Modelling atomic and molecular disk wind tracers

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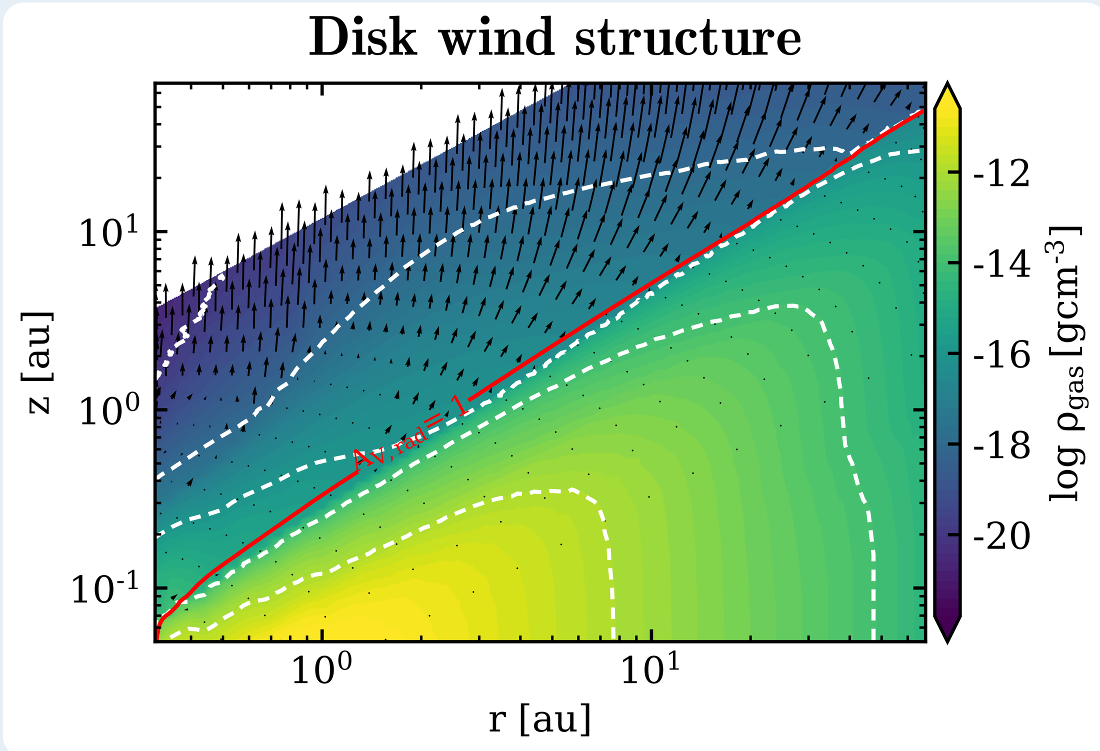
Context

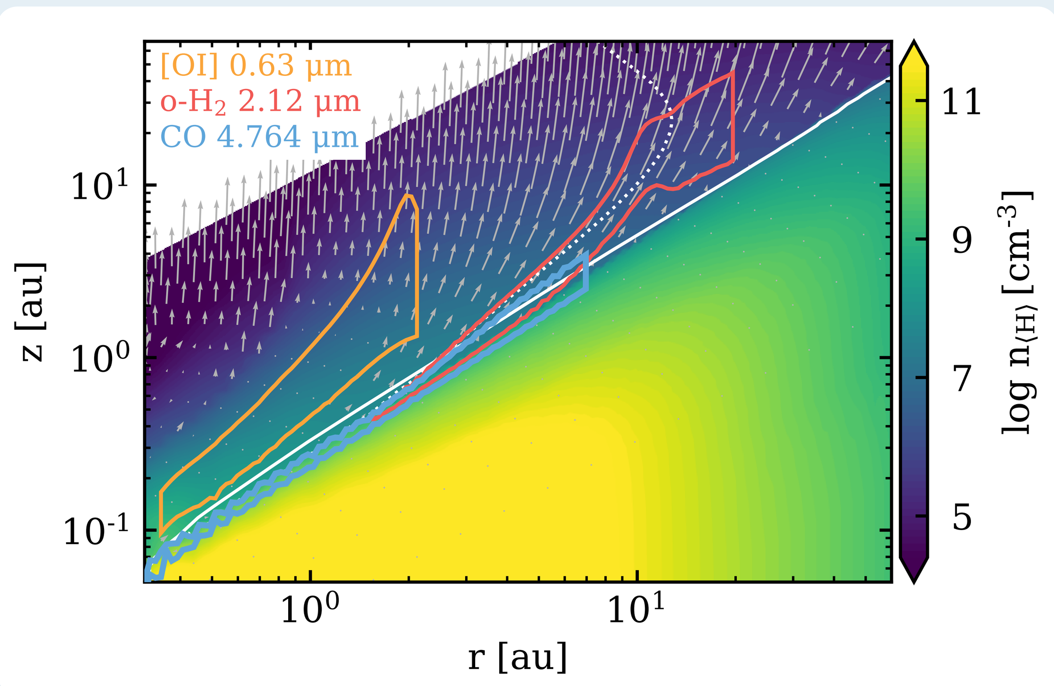
- signatures of disk winds in both atomic & molecular species are now commonly observed (e.g. Gangi et al. 2020; Banzatti et al. 2022)
- many theoretical models for both thermally or magnetically driven winds exits, but a direct comparison of those models to observations is challenging (e.g. computationally expensive, thermo-chemistry, ...)
- here we present an efficient approach that allows for a direct comparison of photo-evaporative disk wind models to observations of the atomic ([OI] 0.63 μm) and molecular tracers (H_2 2.12 μm, CO ro-vib)

Method



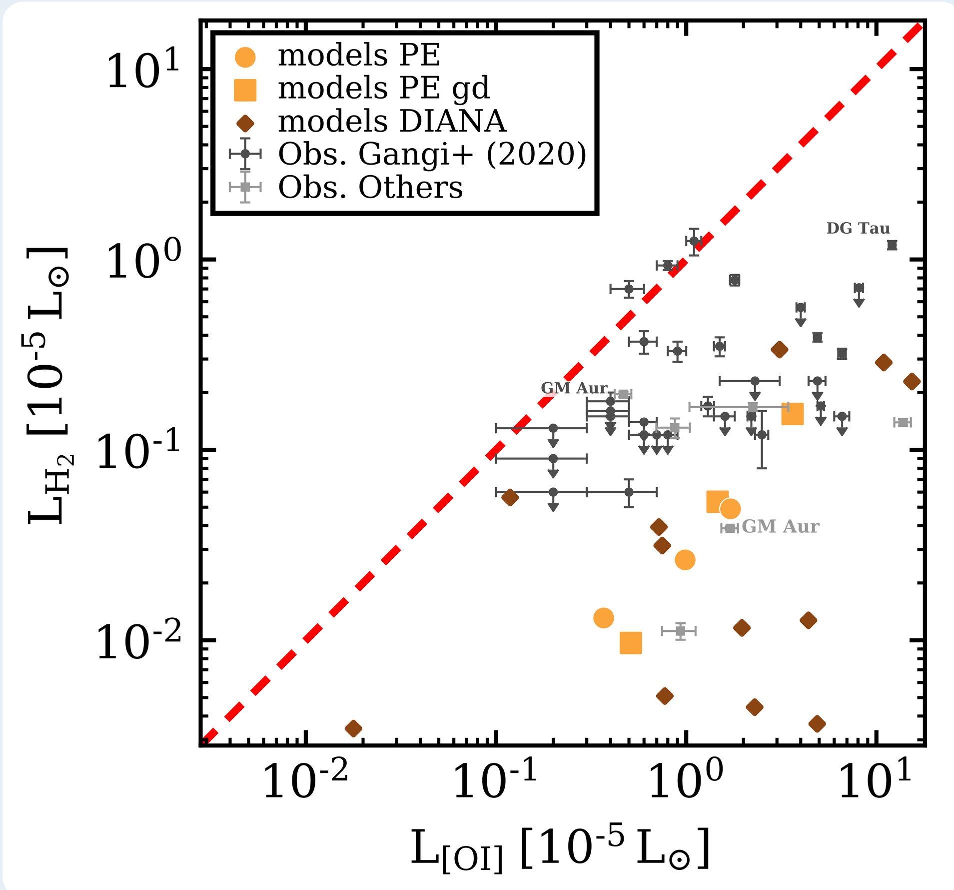
- physical disk/wind density structure and velocity field from 2D EUV/X-ray photo-evaporative disk wind models (Picogna et al. 2019; Weber et al. 2020)
- post-process models with the radiation thermo-chemical disk code ProDiMo (e.g. Woitke et al. 2009; Kamp et al. 2010; Thi et al. 2011) to self-consistently calculate the thermal/chemical structure and spectral line profiles; see **Rab et al. (2022)**

Origin of line emission



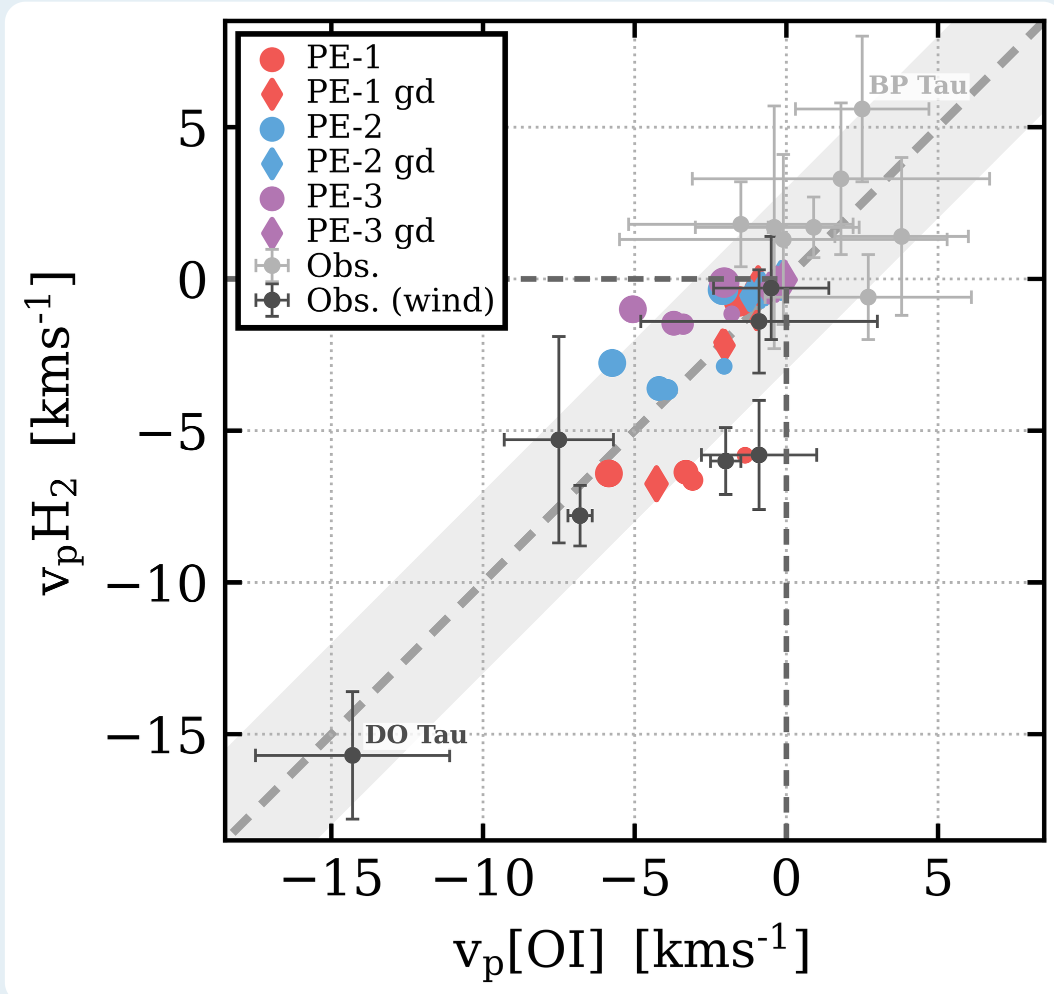
- line emitting regions for the [OI], H_2 and and one CO ro-vib spectral lines.
- CO and H_2 can survive in the wind region; depending on the far-UV flux
- molecules are emitted closer to the disk surface and from larger disk radii compared to [OI], but also trace different regions

Line luminosities



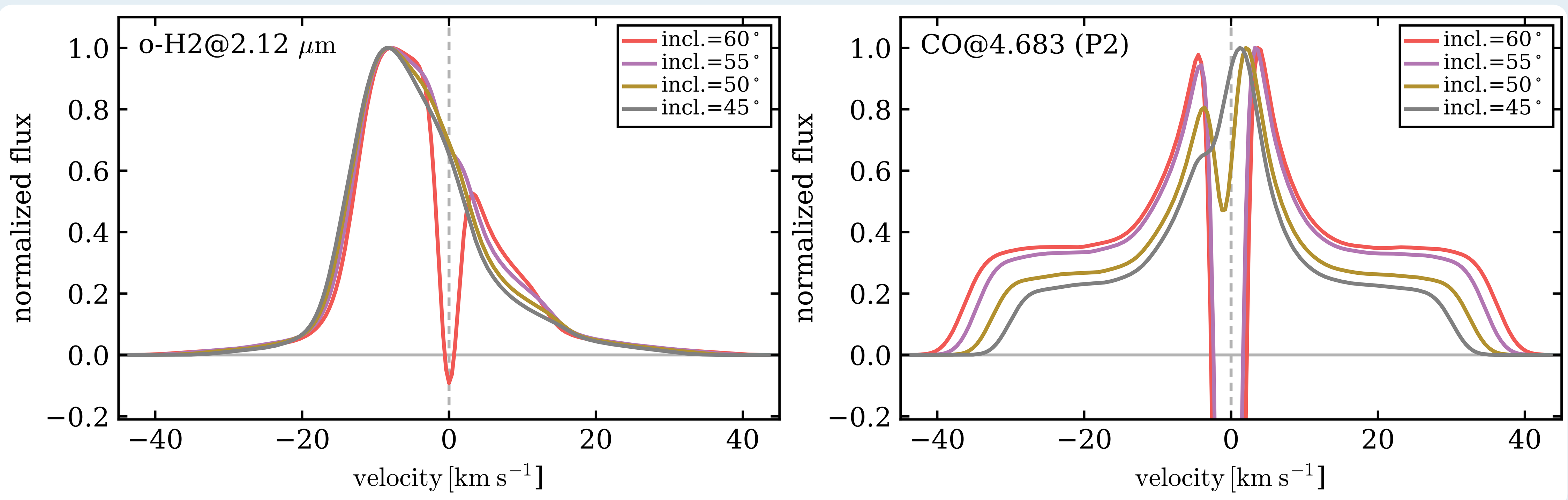
- line lums. are in good agreement with obs. orange: wind models; brown: no wind m.
- tendency to underestimate H_2 line lums.
- not done yet for CO ro-vib

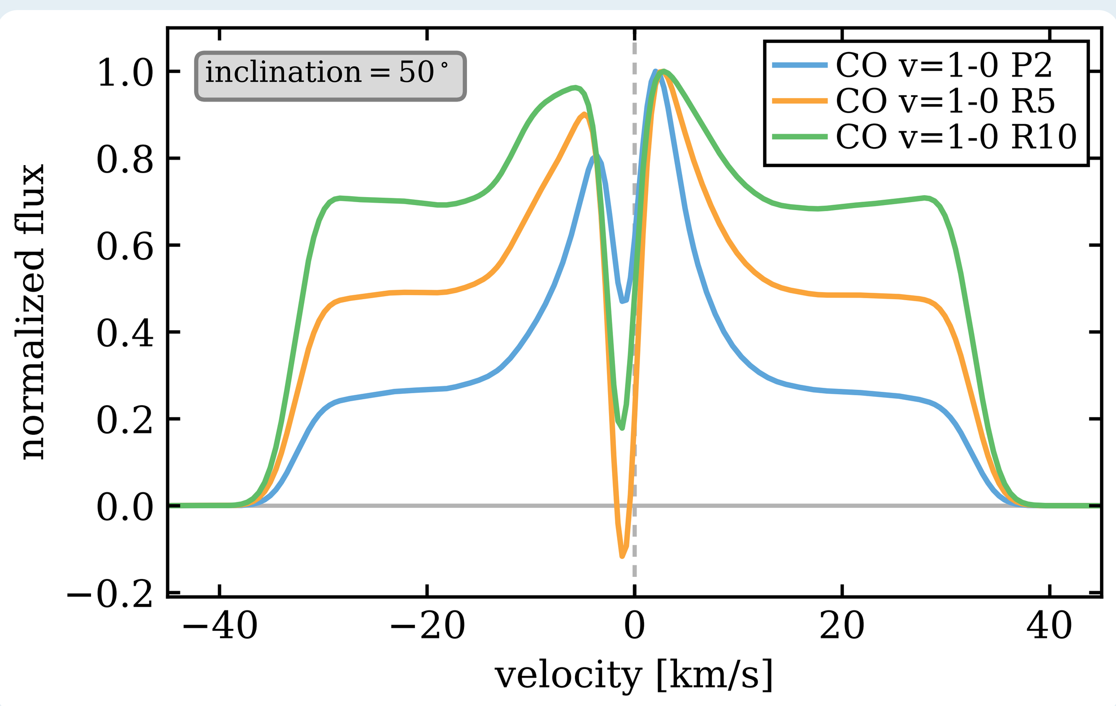
Line kinematics



- following approach of the obs.; modelled line profiles are fitted by Gaussian components to identify velocity components and shift in the peak emission of the line ($\mathbf{v_p}$) e.g. blue-shifted $\mathbf{v_p}$ → disk wind
- good agreement for v_p (models: *coloured symbols*) and FWHM (see **Rab et al. 2022**)

Line profiles (preliminary)





- H_2 and CO line profiles (R=100000)
- if molecules can survive in the outer wind region, self-absorption features appear (as observed in CO, Banzatti et al. 2022)
- dependence on inclination (top panel) different for H_2 and CO → emission origin?
- wavelength dependence of absorption feature in CO (tracing different regions of the wind)
- great potential for deriving wind properties in regions otherwise not seen; models still need to be improved to better understand what we see

Summary & Outlook

- efficient modelling approach to directly confront (magneto) hydrodynamic disk wind models to observations of molecular and atomic wind tracers
- photo-evaporative disk wind models are consistent with the observed line kinematics for the [OI] 0.63 μm & H_2 2.12 μm narrow low-velocity line components (**Rab et al. 2022**)
- determination of wind characteristics from observations requires modelling due to complex disk/wind structure and limited spatial & spectral resolution of observations

Outlook

- apply procedure to MHD disk wind models
- looking for planet-signatures (planet+wind models talk M. Weber)
- prediction for future instruments such as ELT/METIS, but also e.g. ALMA

References: • Banzatti, A., et al. 2022, The Astronomical Journal , 163, 174 • Gangi, M., et al. 2020, A&A, 643, A32 • Kamp, I., et al. 2010, A&A, 510, A18 • Picogna, G., et al. 2019, MNRAS , 487, 691 • Rab, C., et al. 2022, A&A, 668, A154 • Thi, W.-F., Woitke, P., & Kamp, I. 2011, MNRAS , 412, 711 • Weber, M. L., et al. 2020, MNRAS , 496, 223 • Woitke, P., Kamp, I., & Thi, W.-F. 2009, A&A, 501, 383

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