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# A survey on the spectrum of 23 Non-YSO (Young Stellar Objects) emission sources in the Orion Nebula Cluster

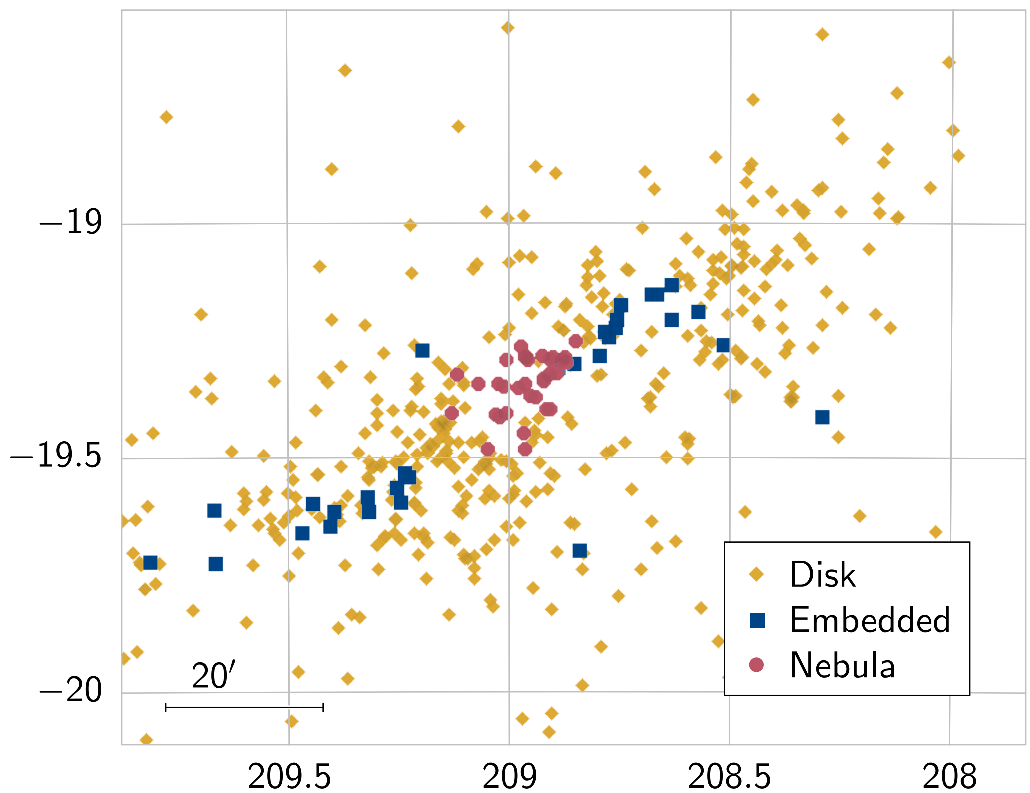


Figure 1: Disk, embedded, and nebula sources in the orion nebula region (adpated from Kounkel et al, 2023)

**Scientific Justification** *Be sure to include overall significance to astronomy. For standard proposals limit text to one page with figures, captions and references on no more than two additional pages.*

Orion Nebula Cluster, known for its rich population of Young Stellar Objects (YSOs), presents a unique opportunity to study star formation processes. This region's diverse star-forming environments make it ideal for analyzing the spectra of Class I and II YSOs, which are known for their stellar disks and accretion processes. We have already been able to do a low resolution spectra survey to separate the disk sources and other sources in that region (Kounkel et al, 2023). During this survey, it has been found that some of the sources in that region shows emission spectrum but are not YSO candidate. The true nature of their disk is still unknown bacause of previous low spectrum survey. The objective of this study is to understand these accretion processes of these sources better by calculating the veiling of spectra (like Gregory et al, 2023).

**Veiling:** Veiling is the ratio of accretion flux to photospheric flux at a given wavelength which provides insights into the strength of accretion disks.

So, if veiling is $r_\lambda$, accretion fluf is $F_{acc,\lambda}$ and photospheric flux is $F_{phot,\lambda}$,

$$r_\lambda = F_{\mathrm{acc},\lambda}/F_{\mathrm{phot},\lambda}$$

By comparing observed spectra to established models, we aim to derive the accurate veiling of the sources which will help us classify the strength and nature of the accretion disk. The strength and nature of these accretion disk will lead us to further conclusion on how we can compare them with Young Stellar Object (YSO) emission.

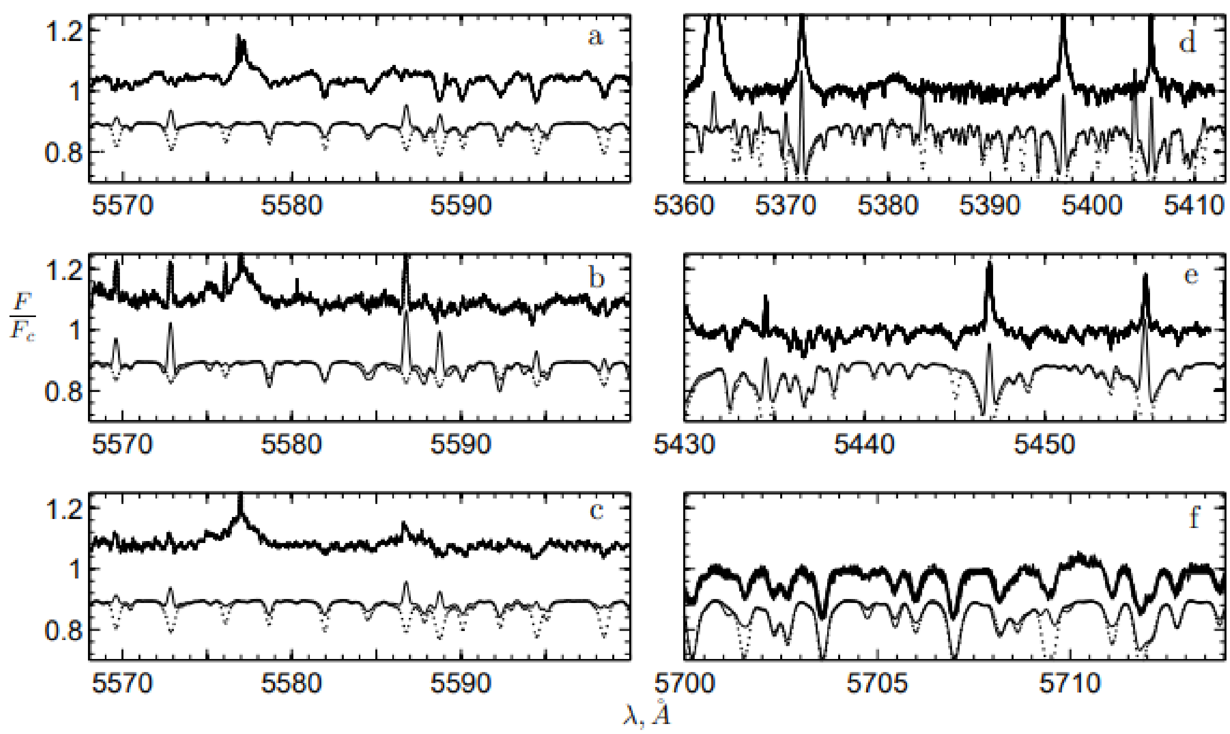


Figure 2: Calculated and observed spectra of heavily veiled six different sources (adapted from Dodin et al, 2012). The thick curve indicates the observed spectrum, while the thin solid line indicates the spectra of the models from the table. The dotted line indicates the spectra of the same models calculated by disregarding the emission in lines.

**References**

Dodin, A. V., & Lamzin, S. A. 2012, Astronomy Letters, 38, 649.

Gregory J. Herczeg et al 2023 ApJ 956 102.

Kounkel, M., Zari, E., Covey, K., et al. 2023b, ApJS, 266, 10.

Kwan, J., & Fischer, W. 2011, MNRAS, 411, 2383.

**Experimental Design** *Describe your overall observational program. How will these observations contribute toward the accomplishment of the goals outlined in the science justification?*

We have a target of 23 sources - all in the Orion nebula region that were found to be emission sources but non-yso candidates (Kounkel etal. 2023). We are planning to get high resolution spectrum of these sources so that we can calculate veiling and other properties of these sources to compare them with YSO candidate. We are planning to use IGRINS-2, available at both Gemini North and Gemini South, for its capability in this spectral range and resolution. We are also planning to target for a 10 $\sim$ 15 magnitude limit as that will give us the best YSO spectrum considering lower exposure time based on the region (Orion nebula) that we are targeting for.

The H-band (1.49-1.80 micrometers) and K-band (1.96-2.46 micrometers) wavelength range of IGRINS-2 are ideal for studying YSOs. These bands are less affected by interstellar dust extinction, allowing us to observe regions obscured in optical wavelengths. These bands also include key spectral lines and features relevant to YSOs, such as molecular hydrogen emission, CO overtone bands, and Brackett series lines, which are essential for studying accretion processes, disk properties, and outflows.

A high spectral resolution like IGRINS 2 ($R \approx 4000$) will enable us to resolve fine spectral details, crucial for accurately measuring line profiles, velocities, and widths. This can provide insights into the kinematics of accretion disks and outflows. High resolution will also help in calculating the most accurate veiling which is vital for studying the environments around YSOs.

Also, the adequate spectral sampling in IGRINS-2 ensure that each spectral feature is well-represented across several pixels, enhancing the quality of the spectral data and allowing for precise measurements.

The Gemini telescopes' locations are advantageous for observing Orion, given the position of Orion near the celestial equator. This setup will allow a detailed spectral analysis of the YSOs, enhancing our understanding of their accretion processes and disk properties.

**Technical Justification** *Describe the observations to be made during this observing run. Justify the specific telescope, the exposure times, and the constraints requested (seeing, cloud cover, sky brightness, and, if appropriate, water vapor). If applying for instruments on both Gemini North and South, state the time request for each site. If a Band 3 allocation is acceptable, give the Band 3 time requested from each partner.*

The technical approach draws inspiration from high-resolution studies focusing on a specific region. IGRINS-2, with its high spectral resolution, is ideal for this study. The target YSOs are within the magnitude range suitable for IGRINS-2, with coordinates based on (Kounkel et al., 2023). The coordinate that we are targeting for all 23 sources is given in Table 1. The exposure time will be calculated to achieve an optimal signal-to-noise ratio, allowing for precise veiling measurements.

| No. | RA (J2000) | DEC (J2000) |
|---|---|---|
| 1 | 81.67344 | -0.68123 |
| 2 | 82.83596 | -0.82218 |
| 3 | 83.0266 | -1.18337 |
| 4 | 83.46863 | -1.2674 |
| 5 | 83.74821 | -0.31663 |
| 6 | 82.74104 | -0.67716 |
| 7 | 83.3738 | -1.17832 |
| 8 | 84.31109 | -1.03071 |
| 9 | 82.30297 | -0.17189 |
| 10 | 82.63803 | -2.35194 |
| 11 | 80.48922 | 0.19505 |
| 12 | 82.69984 | -1.45327 |
| 13 | 83.29713 | -0.62808 |
| 14 | 83.25821 | -0.34984 |
| 15 | 81.12437 | 0.39607 |
| 16 | 81.2036 | 0.53855 |
| 17 | 83.60988 | -0.56424 |
| 18 | 82.52106 | -2.25645 |
| 19 | 81.43542 | -1.32287 |
| 20 | 82.33883 | -0.47665 |
| 21 | 82.50549 | -0.34623 |
| 22 | 83.41696 | -1.58486 |
| 23 | 84.44592 | -0.35335 |

Table 1: RA and DEC of 23 sources.

**Exposure time calculation:**

We're aiming for a signal to noise ratio of 50 $\sim$ 100 as that would be the best to compare it with the exisiting model to get the veiling and other properties. We are also targeting for a K magnitude of 13. Based on these information and the configurations for IGRINS -2, we need a total exposure time of $\sim$ 10400 s or $\sim$ 2.89 hours for a signal to noise ration of $\sim$ 100 (the best that we need). But we can reduce the signal to noise to 83 to reduce the total exposure time to $\sim$ 7200 s or $\sim$ 2 hours as that would be sufficient for our study.