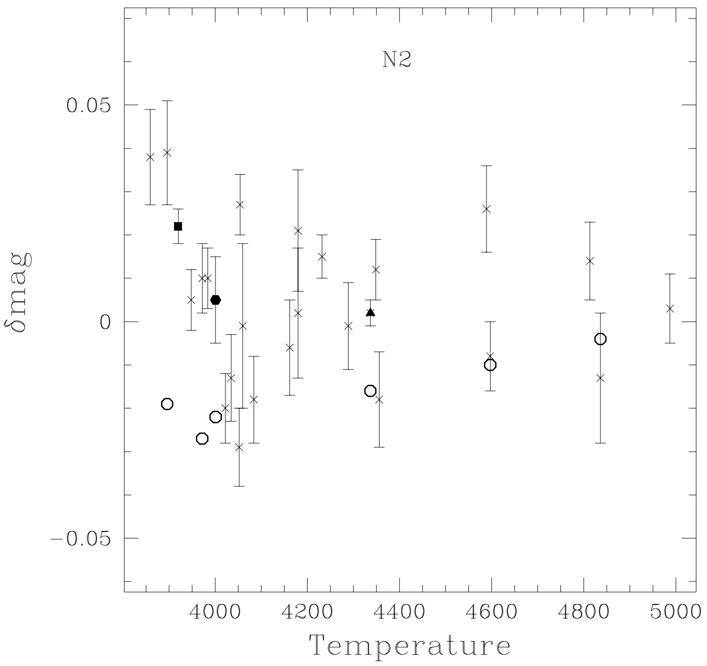

Figure 4: *The Magnitude difference in N2*

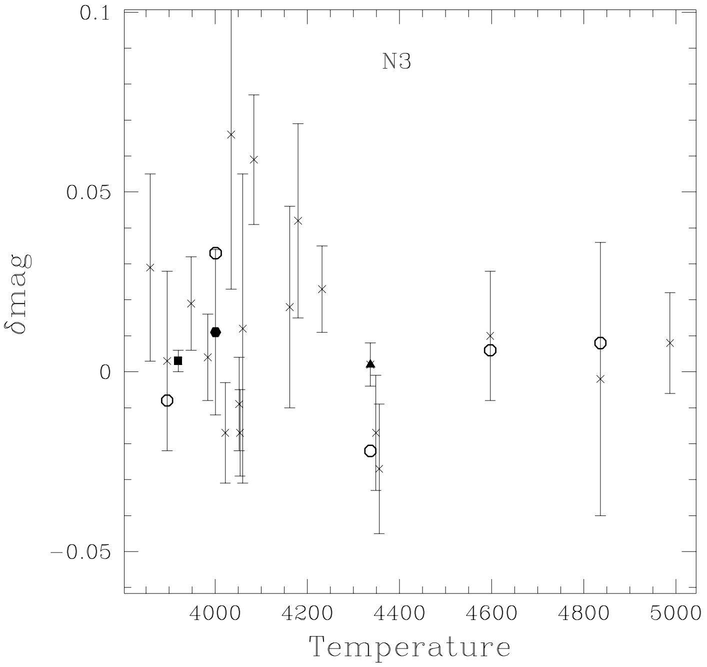

Figure 5: *The Magnitude difference in N3*

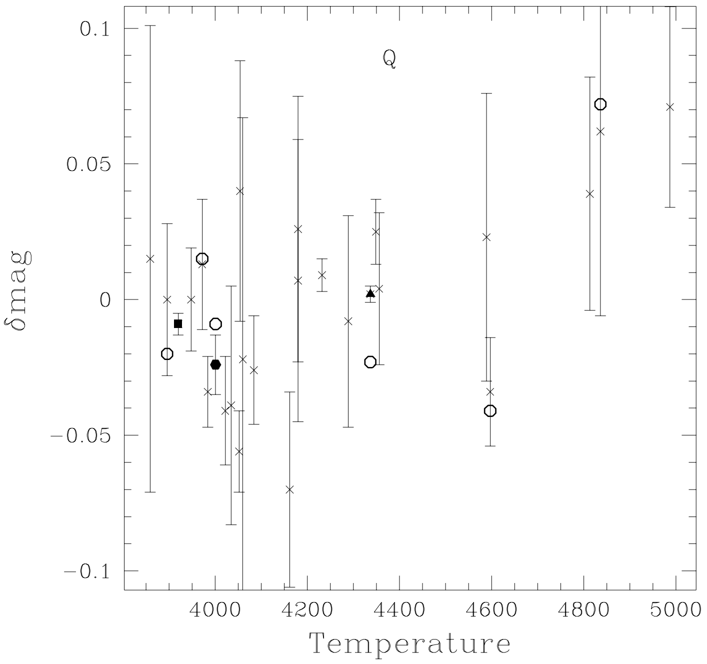

Figure 6: *The Magnitude difference in Q*