Introduction

In section 3.2 of Dunham *et. al.* (2008), we obtained a crucial wavelength for measuring internal luminosity, L_{int}, of embedded, low-luminosity protostars, allowing astronomers to circumvent the traditional multi-wavelength observations typically required for studies of these objects. Specifically, Dunham *et. al.* discovered that the flux values at 70 microns, F_{70}, were tightly correlated with L_{int} when simulating embedded, low-luminosity systems using radiative transfer models. A linear fit at that wavelength subsequently yielded coefficients of $m = 1.06$ and $b = -9.02$.

However, the motivation behind this project stems from the observation that the correlation was only derived for protostars whose envelopes' variable masses were between 1-10 solar masses, implying that the study failed to consider protostars whose cores contained less than 1 solar mass. In other words, it was only tested for younger protostars whose mass distributions were still heavily centered around their surrounding envelopes (so-called class 0 objects). To add insult to injury, astronomers have been widely misusing the original 70 micron correlation by frequently applying it to non-class 0 protostars, and in doing so, implicitly introducing an error factor into their calculations that has gone largely unnoticed.

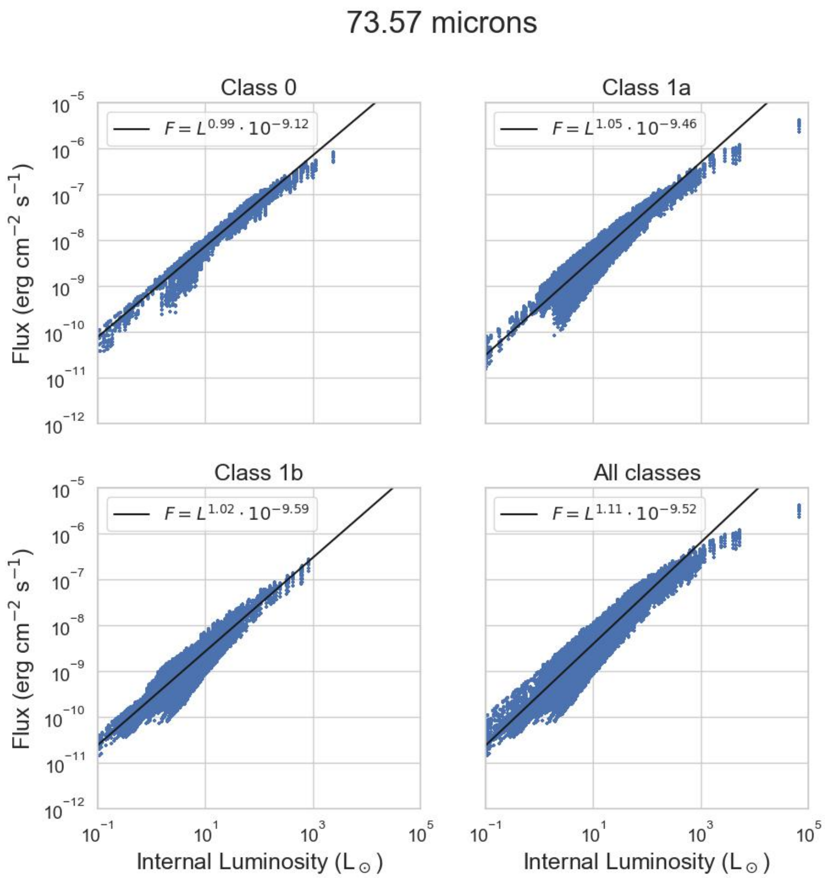
With that in mind, the goals of this project are threefold; by repeating the derivations performed by Dunham *et. al.*, this time considerably extending our considerations, we aim to: 1. Determine if the original 70 micron correlation still holds for older protostellar systems (so-called class 1a and 1b objects). 2. Compute a correction factor for studies that misused the Dunham *et. al.* (2008) result. 3. Provide a suite of observing windows (in wavelength space) where F and L_{int} remain sufficiently correlated, rather than a singular entry point.

**for clarity, we'll refer to the original fit as* `dfit` *(a.k.a. Dunham's fit), and the updated fit as* `yfit` *(a.k.a. Yek's fit).*

Results

Upon inspection of the available data closest to 70 microns, we notice a strong positive correlation between F and L_{int} for class 0 targets. This is supported by a correlation coefficient of `0.98`, and is consistent with the findings of Dunham *et. al.* (2008).

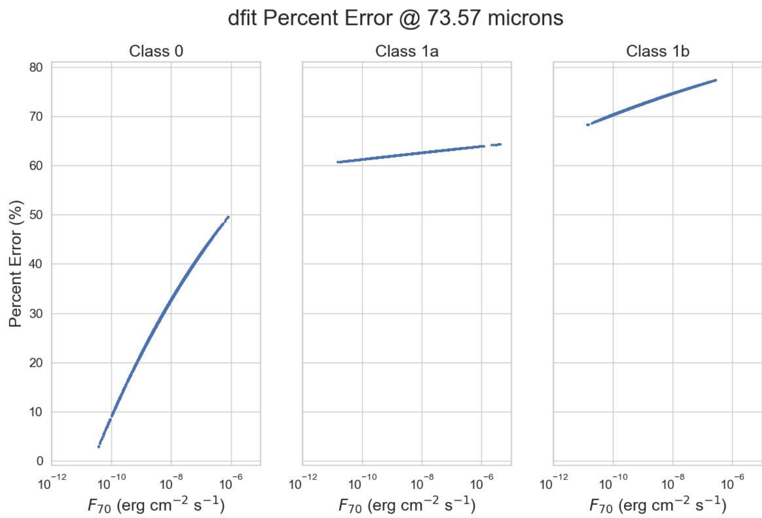
Intriguingly, while slightly weaker for class 1a and 1b objects, this correlation appears to hold firm, yielding near identical correlation coefficients of `0.95`. A combined analysis of the data at all 3 classes also yields a correlation coefficient of `0.95`.



Next, we compute the percent error introduced by using `dfit` as opposed to `yfit` as

$$\text{Percent Error} = \frac{|L_{\text{yfit}} - L_{\text{dfit}}|}{L_{\text{yfit}}} \times 100$$

We find that for class 0 objects, `dfit` underpredicts by roughly `2% - 50%`; roughly `60% - 65%` for class 1a objects; roughly `68% - 78%` for class 1b objects. In other words, the higher the expected flux, and the older the protostellar object, the larger the percent error in predicted luminosity introduced from `dfit`.

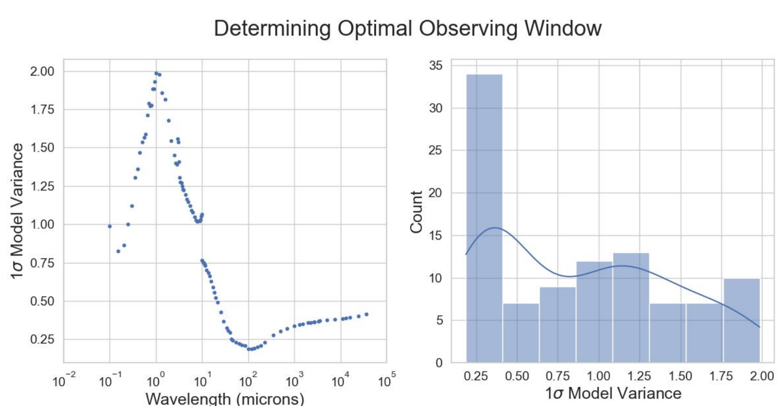


Finally, we expand our considerations to all available wavelengths by setting an upper-threshold value for the 1 σ standard deviation of model variances V, which is defined as

$$V = \log_{10}(L_{\text{pred}}) - \log_{10}(L) = \log_{10}\left(\frac{L_{\text{pred}}}{L}\right)$$

where L_{pred} denotes the predicted luminosity, and L the actual luminosity.

We find that for a somewhat arbitrary threshold of `0.333`, we obtain an optimal wavelength range between 10^1 and 10^2 microns. In other words, any measurement of internal luminosity for embedded, low-luminosity targets can be performed within this range with a high-degree of confidence (and correspondingly low-degree of uncertainty), using the appropriate linear fit provided by `yfit`. Naturally, more generous thresholds yield larger wavelength ranges, and vice versa.



Conclusion

1. Determine if the original 70 micron correlation still holds for older protostellar systems (so-called class 1a and 1b objects).
    - Yes, though the correlation is *slightly* weaker w.r.t. class 0
2. Compute a correction factor for studies that misused the Dunham *et. al.* (2008) result.
    - `2% - 78%` percent error, depending on the input flux and protostellar age
3. Provide a suite of observing windows (in wavelength space) where F and L_{int} remain sufficiently correlated, rather than a singular entry point.
    - Between 10^1 and 10^2 microns

**relevant analyses alongside detailed documentation can be found in* `src/`*; higher resolution images can be found in* `fig/`*; raw data available upon request.*