Synthetic Features of Protostellar Outflows

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1. Present the synthetic features of our outflow model
2. Clues we may learn from modeling

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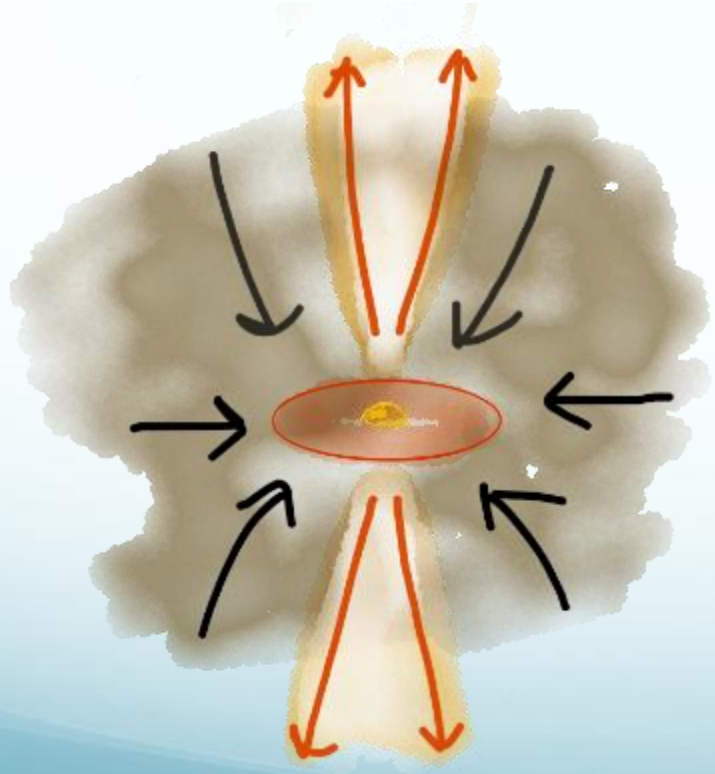
Molecular Outflows

Observed feature and wind model

Molecular Outflows

- Context
  - Isolated low mass star formation
- Characteristics of young outflows
  - High-velocity collimated jet
  - Low-velocity less-collimated shell



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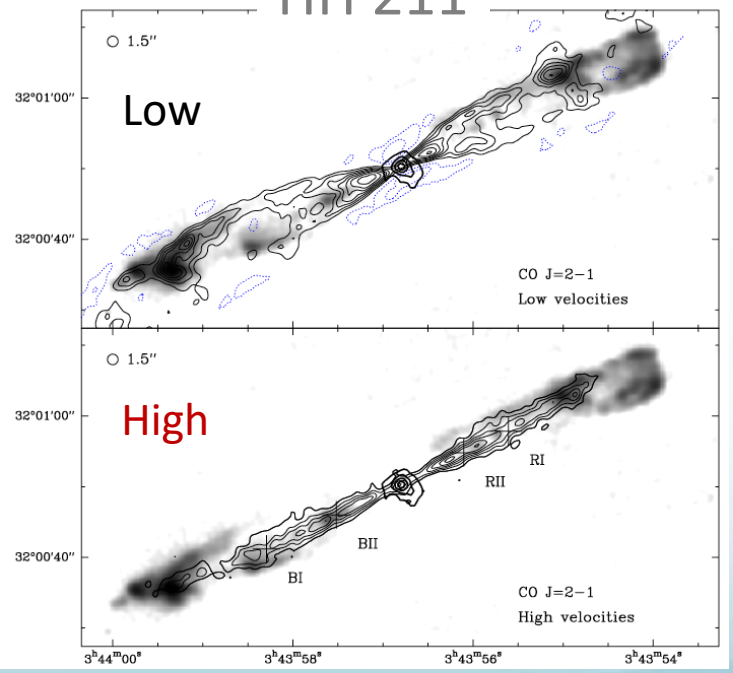
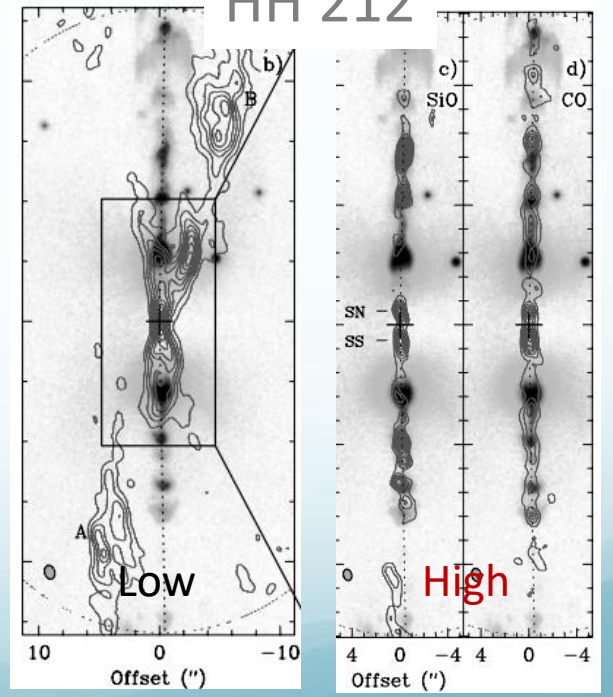
HH 211



Gueth & Guilloteau 1999

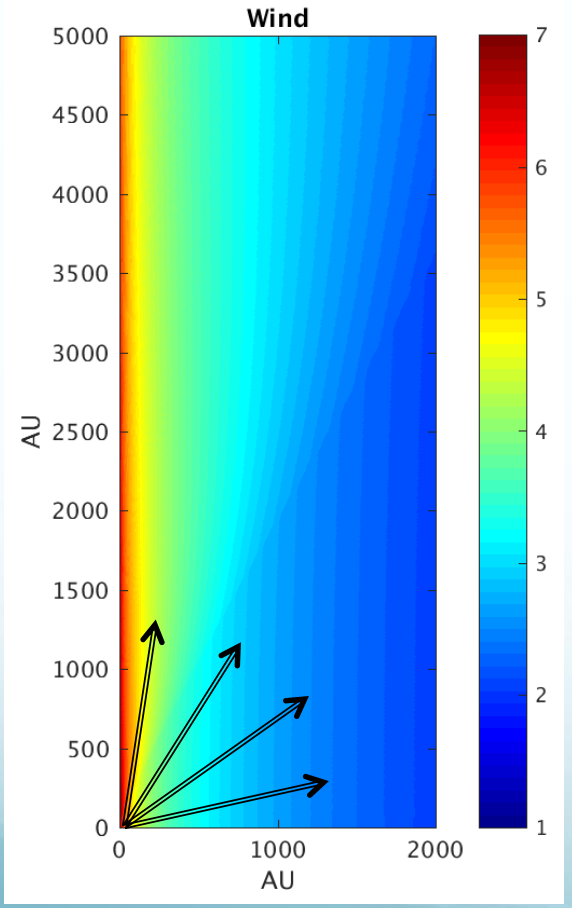
HH 212



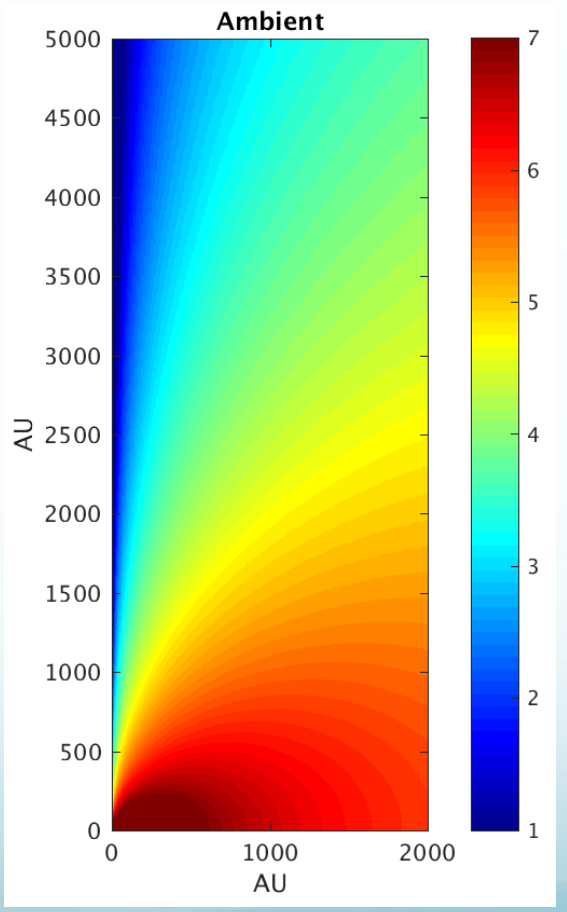
Lee+ 2007

The Wind Model

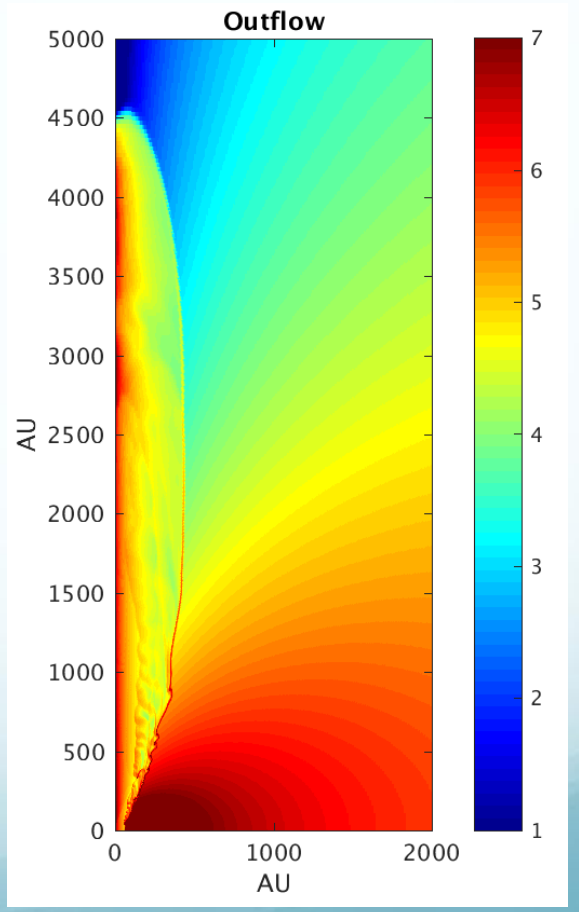
Density structure resembling that predicted by the X-wind theory (Shu+ 2000)



Ambient toroid-like mass distribution (Li & Shu 1996)



The unified wind model of Shang+ 2006



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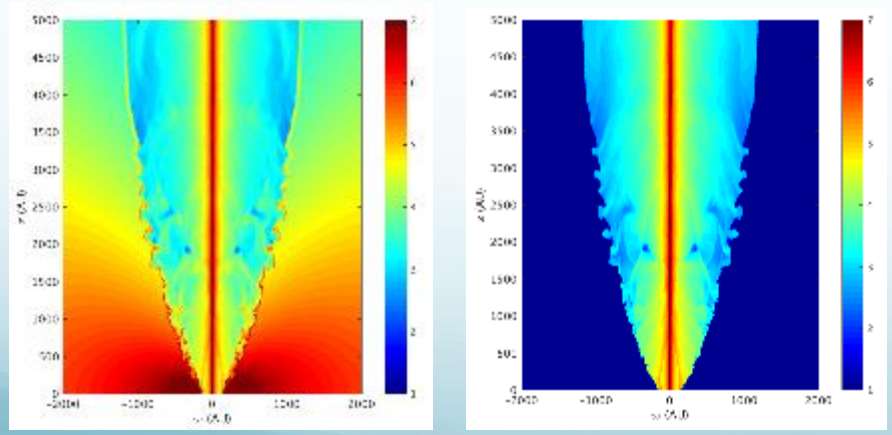
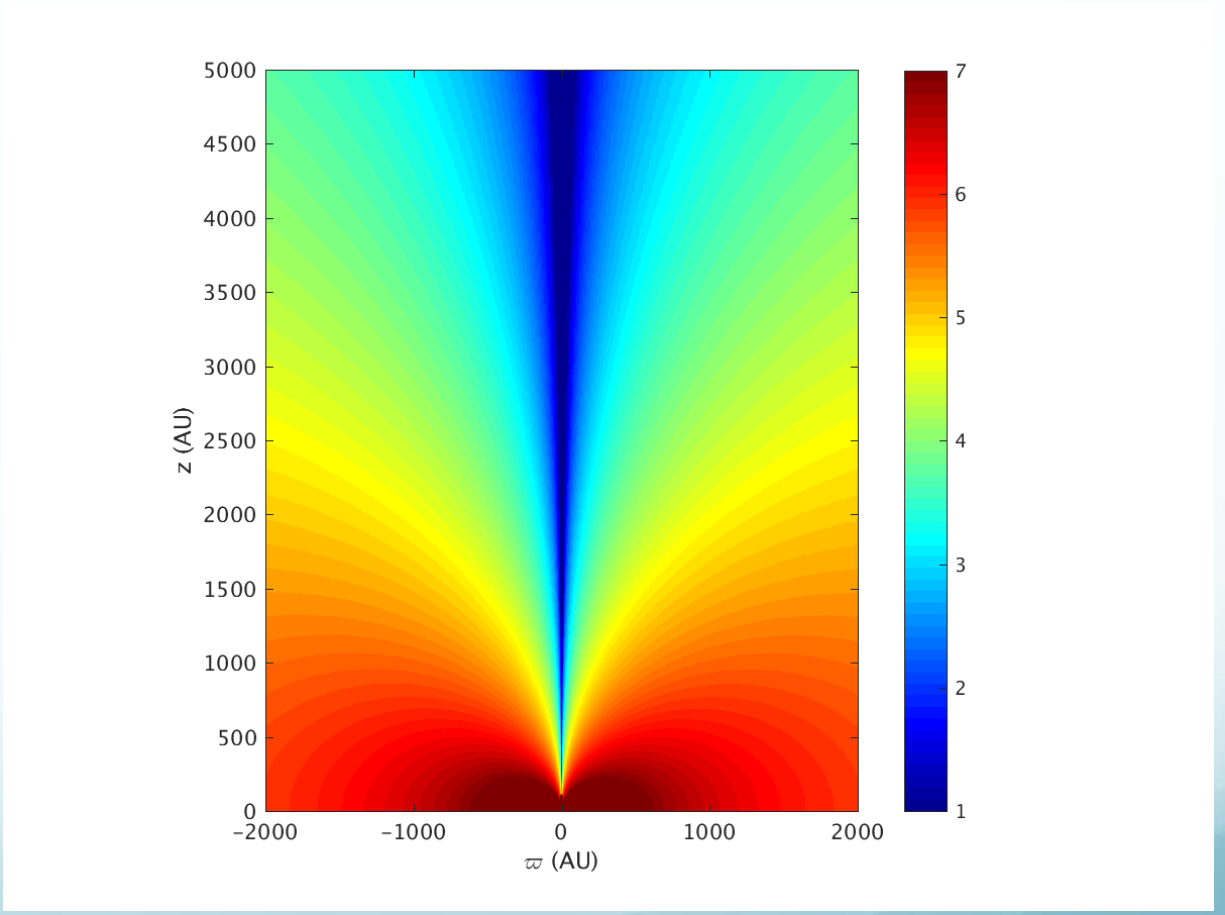
The Wind Model

- Ideal MHD Simulation
  - Zeus-TW magnetohydrodynamic code (Krasnopolsky+2010)
  - 2D-axisymetric spherical coordinate
- Two-Temperature scheme using a tracer field (Wang+2015)





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Synthetic Features of Molecular Outflows

Morphology and kinematics reproduced

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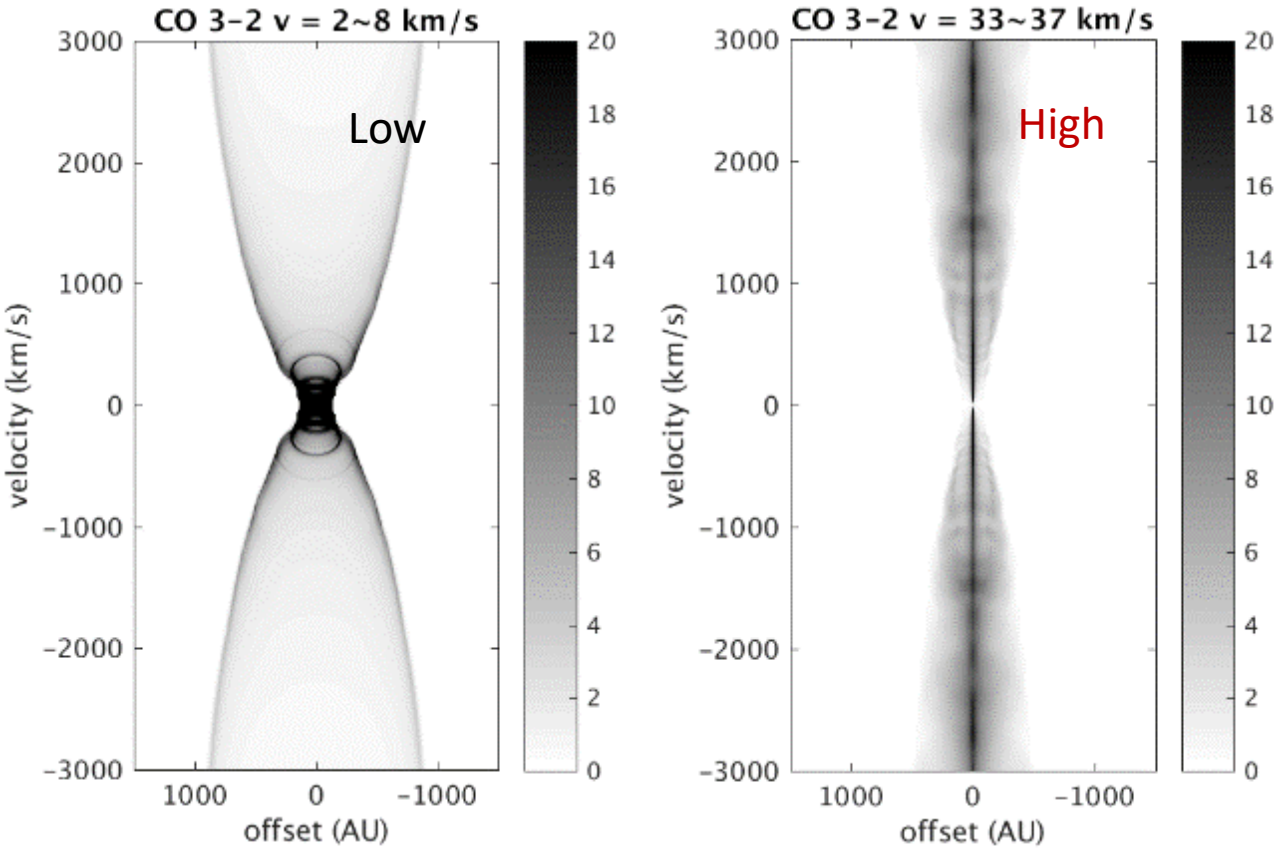
Jet & Shell Characteristics



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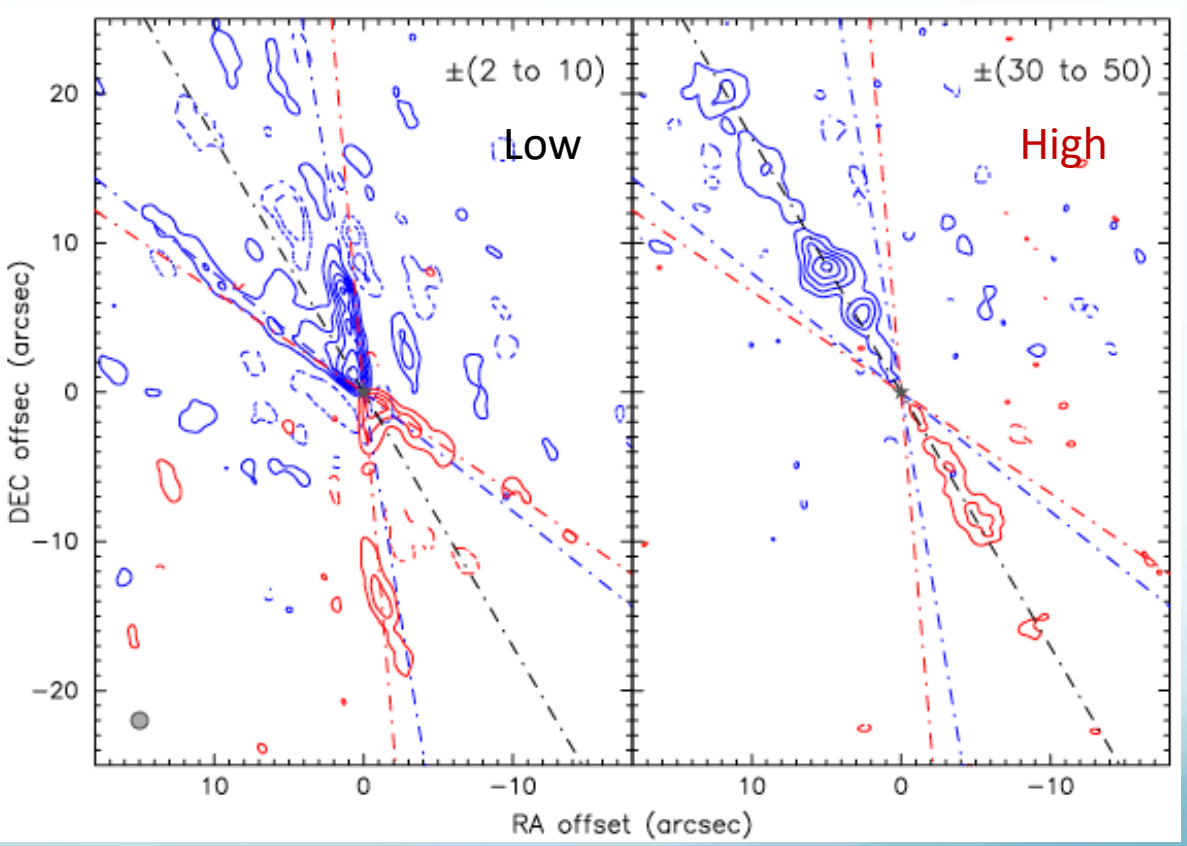
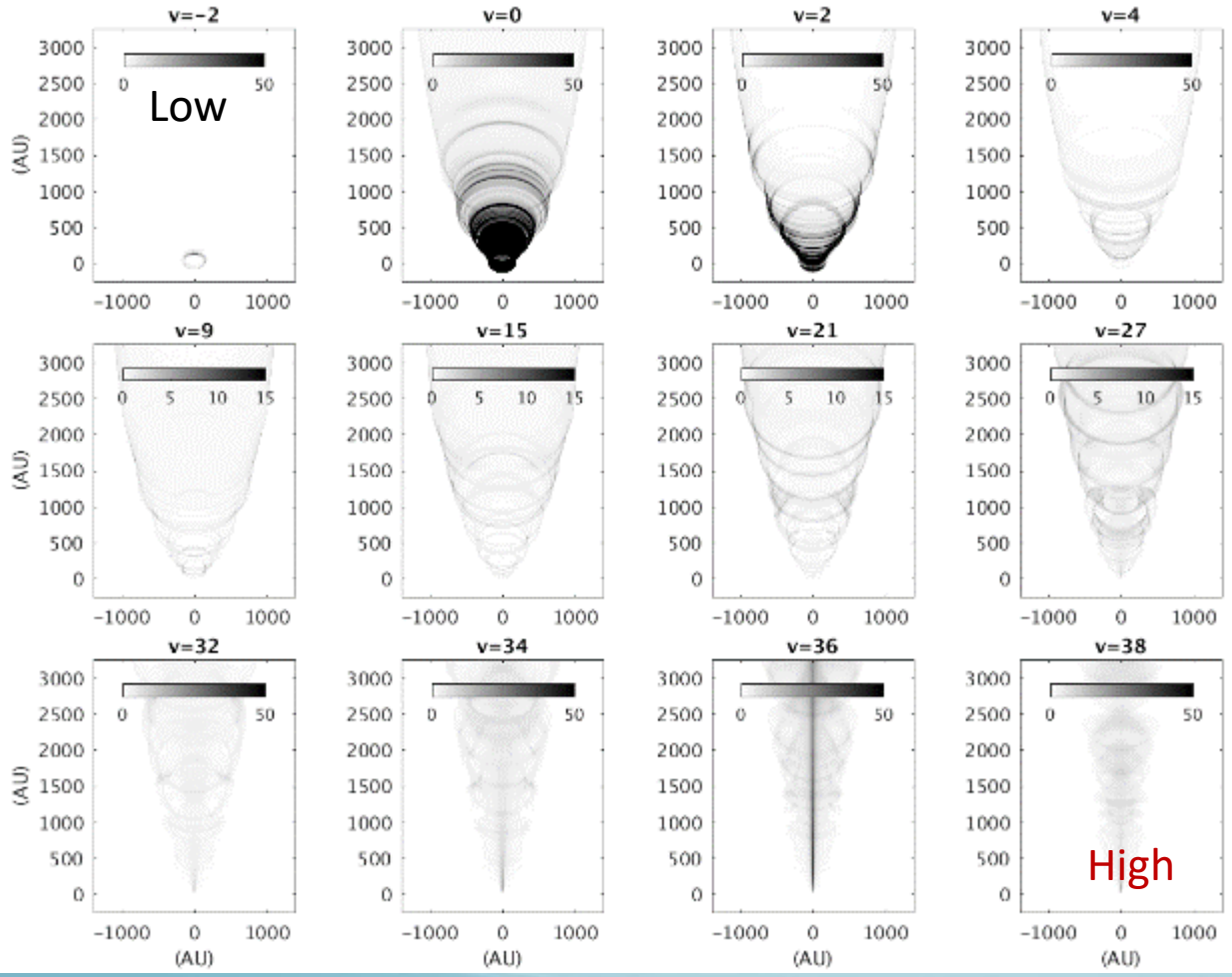


Wang+ 2014

Channel Maps



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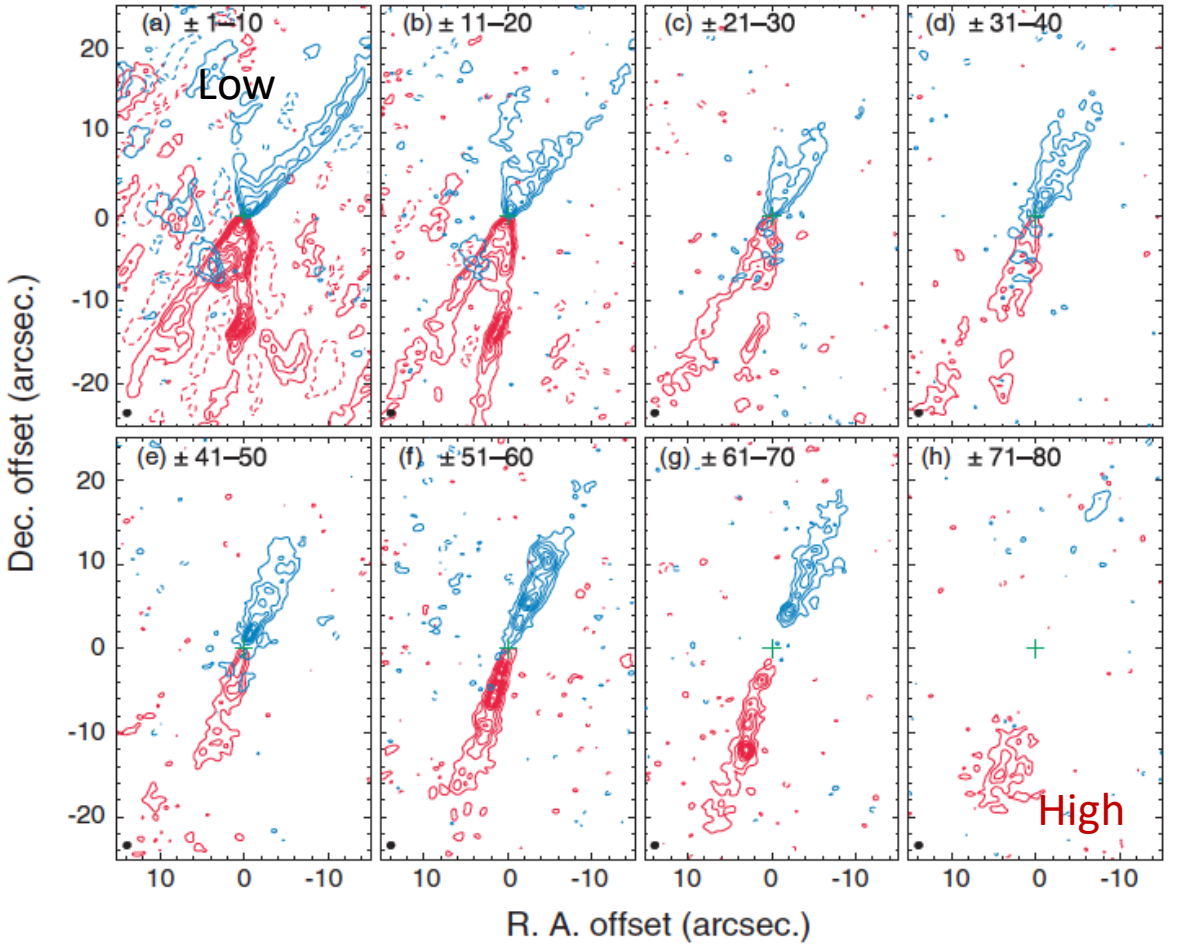
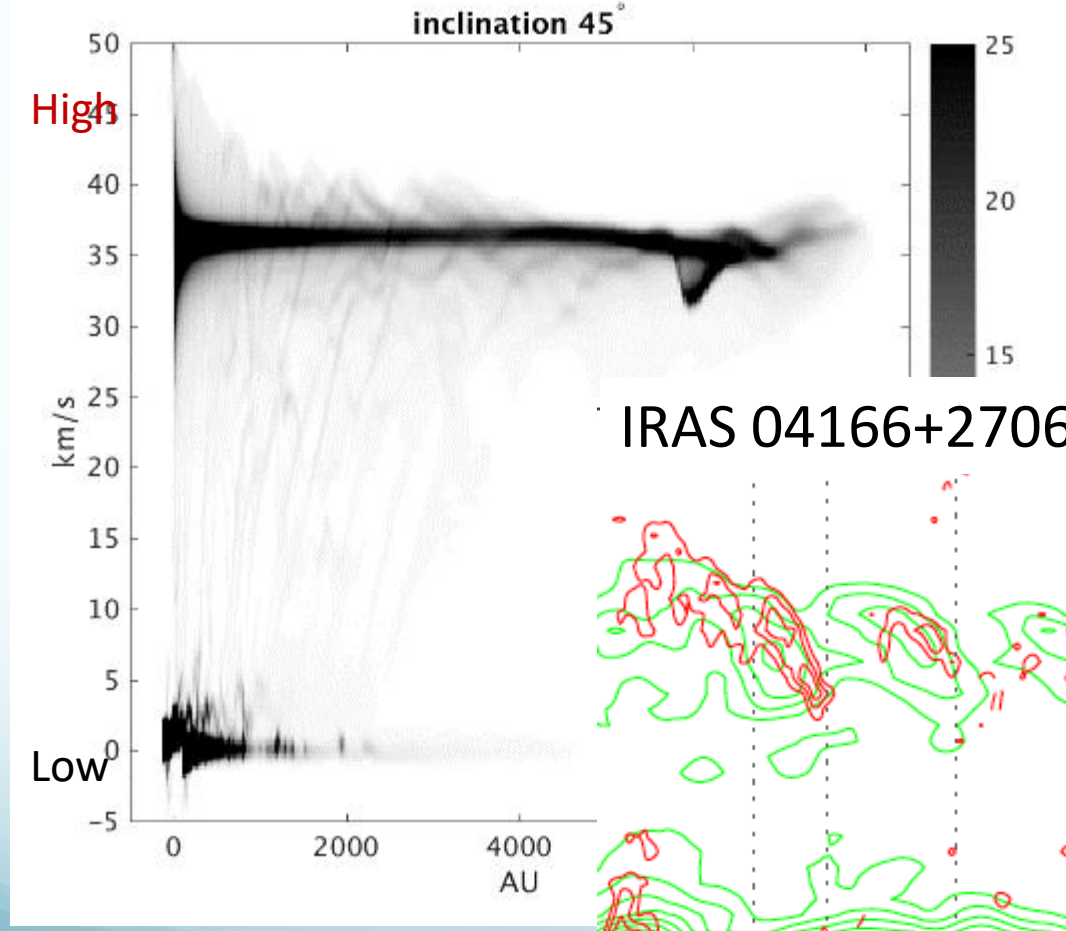
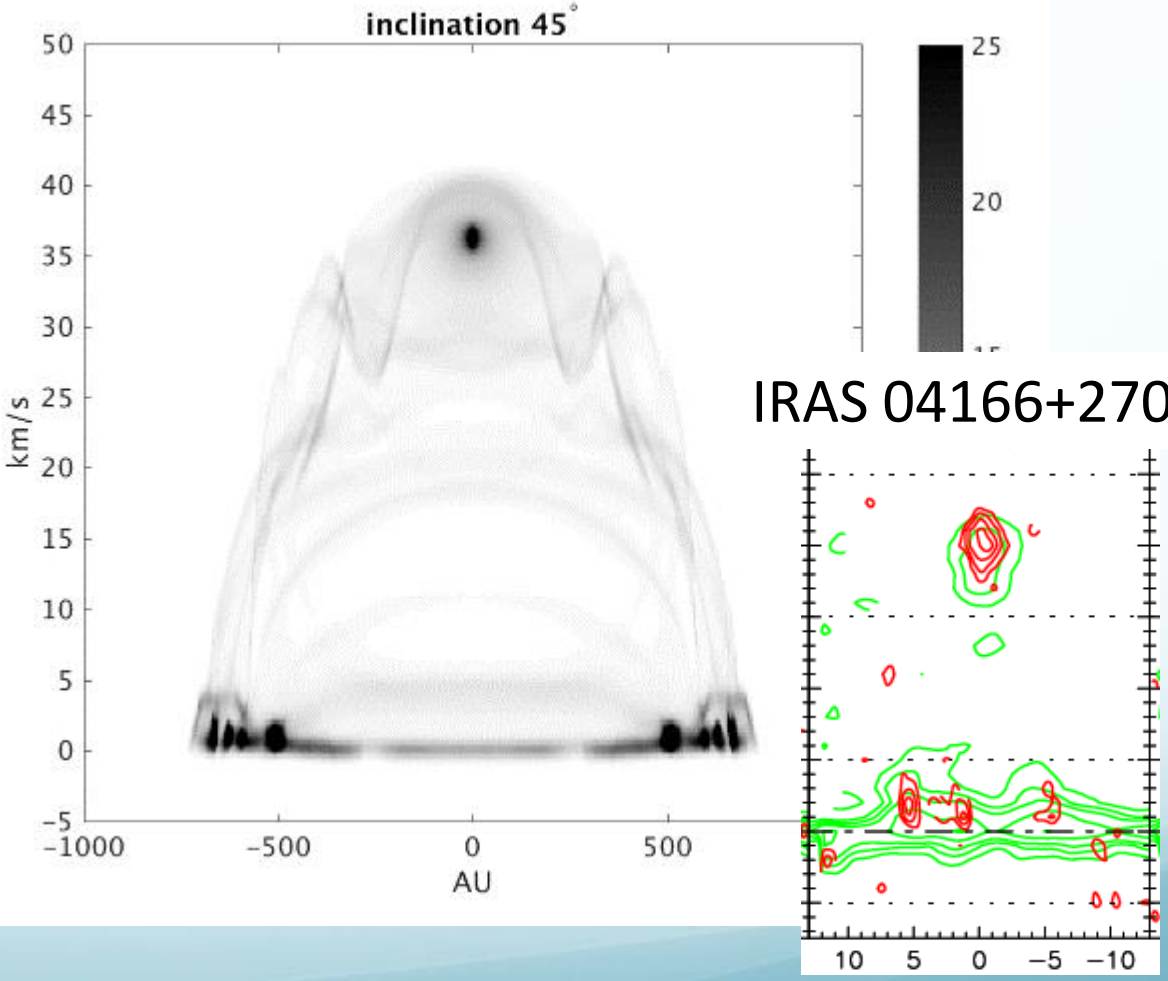


Hirano+ 2010

Kinematics





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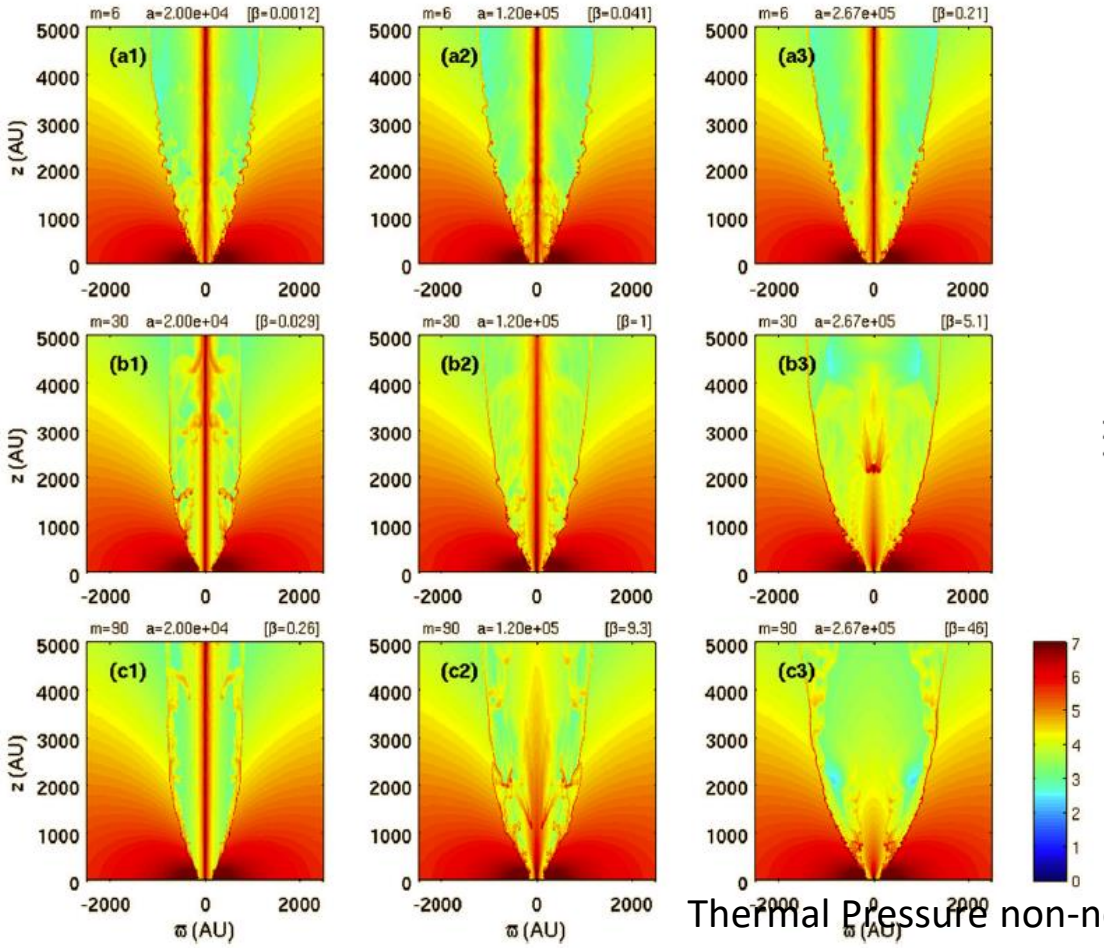
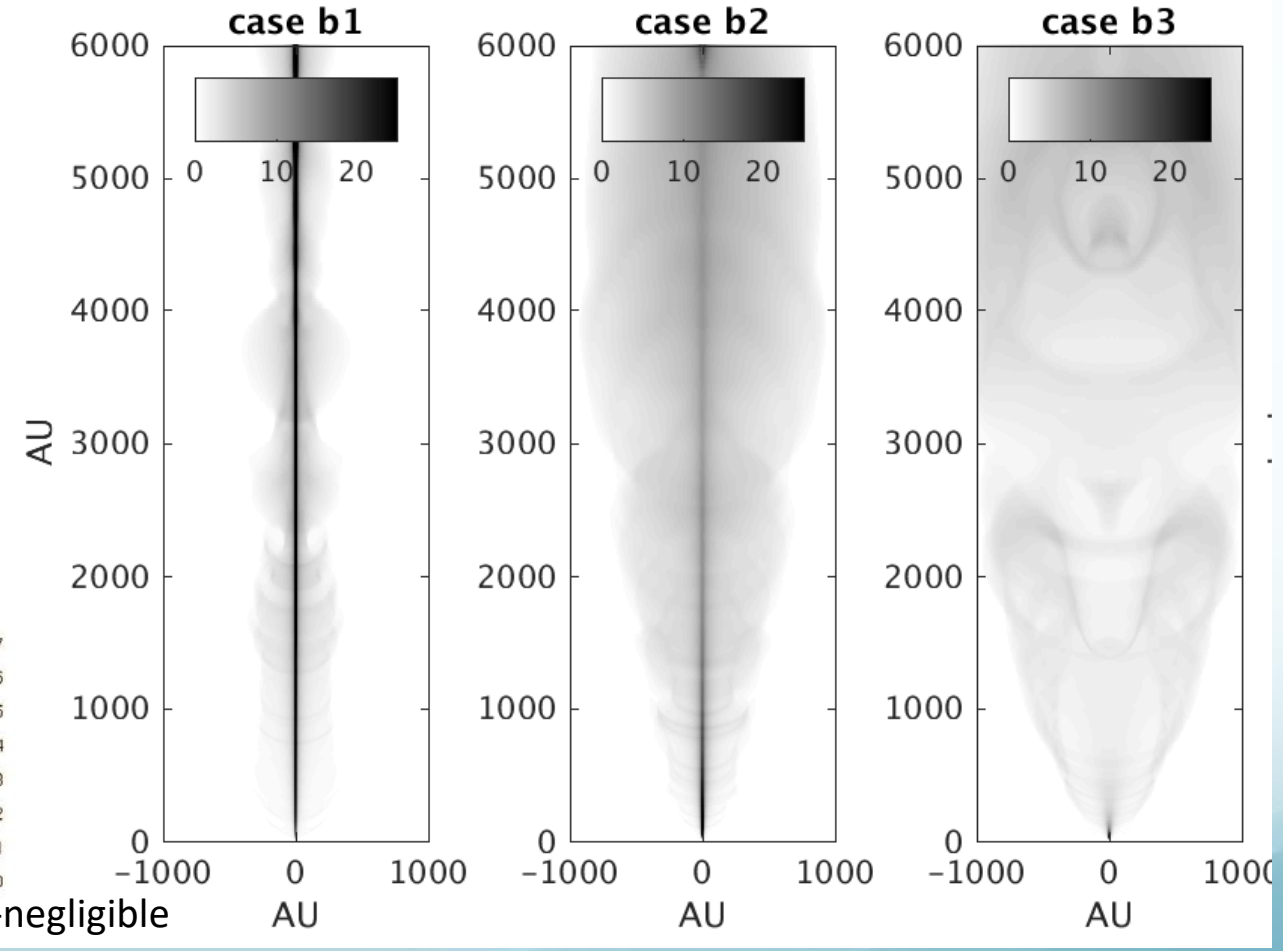
Wang+ 2014

Clues from The Synthetic Features

Insights & information

I. Effect of Thermal Pressure





Thermal Pressure non-negligible

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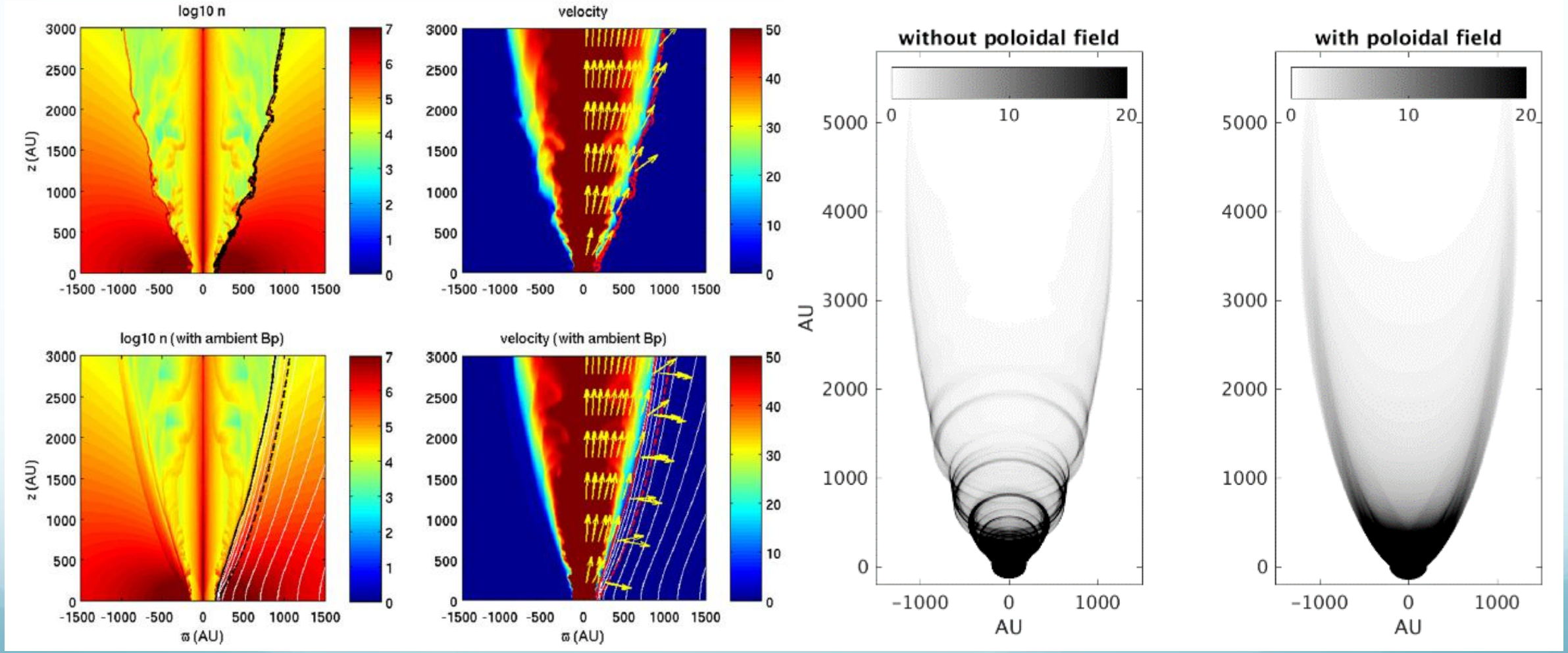
Wang+ 2015

II. Effect of Ambient Poloidal B Field



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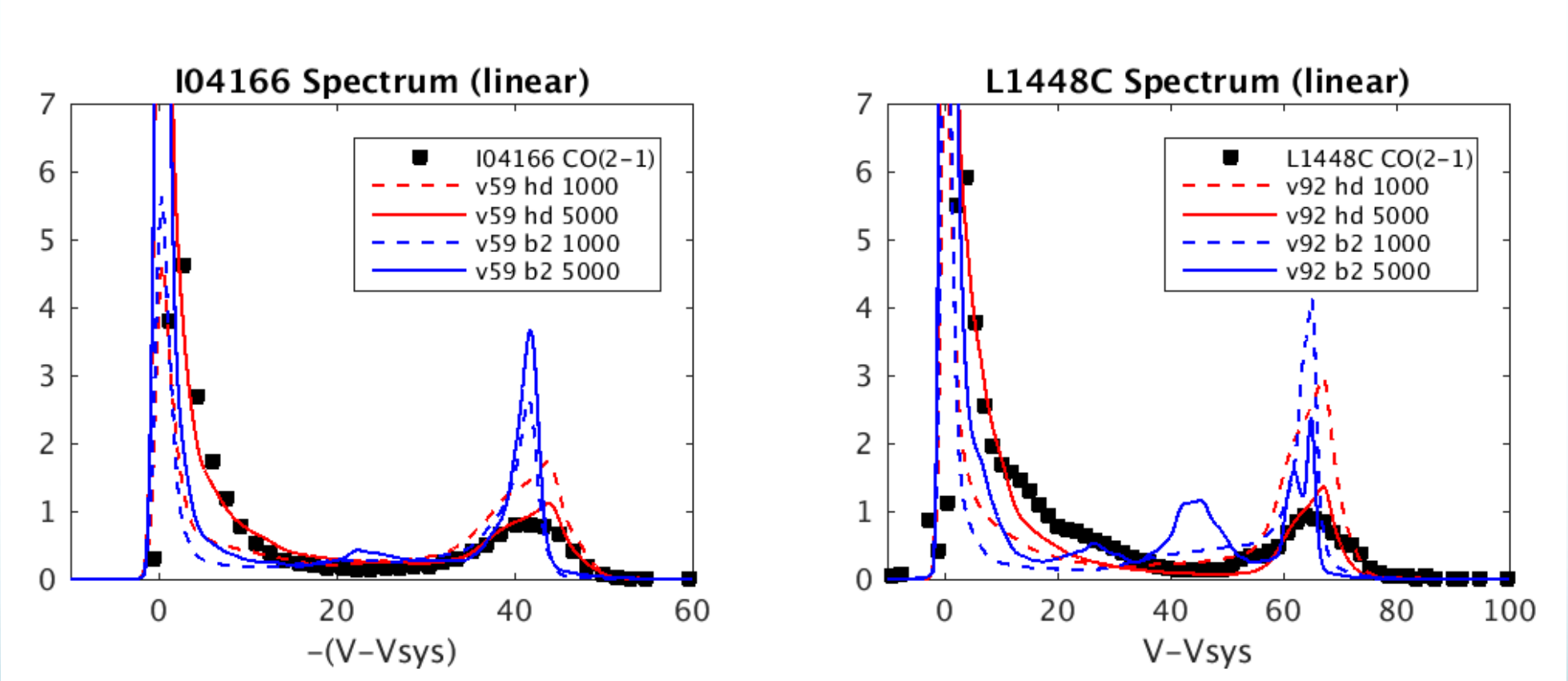
Wang+ 2015

III. The Shape of Spectral Wing



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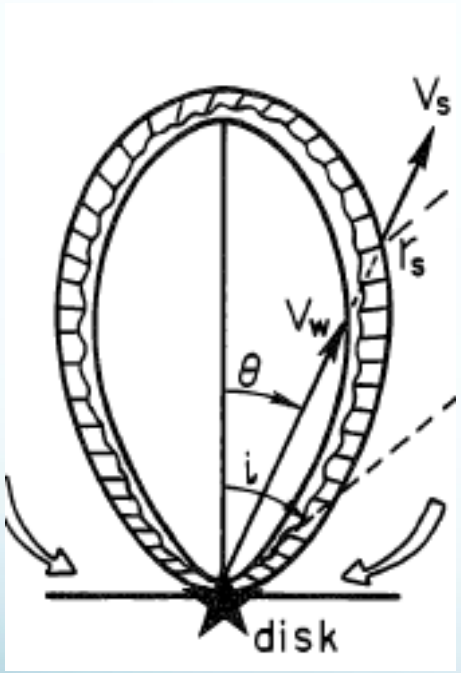
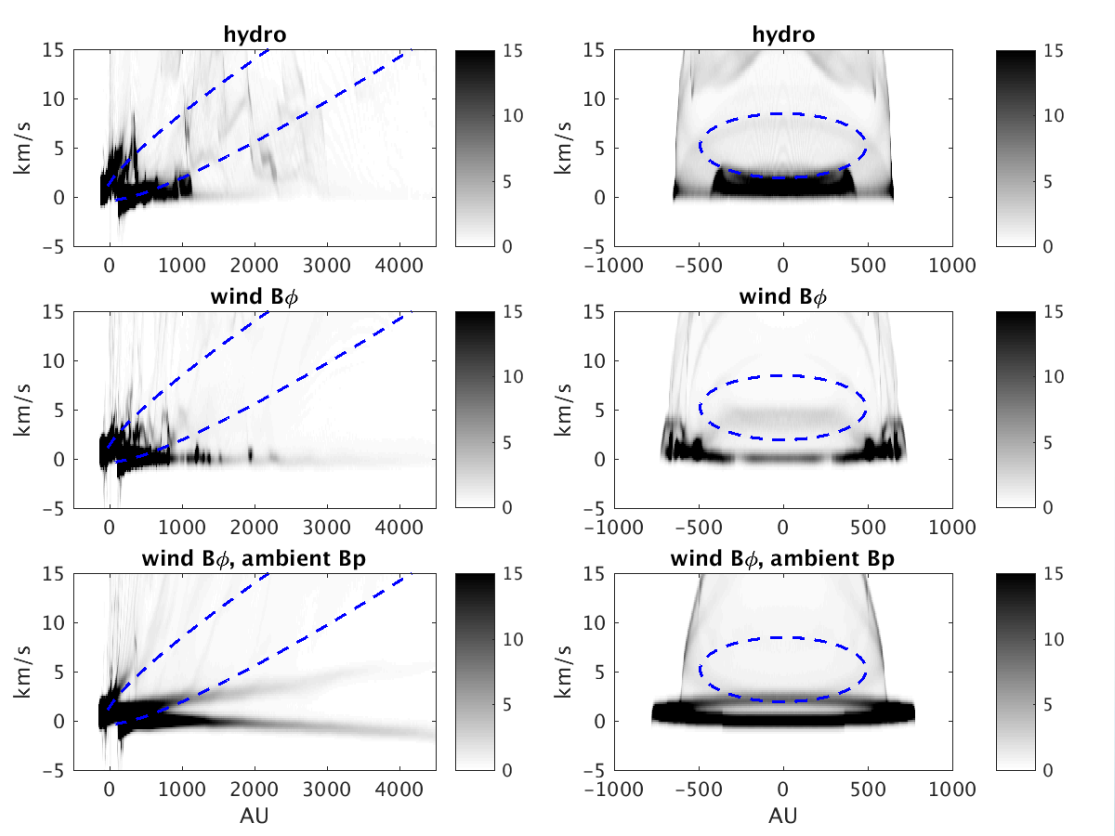
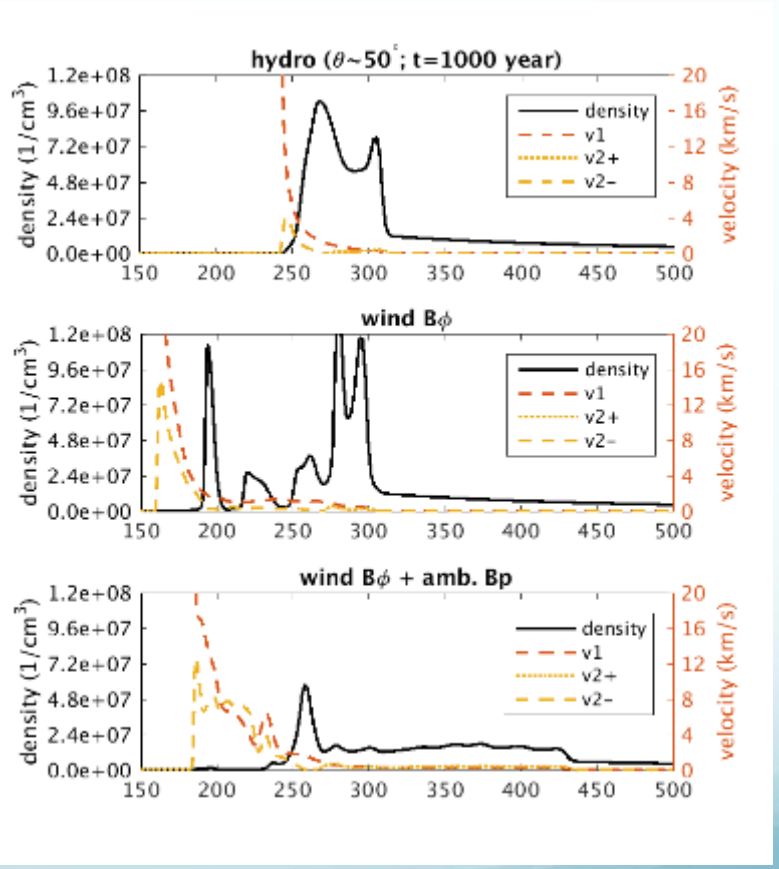
Spectral data from Tafalla+2010

B-Field in Wind-Ambient Interaction



Shu+ 1991





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Summary

- We construct synthetic images, PV diagrams, and spectra to more realistically examine the properties of the unified wind model.
- The model can capture the general outflow morphology and kinematics.
- We discuss the shape of the outflow spectral wing in framework of the model. The result suggests that the presence of magnetic field modifies the wind-ambient interaction in a way that disfavor the growth of spectral wing components.
- The model provides a framework for thinking of outflow problems.

Thank you.

"The most that can be expected from any model is that it can supply a useful approximation to reality: All models are wrong; some models are useful". - George Box