

**Subaru + CIAO + AO  
Direct Observations of  
Bridged Twin Protoplanetary Disks in a Young Multiple Star**

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**Observational Studies of  
Protoplanetary disks in a Multiple star**

**Protoplanetary disk**

- natural by-products of stellar evolution
- precursors of planet formation

**Formation a single star→advanced**

**Formation of binaries →unexplained mystery**

**If a forming star has close companions,**

**→PP disk may be influenced.**

- **Single (Sun) : Minority**
- **Multiple : Majority (more than 70%)**
  - studying star & planet formation in multiple system
  - general processes of star and planet formation

## History of Young Binary Formation Studies

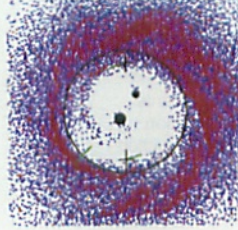
### ~Accretion from circumbinary disk to circumstellar disks

In Young binary, ①circumprimary disk ②circumsecondary disks ③circumbinary disk.

#### Observations



#### Theoretical Studies



SPH model  
Artymowicz & Lubow  
(1996)

Artymowicz & Lubow (1996)  
Bate and Bonnell (1997)  
Guenther & Kley (2002)  
Ochi, Sugimoto & Hanawa (2005)

A circumbinary disk can supply mass to the circumstellar disks through a gas stream that penetrates the disk gap without closing it.

→ This infalling material through the spiral arm plays an important role in the formation of circumstellar disks. However, circummultiple disks and spiral arms have never been directly resolved to date.

No observational data enables a comparison with theoretical models of mass accretion in binary systems, particularly inner area of young binary. Observations and theoretical studies have proceeded independently.

High resolution+High contrast observations

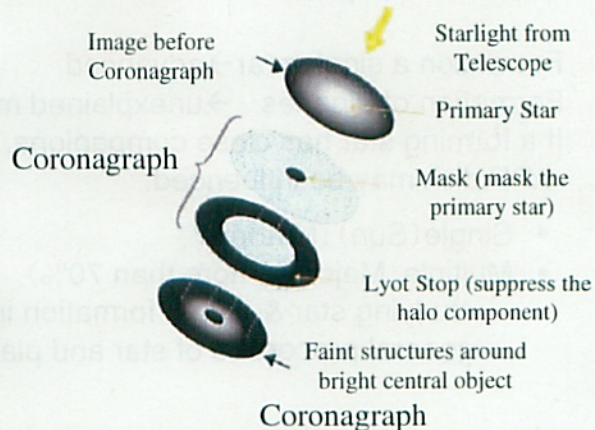
- resolve inner areas of young binaries
- Subaru + Coronagraph + AO
- Report one of our result.

## instrument: CIAO+AO

- CIAO (Coronagraphic Imager with Adaptive Optics): instrument for imaging faint objects close to much brighter objects
- AO: obtain sharpen images
- Coronagraph: obtain high contrast images of faint circumstellar matter around a bright central object



CIAO



### Observations

Telescope	Subaru Telescope
Camera	CIAO+AO
Wavelength	1.65(H)[ $\mu$ m]
Pixel scale	0."0213/pixel
Field of View	22"
Diameter of Occulting Mask	0".8
FWHM	0."1

**Method, Results and Discussions  
are deleted as they include  
unpublished data.**

## Summary

1. We present the direct image of an interacting binary protoplanetary system. Both circumprimary and circumsecondary disks were successfully resolved, the first such observation for a young stellar object.
2. The binary system exhibits a bridge of infrared emission connecting the two disks and a long spiral arm extending from the disk.
3. Bridge corresponds to gas flow and a shock wave caused by the collision of gas rotating around the primary and secondary stars.
4. Fresh material streams along the spiral arm, confirming the theoretical proposal that gas is replenished from a circummultiple reservoir.
5. Our observations provide the first direct image that enables a comparison with theoretical models of mass accretion in binary systems. The observations of this binary system provide a great opportunity to test and refine theoretical models of star and planet formation in binary systems.

Thank You!!!!