Tracing Discs Around Massive YSOs using CO Emission

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Abstract

There is little observational evidence that discs play a role in massive star formation. We present spectra of 20 massive young stellar objects (MYSOs) displaying CO first overtone bandhead emission. We model the emission under the assumption that it originates in a circumstellar disc, and find good fits to all spectra. The best fitting discs are found to be spread across a wide range of inclinations, consistent with accretion disc models, and within the dust sublimation radius. Our results provide strong evidence for small scale gaseous accretion discs, supporting the scenario in which massive stars form via disc accretion.

1: Background

The formation processes and mechanisms of massive stars are not well known. Recent models (Krumholz *et al.* 2009, Kuiper *et al.* 2011) have suggested these objects could form in a similar way to low mass stars, via an accretion disc, but there is a lack of observational evidence of discs around massive young stellar objects (MYSOs).

However, MYSOs evolve very quickly, and are therefore shrouded in their parent cloud material for their entire formation period, so an indirect method of probing the circumstellar material close to the central star is required.

Hot and dense CO gas (T = 2500-5000 K, $n > 10^{12}$ cm^{-3}) can be excited ro-vibrationally, which produces an interesting spectral emission feature - a CO bandhead (see insets to Fig. 1).

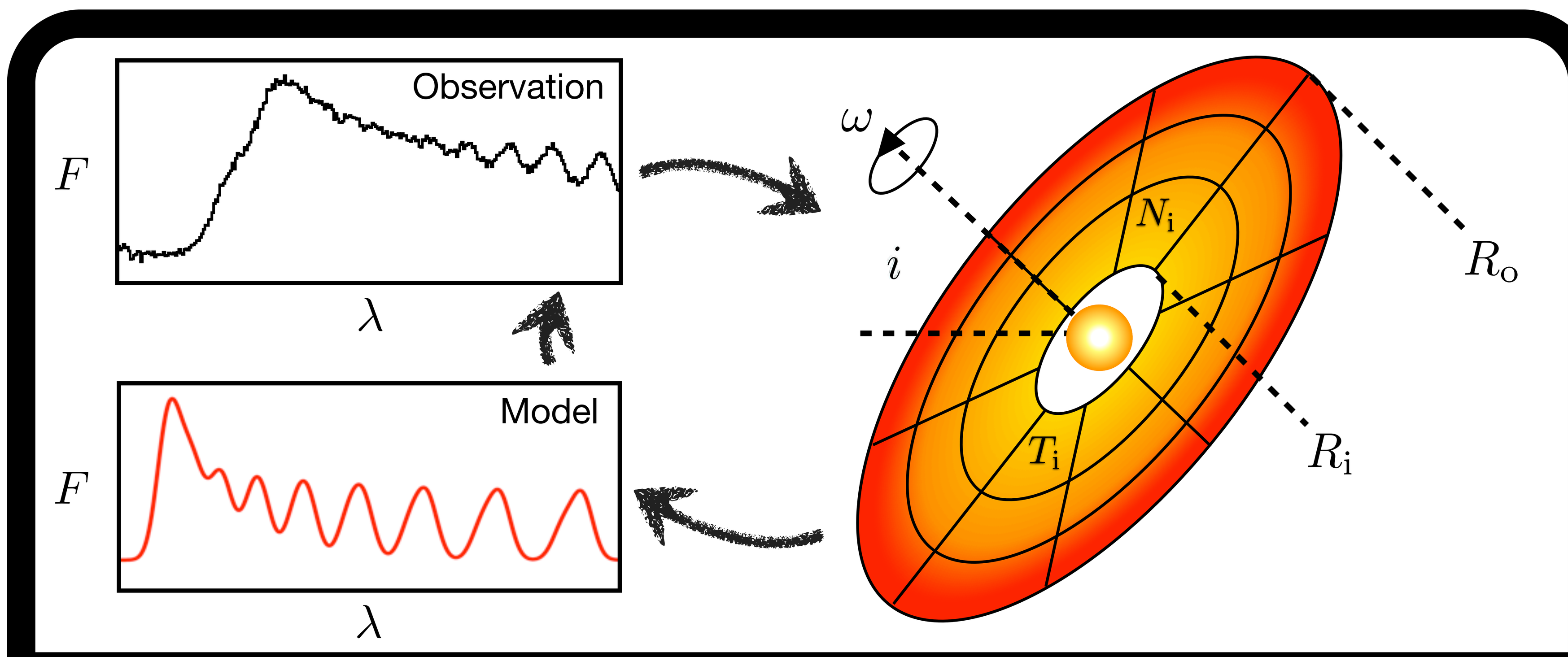

Fig. 1 — Schematic of the disc model and fitting approach used in our study. The emission from each cell within the disc (75x75) is calculated from the temperature and density structure, and then combined to produce the final model CO bandhead spectrum for the disc.

2: Methods

We have obtained high resolution (R ~ 30,000) VLT/CRIRES spectra of 20 targets from the RMS Survey of MYSOs that exhibit CO bandhead emission. We have fitted the emission using a model of a thin Keplerian disc (see Fig. 1). We use a custom IDL program to create the artificial CO spectra and fit the data using the AMOEBA downhill simplex algorithm.

3: Results

- All spectra were well fit by the model (see Fig. 2). The discs are spread across a wide range of inclinations, and their physical structures are consistent with accretion disc models.
- All discs are found to be close to, or within, the dust sublimation radius.
- The objects were found to be no different to the general ensemble of MYSOs in the RMS survey, based on NIR and MIR colours, and are therefore likely to be spread across all evolutionary stages.

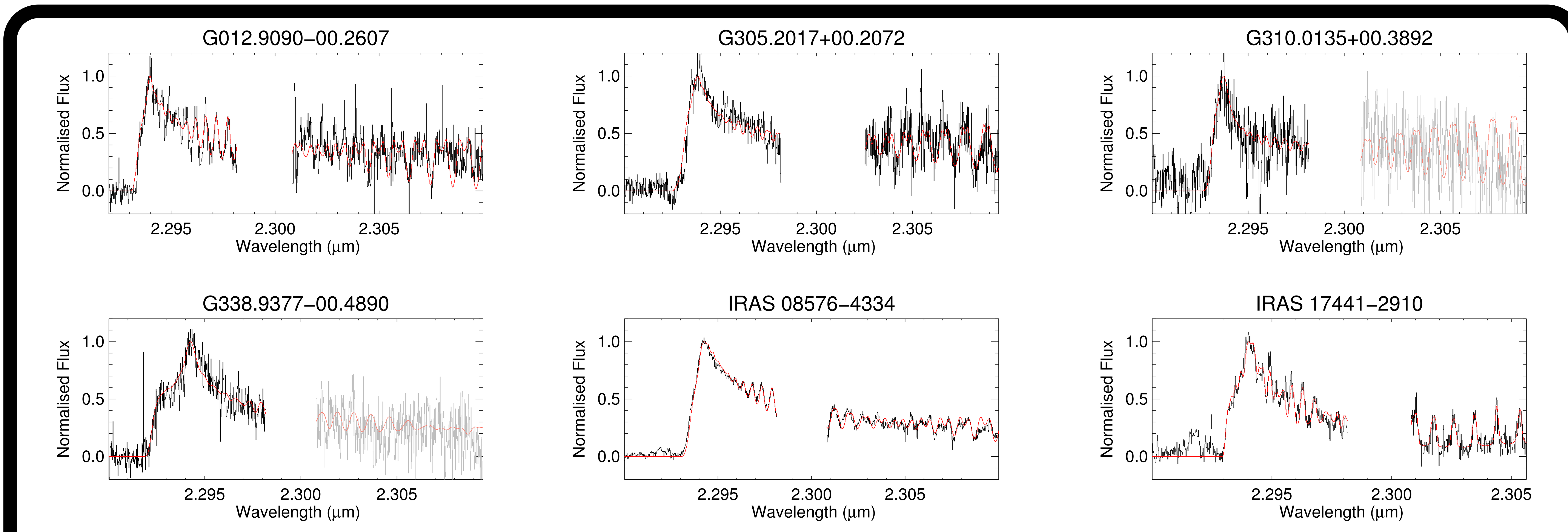

Fig. 2 — CO bandhead spectra and best fitting models of 6 of the MYSOs. Greyed-out regions were not included in the fitting procedure.

4: Conclusions

Our results demonstrate that CO first overtone bandhead emission in the spectra of MYSOs appears to originate from circumstellar discs in Keplerian rotation. The presence of small scale, gaseous discs around MYSOs supports the scenario in which massive stars form via disc accretion.

5: References

Based on Ilee *et al.* 2013, *MNRAS*, 429, 2960
Krumholz *et al.* 2009, *Sci*, 323, 754.
Kuiper *et al.* 2011, *ApJ*, 722, 1556.
Red MSX Source (RMS) Survey:
http://www.ast.leeds.ac.uk/RMS/