

# Complicate Structure of Interacting Binary: Outflow and Gas Stream [UY Aur Case]

Tae-Soo Pyo (Subaru Telescope)

M. Hayashi (NAOJ), T. L. Beck (STScI), C. J. Davis  
(Liverpool John Moore Univ.), H. Takami (ASIAA/  
Taiwan)

# Binary Young Stars

- Many Young Stars are born in binary or multiple system (Mathieu 1994; Duchene et al. 2007)
- TMC: 48.9% (Kohler & Leihert 1998)
- Nearby: 9-32% (King et al. 2012, 2013)
- Common in embedded Protostars (Haisch et al 2004; Connelley et al. 2008)

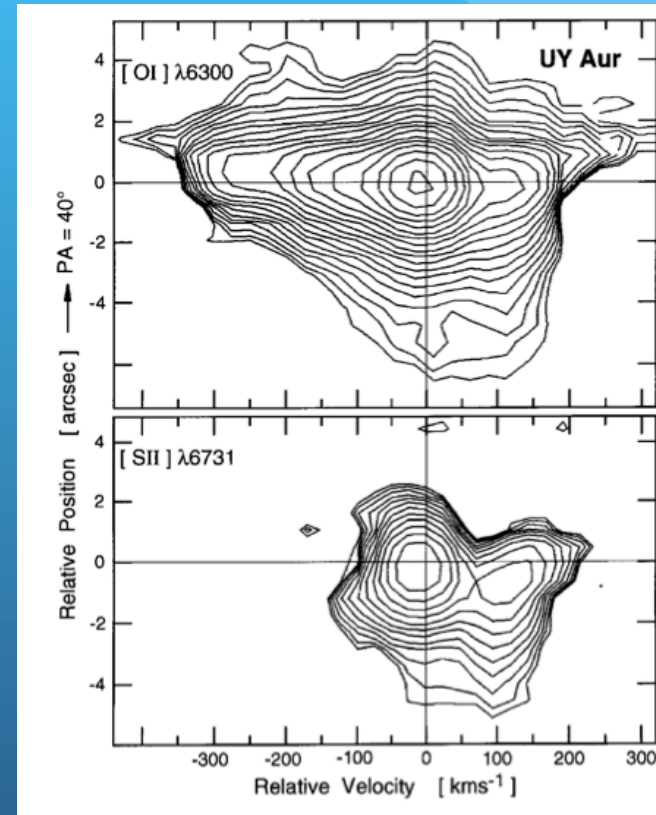
Study of binary system is important to understand star formation.

# Outflows from Binary

- single star : magnetocentrifugal acceleration
  - X-wind: Shu et al. 2000,
  - Disk wind: Konigl & Pudritz 2000
  - Stellar wind: Matt & Pudritz 2008
- outflow/jet from binary
  - dynamical decay of multiple system (Reipurth 2000)
  - single jet/outflow (Machida et al. 2009)
  - engulfed or merged too jets (Murphy et al. 2008)
  - two jets/outflows (e.g. L1551: Fridlund & Liseau 1998; Pyo et al 2002)

# Outflows from UY Aur

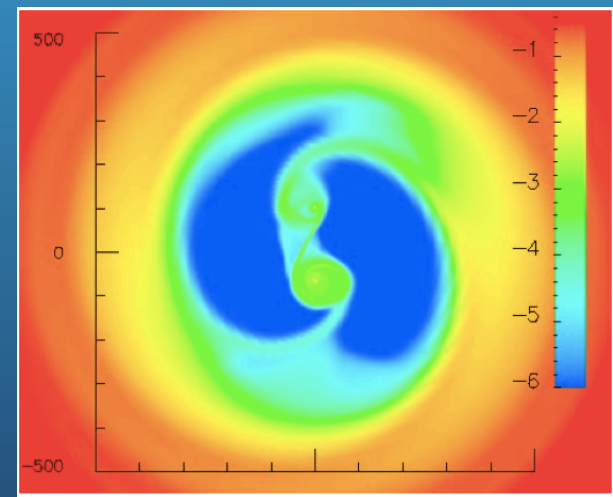
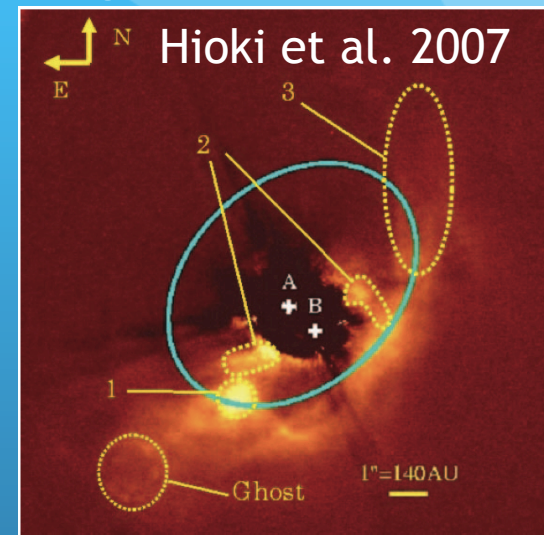
- Optical micro jet (Hirth et al. 1997)
- No long jets: (McGroarty et al. 2004)
- H<sub>2</sub> emission on only secondary: (Herbst et al. 1995)



Hirth et al. 1997

# Circumbinary Disk: UY Aur

- The 2<sup>nd</sup> Circumbinary disk (Dutrey et al. 1994)
  - cf. GG Tau A is 1<sup>st</sup> circumbinary disk
- NIR images w/ AO (Close et al. 1998; Hioki et al. 2007)
- Simulation of gas accretion from circumbinary disk to circum stellar disk (Gunther & Kely 2002; Hanawa et al. 2010; Fateeva et al. 2011;..)

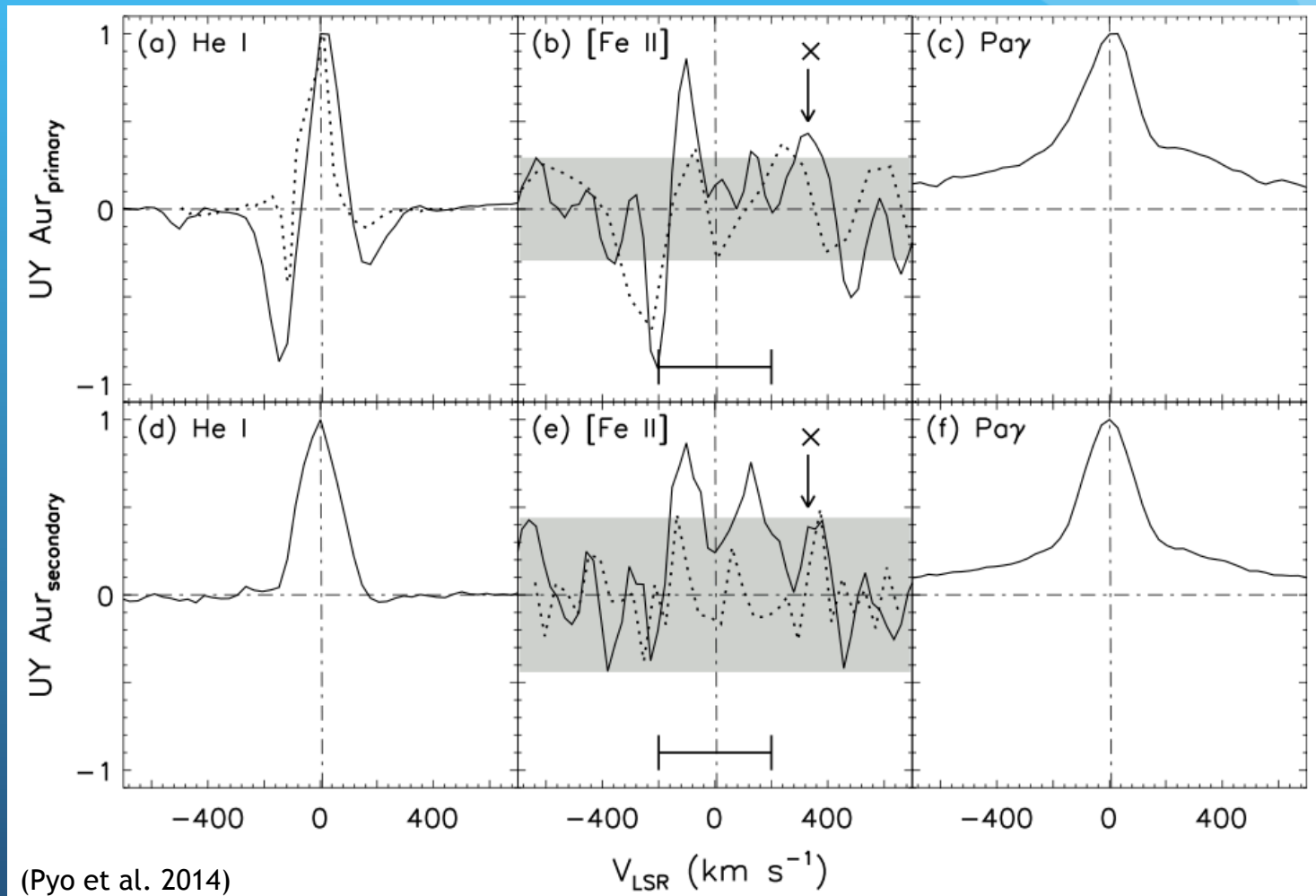


Gunther & Kely 2002

# Observation

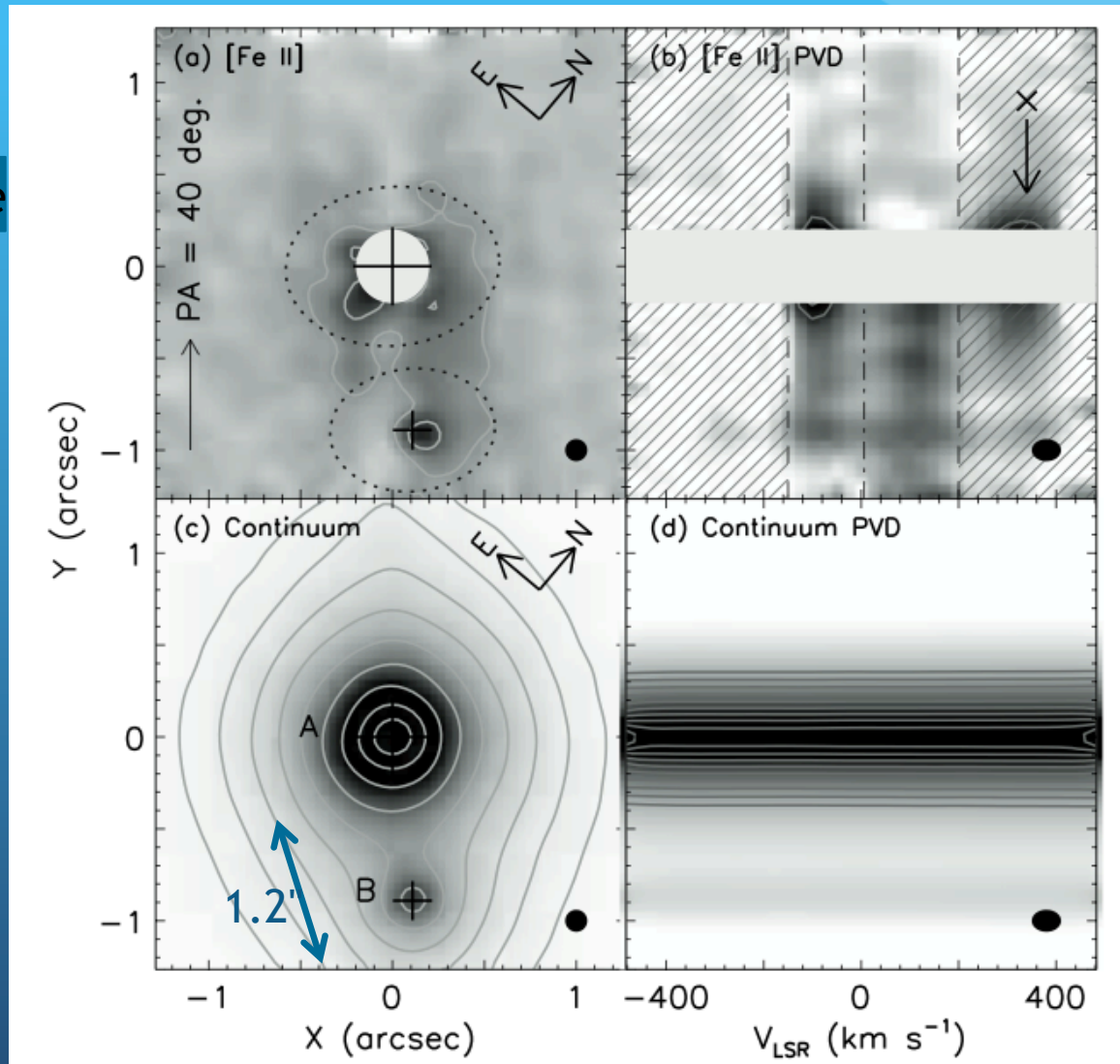
- Subaru-Gemini Time Exchange Program
- NIFS/Gemini : IFU,  $R \sim 5000$
- J-band configuration:  $1.06 - 1.28 \mu\text{m}$
- OBS date: 2007. Feb. 13 UT
- Seeing w/ AO :  $0.14''$

# He I , [Fe II], Pa $\gamma$



# [Fe II] : Shock and Outflows

Line Image



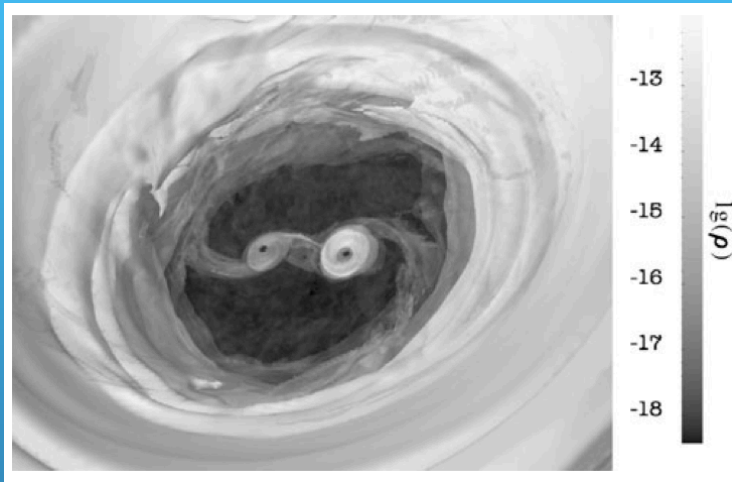
Position Velocity Map

7/26/14

(Pyo et al. 2014)



# Connection between binary



Fateeva et al. 2011

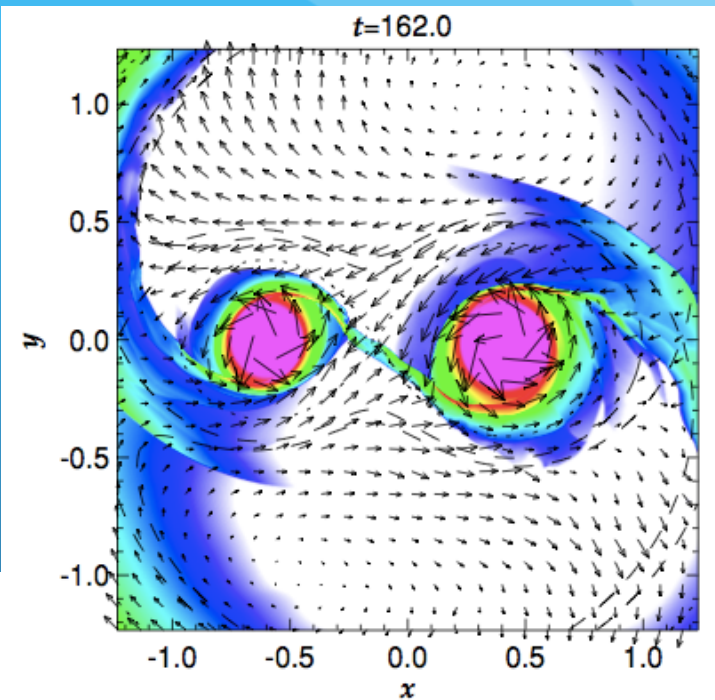
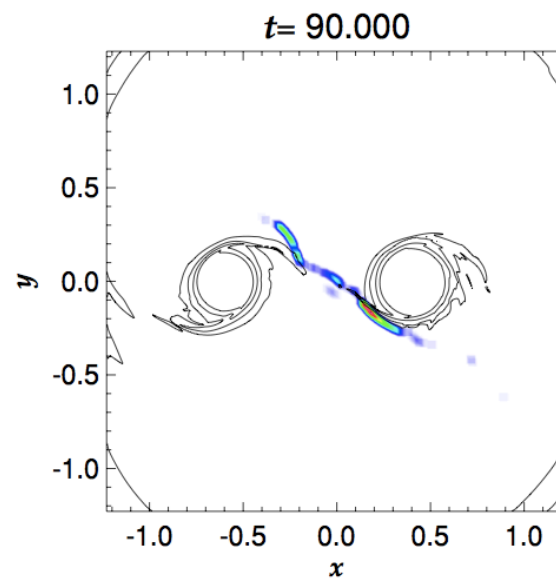
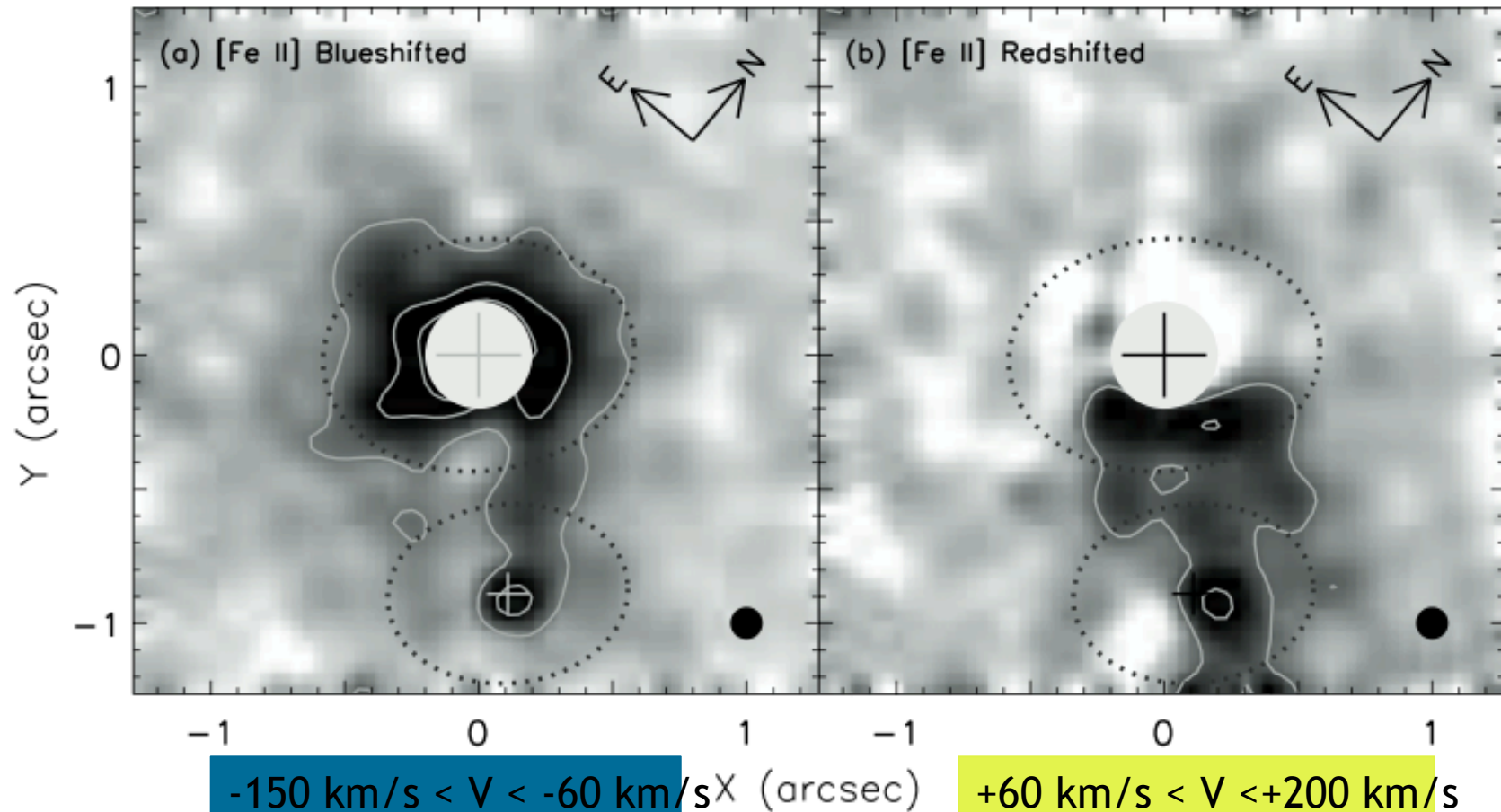


Figure 12. Surface density distribution around the binary at  $t = 162.0$  in model 2.

Hanawa et al. 2010

# [Fe II]: Blue and Red

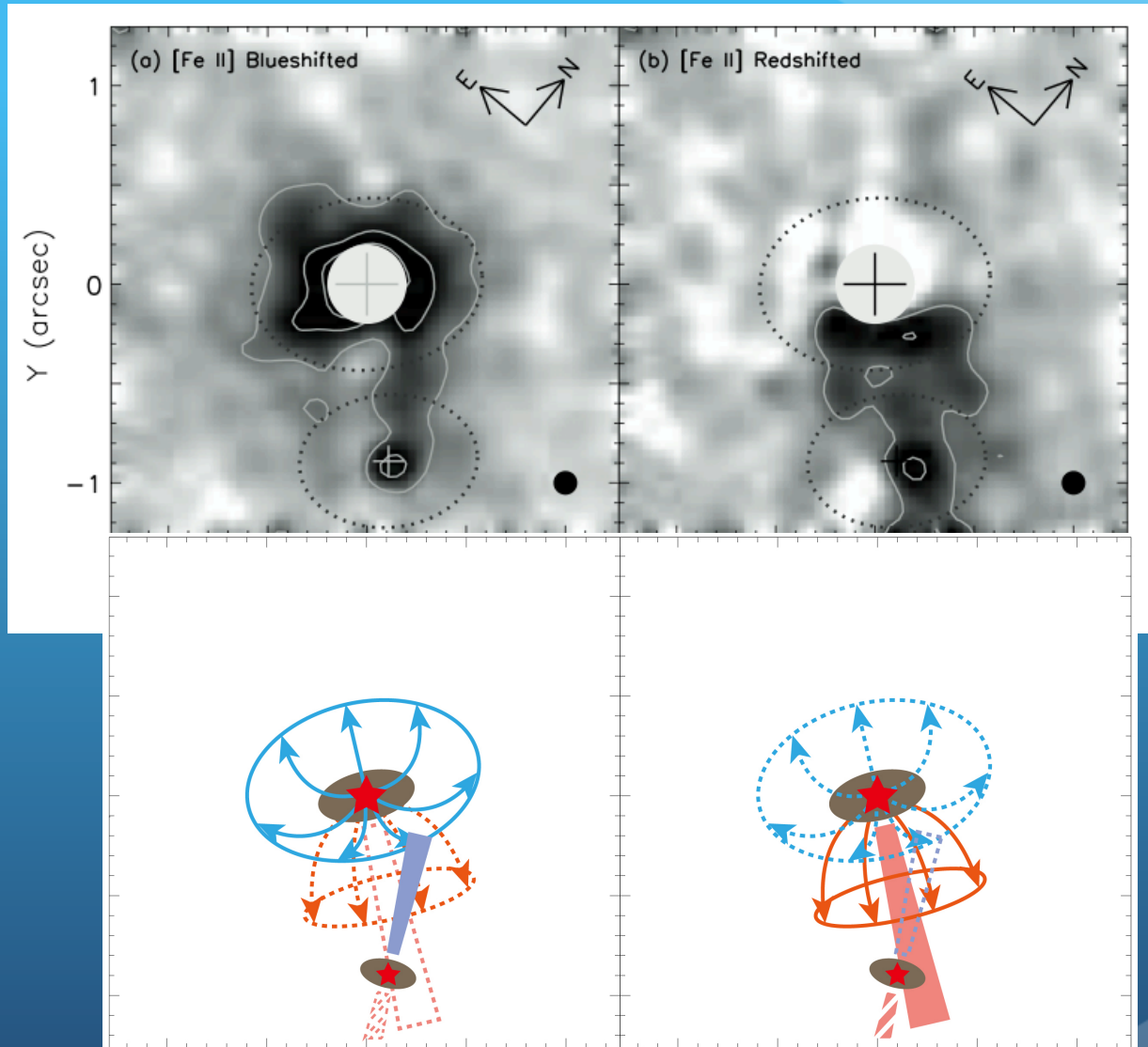


(Pyo et al. 2014)

Velocity too high for gas stream → outflow origin

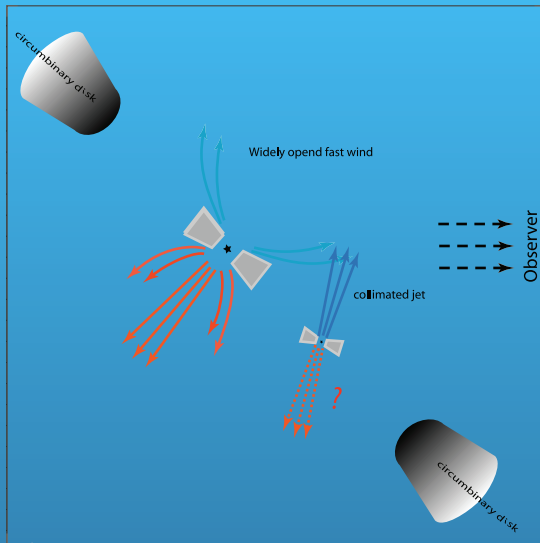
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# Analysis by bipolar outflow context<sup>11</sup>

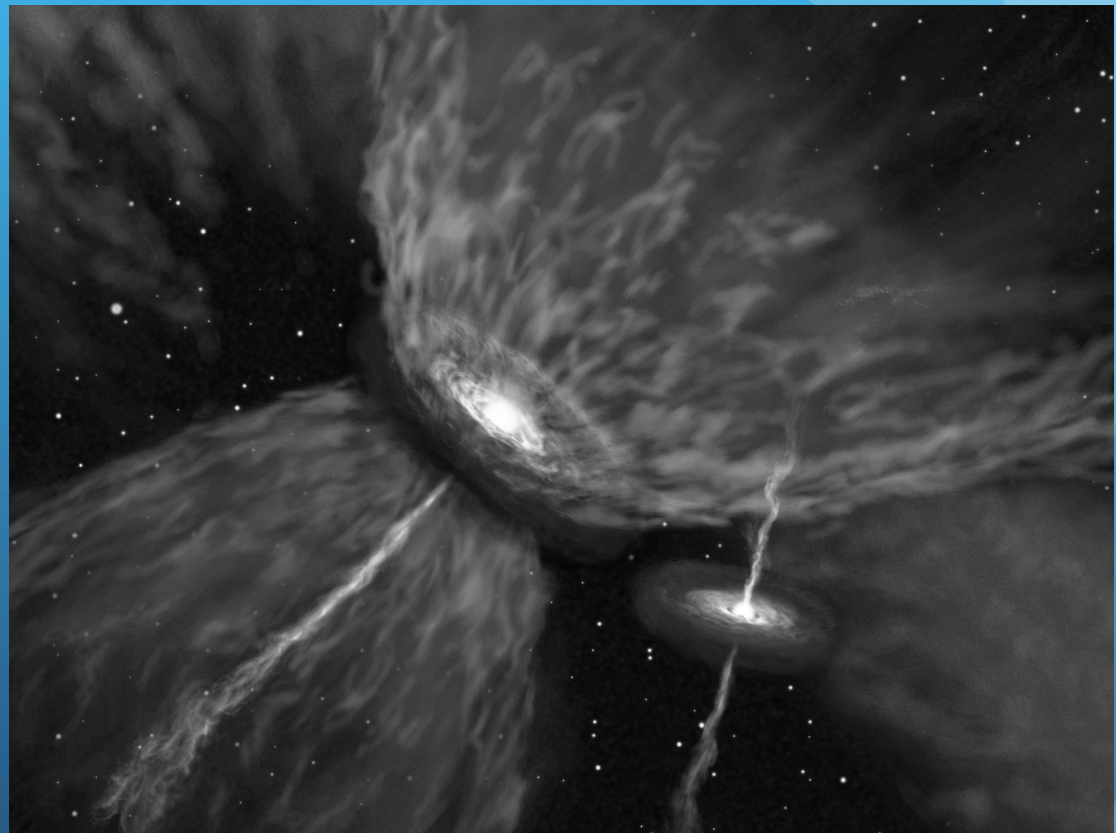


(Pyo et al. 2014)

# [Fe II]: Wind and Jet from Binary

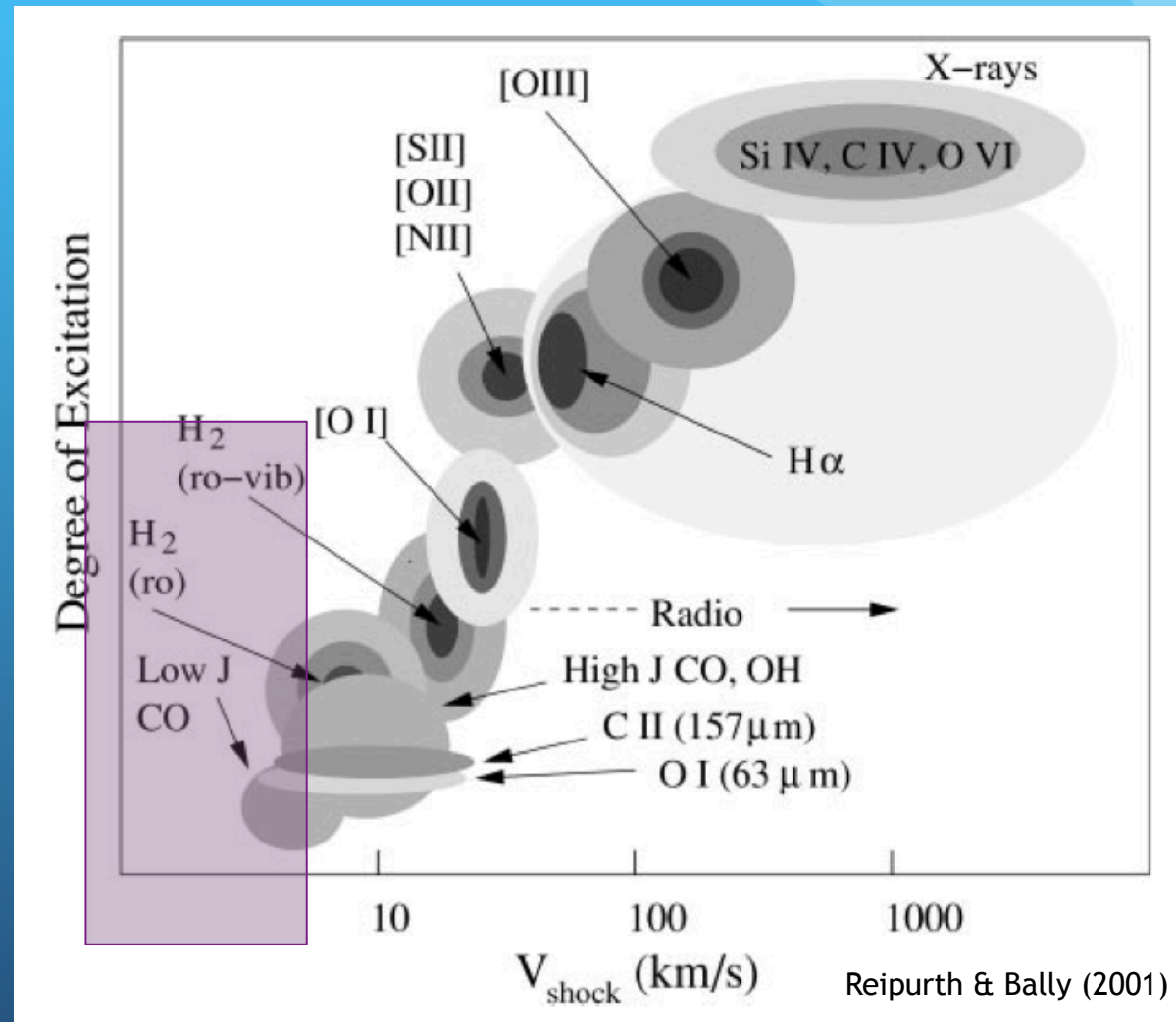


(Pyo et al. 2014)



# How to trace gas stream with shock

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# Summary

- IFS with high angular resolution can reveal the inner structure of interacting binary.
- TMT w/ AO :IRIS (IFU)
  - Atomic and molecular jets (cf. [Fe II], H<sub>2</sub>, He I, ...)
- ALMA : Gas stream (shock) with molecular tracers
  - H<sub>2</sub> (rotational), etc..