Observational Studies of Disk Formation around Protostars

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Disks are everywhere



e.g., Guilloteau & Du 2000; Pietu et al. 2007 Fukagawa et al. 2013



When and How Disks Form?



When and How Disks Form?



SMA Observations

Contour: total integrated intensity Color: mean velocity



Radial Profiles of Rotational Velocities



Yen et al. 2013

Evolution of Rotational Profiles



From slow to fast and then to Keplerian rotation

Yen et al. 2013

Evolution of Rotational Profiles



Caveat: actual time scales depend on initial conditions.

Yen et al. 2013

ALMA Observations Contour: total integrated intensity Color: mean velocity



• Symmetric with respect to the protostar

DEC (J2000)

- Clear velocity gradient perpendicular to the outflow
- Can be reproduced with simple disk models

Yen et al. 2014; Ohashi et al. 2014; Aso et al. submitted to ApJ

From Infall to Keplerian Rotation

Color = model of Keplerian rotation

2

0

1

VELO (km s^{-1})

З

Yen et al. 2014

e.g., L1489 IRS



From Infall to Keplerian Rotation

e.g., L1489 IRS



<u>Color = model of infall+disk</u>





Disks around Class 0 and 0/I Protostars?



- Most (14/17) of Class 0 protostars likely can have Keplerian disks of a 100 AU scale.
- Three sources showing no sign of rotation
 → Keplerian disks (if present) are small <10 AU.

Possible Sign of Magnetic Braking

Multi-scale observations of B335



Summary

• SMA observations:

Evolution from slow, to fast, and to Keplerian rotation on scales of ~1000 AU

• ALMA observations:

Transition from infall to Keplerian rotation

• Larger sample:

Class 0 sources likely can have disks of a 100 AU scale

• Subsample:

No clear sign of rotation \rightarrow very small disk <10 AU. Candidates of effective magnetic braking.