de Alburquerque 2020 Annotated Bibliography – William Balmer "Accretion in low-mass members of the Orion Nebula Cluster with young transition disks"

Goals

- What is your purpose in reading this paper? Based on the title, what might you be able to learn from it and how might that knowledge help you with your project?
  Answer: This is a recent publication that measures accretion in low mass objects; our measurements of Ha are an attempt to measure a proxy of accretion in our low mass targets. Hopefully there is some important context and new implications for low mass variability measurements to be gained by reading this paper.

- Do you have any specific questions you want to answer?
  For example: "I want to know if M-dwarfs and brown dwarfs form in different ways", or "I want to understand whether the observations in this paper are similar to what I'm doing".
  Answer: How is the Orion Nebula Cluster different from the Taurus star forming region? What methods do they use to measure accretion in this paper?

Abstract/Summary

The abstract will usually provide complete clarification of the title, and describe the essence of this study.

- What new questions does the abstract pose to you, if any?
  Answer: What is "broadband spectra" and how can it be used to measure accretion?

Introduction

Read through the introduction, then answer the following. It should outline what work has been done prior to this paper to set the stage/answer big outstanding questions in the field.

- What is the overall importance of this research?
  Answer: the ONC is a young ~2.2 Myr old massive starforming region that is part of a larger molecular cloud. The ongoing investigation into accretion in low mass YSOs makes the ONC a target for observation, but so far the very low mass objects in the cluster haven't been studied in detail because they are very faint

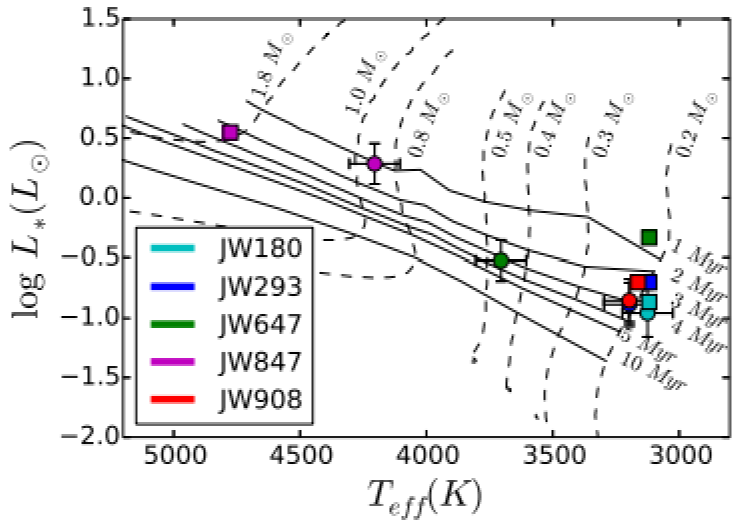
- What are the authors doing in this paper?
  Answer: Sampling, observing and then characterizing accretion in very low mass cluster members.

Figures, Graphs and Tables

Read through all of the figures/graphs/tables and their captions before reading the rest of the paper. Try to get as much information out of them as possible. Then return to them again once you start reading through the paper.

After reading abstract, intro and methods, but *before* reading results and discussion:

Identify and include the **three** most important/useful figures or tables from the paper below (i.e. your highlight reel). For each figure, answer the following:



- Figure 3
  - Describe: What is being shown in this figure?
    - This is an HR diagram that shows the 5 targets in the sample (previous observations in squares, current as dots), as well as evolutionary tracks and isochrones.
  - How are these measurements made? (it may be helpful to paste in the description from the methods)
    - These measurements were made by fitting model or characteristic spectra to the observed spectra and adopting the temperature and luminosities associated with those spectra's spectral type
  - What conclusions can you draw from this data?
    - These objects are low mass, have some scatter in their ages, and their current observations disagree with previous observations
  - How does this data contribute to the argument the authors are making?
    - It proves that their targets are indeed very low mass and late spectral types, according to spectral fits
  - What questions does this data raise for you?
    - What is to blame for the scatter in ages; is that a natural process or some instrumental effect?

Line	λ (nm)	JW180		JW293		JW647		JW908
		$f_{\rm line}$	$\dot{M}_{\rm acc}$	$f_{\rm line}$	$\dot{M}_{\rm acc}$	$f_{\rm line}$	$\dot{M}_{\rm acc}$	$f_{\rm line}$
H10	379.8	2.39(±0.40)e-16	-10.1±0.2	1.70(±0.26)e-16	-10.2±0.1	4.94(±0.20)e-15	-8.8±0.1*	1.68(±0.47)e-16
H9	383.5	2.71(±0.33)e-16	-10.2±0.2	1.70(±0.12)e-16	-10.3±0.1	5.94(±0.38)e-15	-8.8±0.1*	2.11(±0.36)e-16
H8	388.9	3.75(±1.04)e-16	-10.2±0.2	2.80(±0.23)e-16	-10.2±0.1	7.63(±0.37)e-15	-8.8±0.1*	2.30(±0.22)e-16
Ca II (K)	393.4	8.74(±0.13)e-16	-9.8±0.2	7.59(±0.12)e-16	-9.8±0.1	3.83(±0.33)e-15	-9.2±0.1*	9.37(±0.22)e-16
Ca II (H)	396.8	7.27(±0.09)e-16	-9.9±0.2	7.02(±0.07)e-16	-9.9±0.1	5.99(±0.19)e-15	-9.0±0.1	7.84(±0.48)e-16
H7 (Hϵ)	397.0	3.64(±0.16)e-16	-10.3±0.2	2.44(±0.06)e-16	-10.4±0.1	5.89(±0.93)e-15	-8.9±0.1*	2.46(±0.13)e-16
He I	402.6	...	...	...	...	7.65(±0.17)e-16	-8.8±0.1	...
H6 (Hδ)	410.2	3.92(±0.23)e-16	-10.3±0.2	4.69(±0.40)e-16	-10.2±0.1	1.21(±0.07)e-14	-8.7±0.1*	3.17(±0.25)e-16
H5 (Hγ)	434.0	6.02(±0.49)e-16	-10.3±0.2	6.15(±0.85)e-16	-10.2±0.1	1.46(±0.05)e-14	-8.7±0.1*	5.13(±0.62)e-16
He I	447.1	...	...	...	...	1.29(±0.10)e-15	-8.7±0.1	...
H4 (Hβ)	486.1	1.18(±0.05)e-15	-10.3±0.2	1.45(±0.08)e-15	-10.1±0.1	1.85(±0.12)e-14	-8.9±0.1*	1.09(±0.07)e-15
He I	587.6	1.65(±0.20)e-16	-10.2±0.2	1.97(±0.31)e-16	-10.0±0.1	3.75(±0.63)e-15	-8.6±0.1	1.43(±0.40)e-16
He I	667.8	...	...	...	...	1.15(±0.12)e-15	-8.7±0.1	...
He I	706.5	...	...	...	...	8.43(±0.96)e-15	-8.7±0.1	...
Pa7 (Paδ)	1004.9	...	...	...	...	7.46(±1.87)e-15	-8.6±0.2	...
Pa6 (Paγ)	1093.8	...	...	...	...	1.21(±0.23)e-14	-8.5±0.1	...
Pa5 (Paβ)	1281.8	...	...	...	...	8.27(±1.27)e-15	-8.9±0.1	...
Br7 (Brγ)	2166.1	...	...	...	...	3.05(±0.12)e-15	-8.7±0.1	...
Mean			-10.1		-10.1		-8.7	

- Table 6
  - Describe: What is being shown in this figure?
    - This is a table of fluxes and calculated mass accretion rates for each observed accretion tracer in the spectra taken of each sample object. At the bottom the mean of the accretion rates is shown for each accreting object
  - How are these measurements made? (it may be helpful to paste in the description from the methods)
    - They converted line flux to accretion luminosity via equation 3, and then accretion luminosity to mass accretion rate via equation 4

In a first step, we measured the line fluxes of all the previous lines, and we converted them to line luminosities by assuming the stellar distances listed in Table 1. The accretion luminosity was estimated through the empirical relation

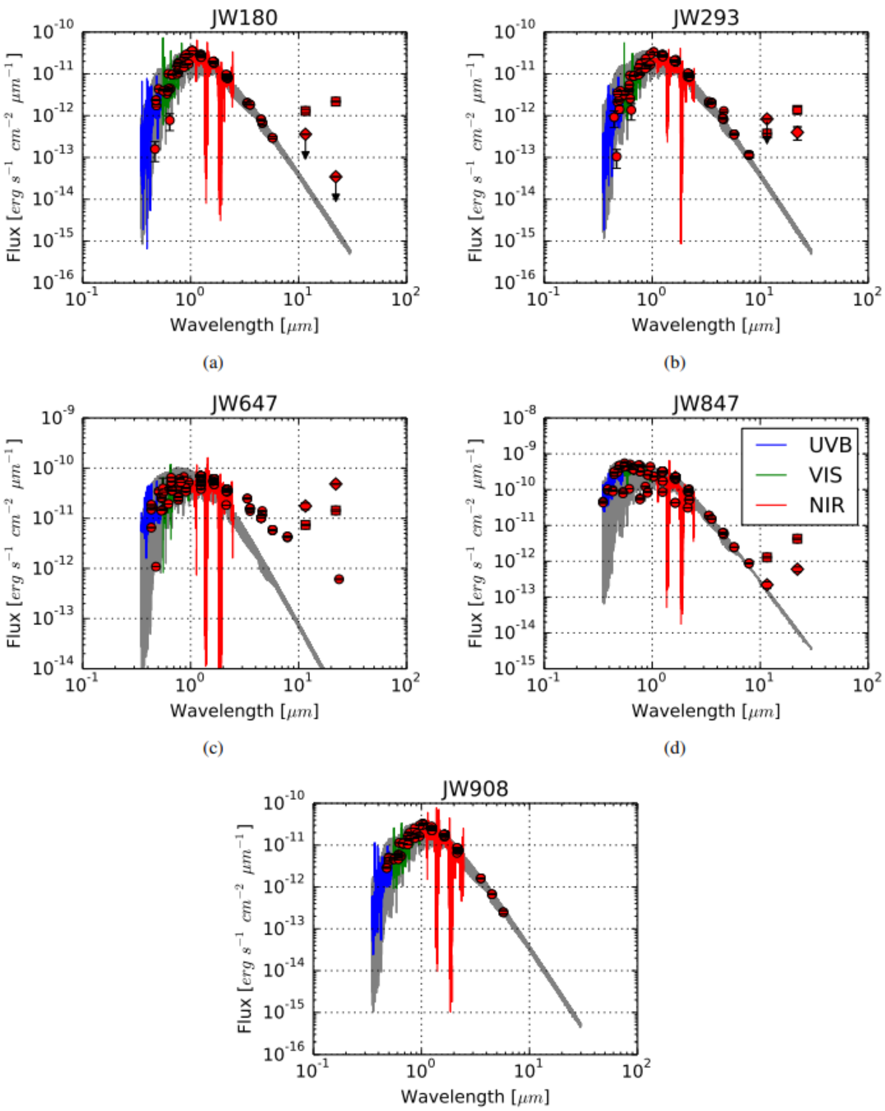
$$\log(L_{\rm acc}/L_\odot) = a \log(L_{\rm line}/L_\odot) + b\,, \quad (3)$$

with the coefficients a and b from Alcalá et al. (2014). From the accretion luminosities, we can now derive the mass accretion rates with the following equation:

$$M_{\rm acc} = \left(1 - \frac{R_*}{R_{\rm in}}\right)^{-1} \frac{L_{\rm acc} R_*}{G M_*} \approx 1.25 \frac{L_{\rm acc} R_*}{G M_*}\,, \quad (4)$$

where $R_{\rm in}$ is the star's inner-disk radius, which corresponds to the truncation radius of the disk. Like in Gullbring et al. (1998) and Alcalá et al. (2014), we assume $R_{\rm in} = 5R_*$. The measured $\dot{M}_{\rm acc}$ for the different lines are listed in Table 6. Since the emis-

  - What conclusions can you draw from this data?
    - The larger object JW647 has an accretion rate that's more than an order of magnitude larger than the two VLM accretors, who have essentially the same accretion rate (which makes sense because they are the same spectral type so likely very similar in mass)
  - How does this data contribute to the argument the authors are making?
    - It shows they've found accretion in 3 of their sampled objects
  - What questions does this data raise for you?
    - Why do some of the objects not have line fluxes for some of the tracers (like the Pa lines)?



- Figure 6
  - Describe: What is being shown in this figure?
    - The SED for each object, a grey model spectra, and available vizier spectra as red dots
  - How are these measurements made? (it may be helpful to paste in the description from the methods)
    - Spectra in color were taken on the X-shooter instrument, the rest are literature measurements
  - What conclusions can you draw from this data?
    - It looks like four of the five targets in the sample have NIR excess that could indicate they host circumstellar disks.
  - How does this data contribute to the argument the authors are making?
    - It makes sense that they observed accretion in these objects if they have circumstellar disks to accrete from
  - What questions does this data raise for you?
    - Why are there targets with disks but no accretion?

After reading results and discussion:

- Describe any additions/corrections/new insights/questions based on reading the author's interpretations of the figures.
  For example: "The color-magnitude diagram in Figure 2 actually showed two populations of stars, not just one, and was meant to show trends in evolution. I want to know why the populations look different even though they're the same age."
  Answer: apparently these objects don't meet the accretion criterion of previous studies they are obviously still accreting, implying VLM objects necessitate a new accretion threshold

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Body of the paper: Results & Discussion

Now it is time to read through the entire paper.

From your reading of the Results & Discussion sections, try to answer **at least three** of the questions that you came up with from reading the title, abstract and figures. Do not get bogged down in the details of the procedure or analysis sections. Read for broad concepts that will allow you to understand the figures.

- Question 1: What is "broadband spectra"?
  Answer: This means that the X-shooter instrument can take spectra across long stretches of wavelength space. Instead of just measuring a small part of wavelength space around some important line profile, the instrument takes a measurement of all the UV, or optical, or NIR light that encounters the instrument.

- Question 2: How can broadband spectra be used to measure accretion?
  Answer: Broadband spectra has the benefit of including lots of different emission lines (see table 6) so many different somewhat independent measurements of accretion can be made and compared in order to more accurately determine the true accretion rate

- Question 3: How does the ONC compare to the Taurus starforming region?
  Answer: The ONC has an average age of 2.2 Myr, but includes low mass accreting objects that host circumstellar disks that are very comparable to those in Taurus, which seems to be on average younger (~1Myr)

Take-home for you

- Briefly summarize what from this paper is relevant to your project.
  For example: "Good introduction that explains...", "Table 2 has the collection of data for

related types of stars", "Interesting examples of young stellar object lightcurves", etc.
Summary: A good illustration of the process of determining mass accretion rates through line measurements, and an example that these measurements can still be made for very low mass objects.

- List questions to follow up that are relevant to your project.
  Answer: how does the class or structure of a circumstellar disk affect its accretion rate?

- List methods/techniques that may be of use to you.
  Answer: not applicable

- List any references that you want to follow up.
  Answer: White & Basri 2003, Biazzo et al. 2009

*Adapted from templates used in the Jaswal and Follette Labs, Amherst College.