Counter-rotating, Infalling Envelope around the central Keplerian Disk in IRAS 04169+2702

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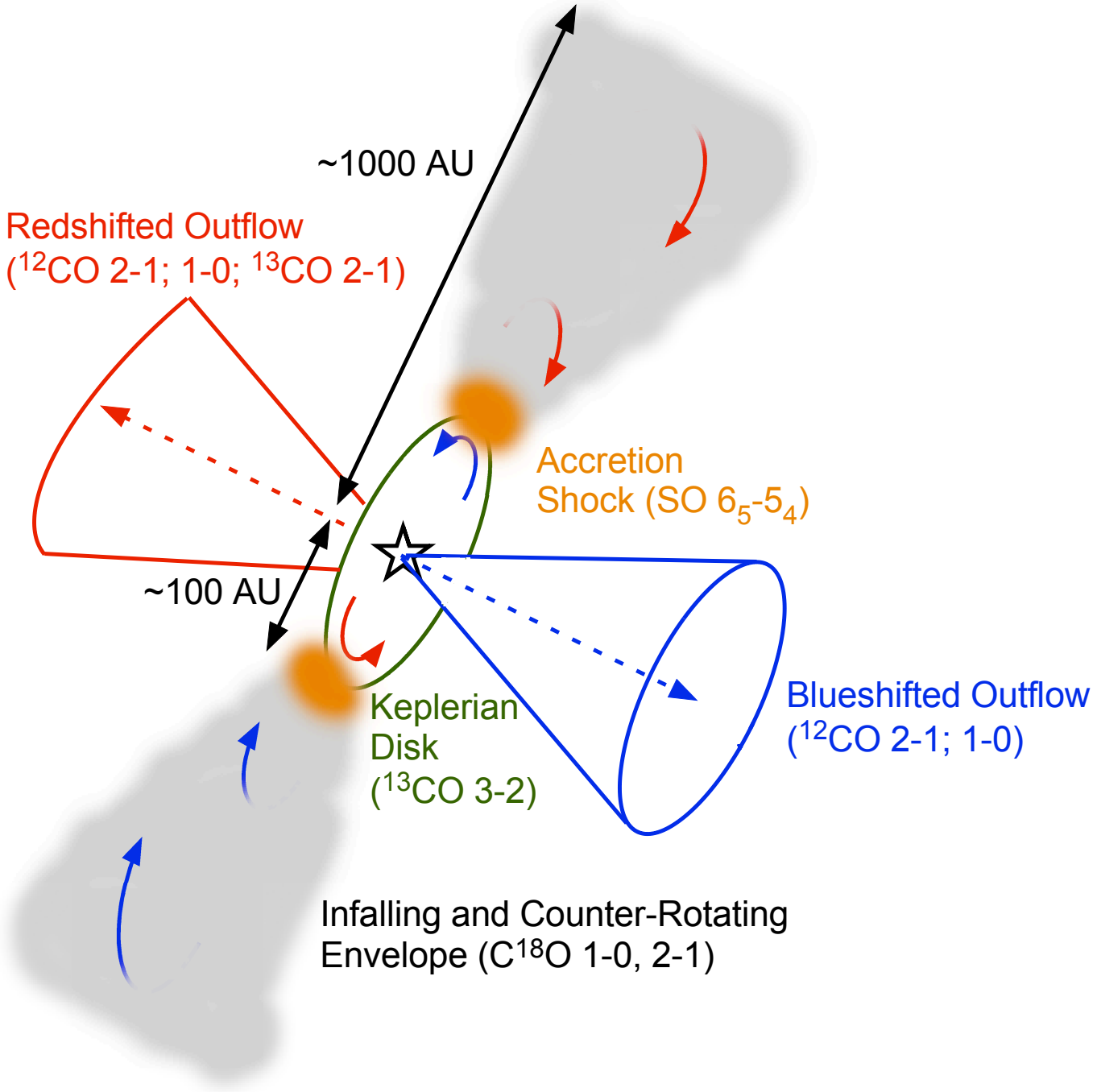
この発表の内容:

Class I 原始星 IRAS 04169+2702 の SMA 観測の結果



Introduction

Rule of Magnetic Fields in Protoplanetary-Disk Formation

—> Still Controversial.

Magnetic Braking cannot make Large (>10 AU) Disks ?

Non-Ideal MHD Effects can form Disks ?

Magnetic Fields are not easy to measure observationally.

Evidence for Magnetic Fields from Observed Gas Motions ?

—> Counter Rotation!!

Our Target: Class I Protostar IRAS 04169+2702

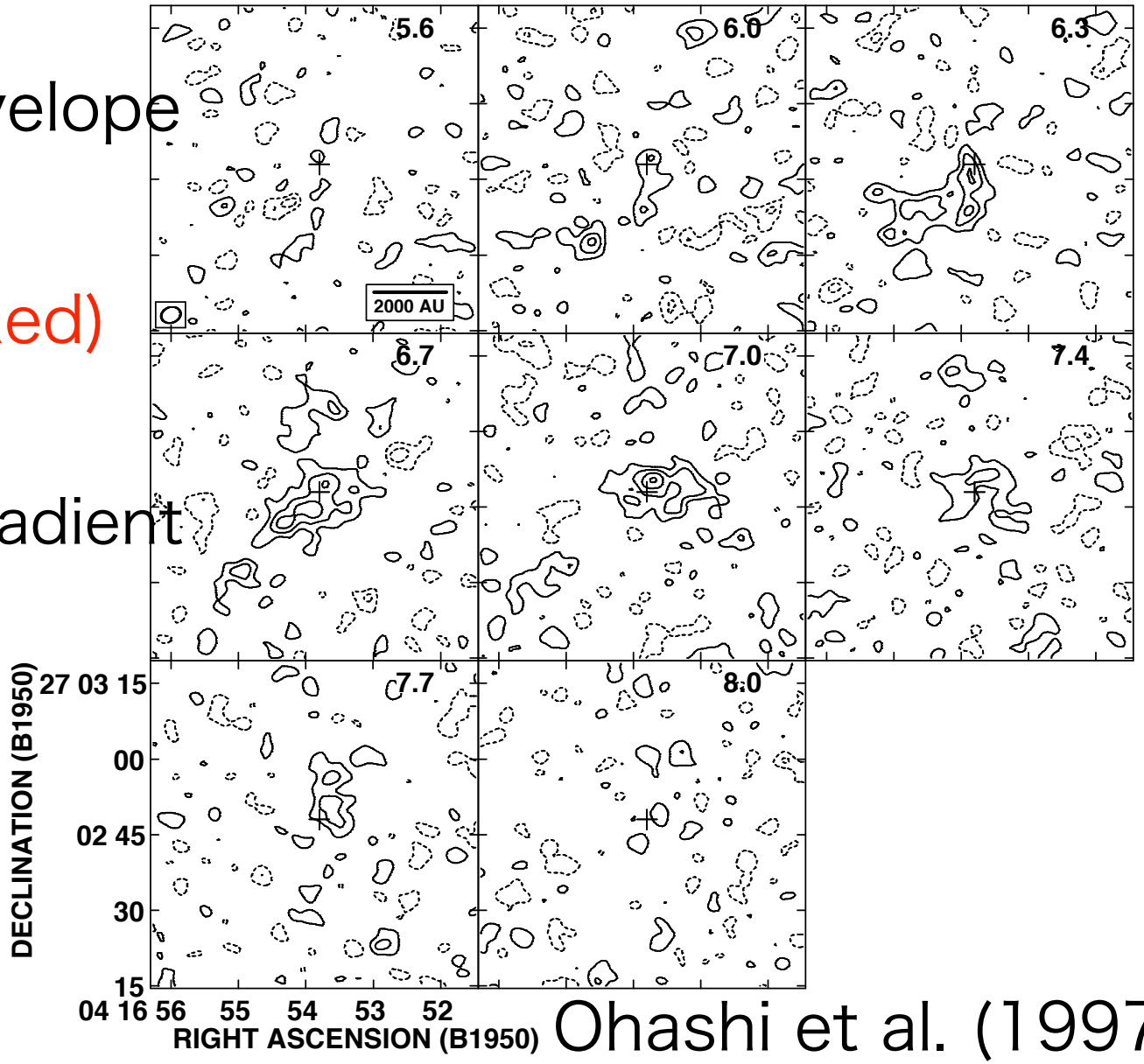
Tbol ~133 K; Lbol ~0.76 Lsolar; in the B213 Cloud

2200×1100 au Envelope in $C^{18}O$ (1-0)

NW (Red)

Envelope Velocity Gradient

SE (Blue)



Ohashi et al. (1997)

SMA Observations of IRAS 04169+2702

^{13}CO (3-2) with the Extended & VEX Configurations

Resolution ~0.5 arcsec

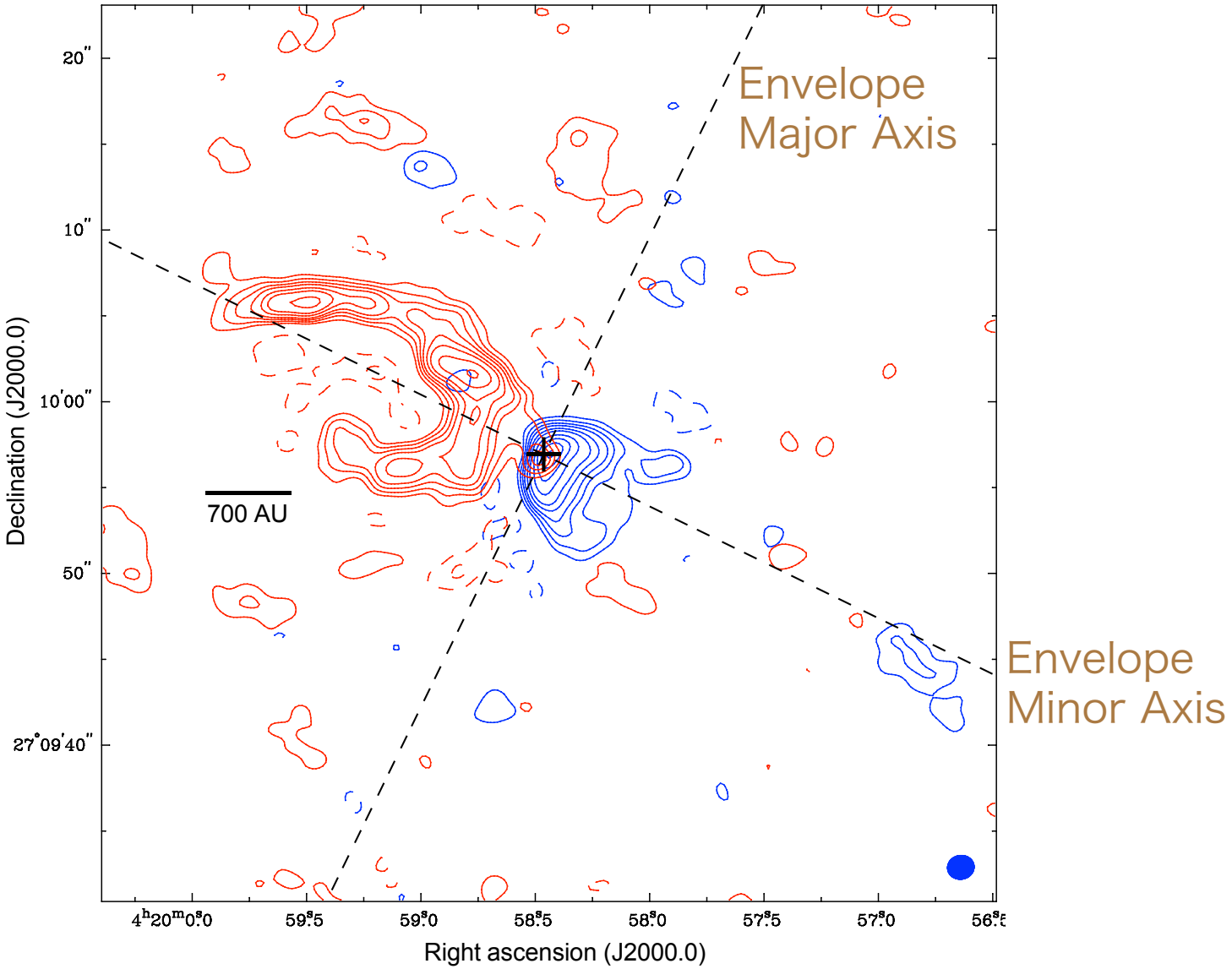
SMA Archival Data of IRAS 04169+2702 (PI. Tyler L. Bourke)

^{12}CO (2-1), C^{18}O (2-1), and SO (6_5-5_4)
with the Compact Configuration

Resolution ~2-3 arcsec

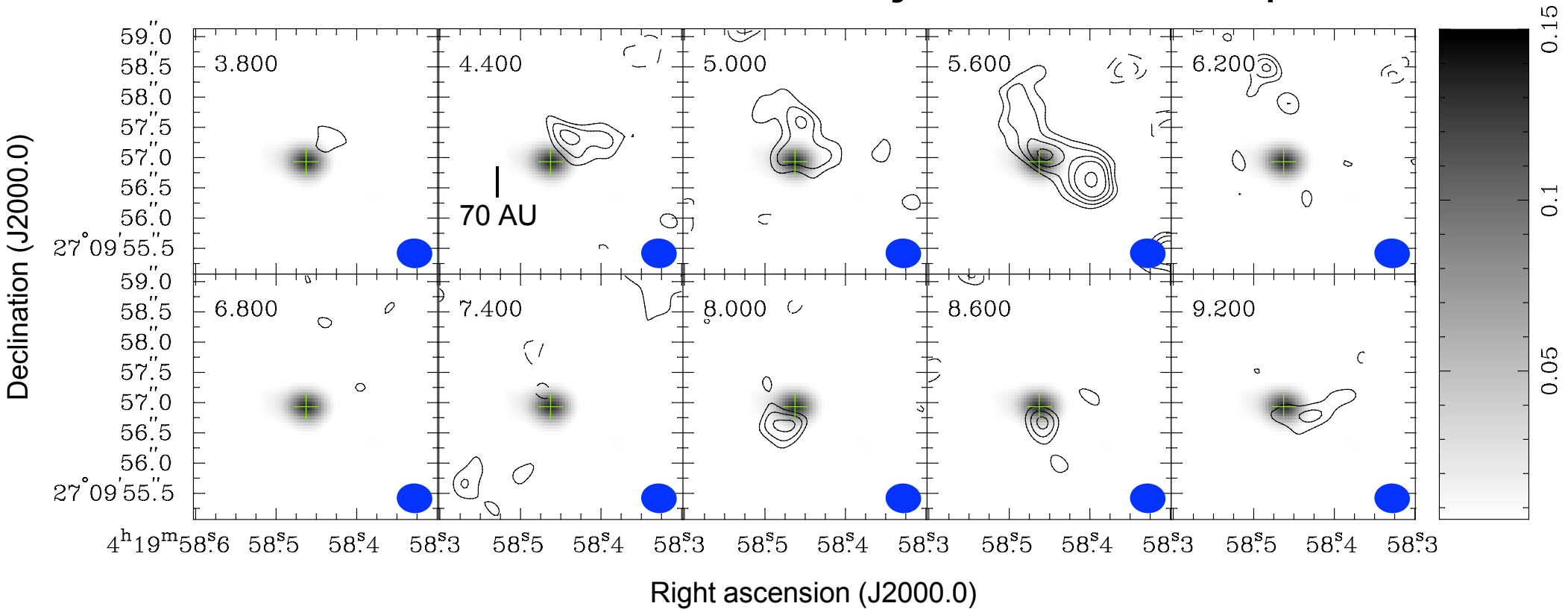
Apparently No ALMA data for this Source.

^{12}CO (2-1) Outflow



Outflow Direction Perpendicular to the major axis of the r~1000 AU scale C^{18}O (1-0) Envelope

SMA ^{13}CO (3-2) Velocity Channel Maps



NW (Blue)

r~100 AU scale Disk

SE (Red)

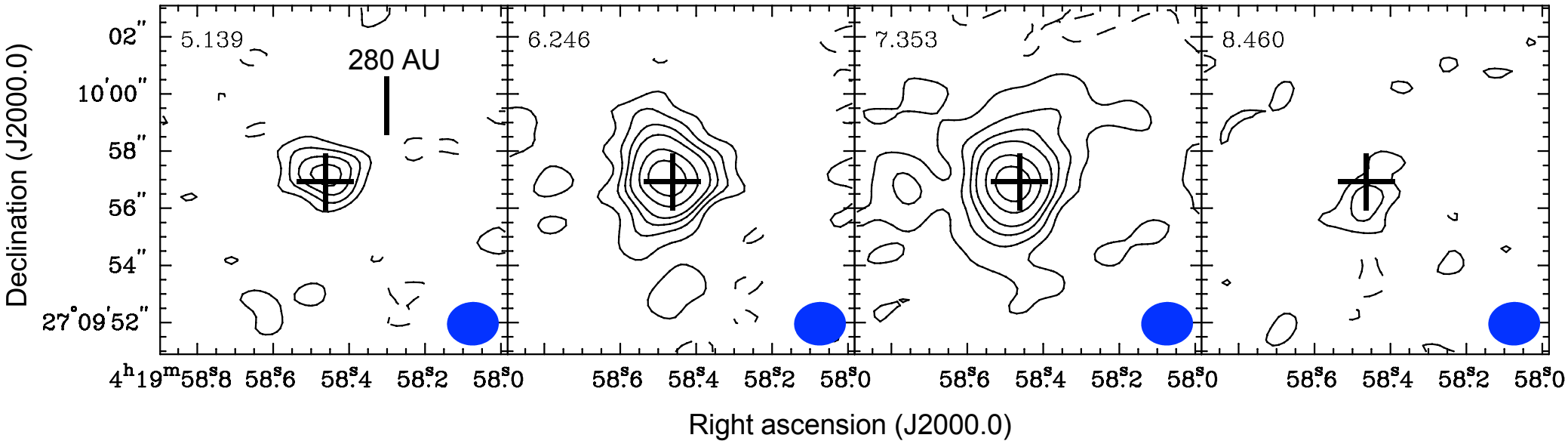
NW (Red)

r~1000 AU Envelope

SE (Blue)

Opposite!!

SMA SO (6_5-5_4) Velocity Channel Maps



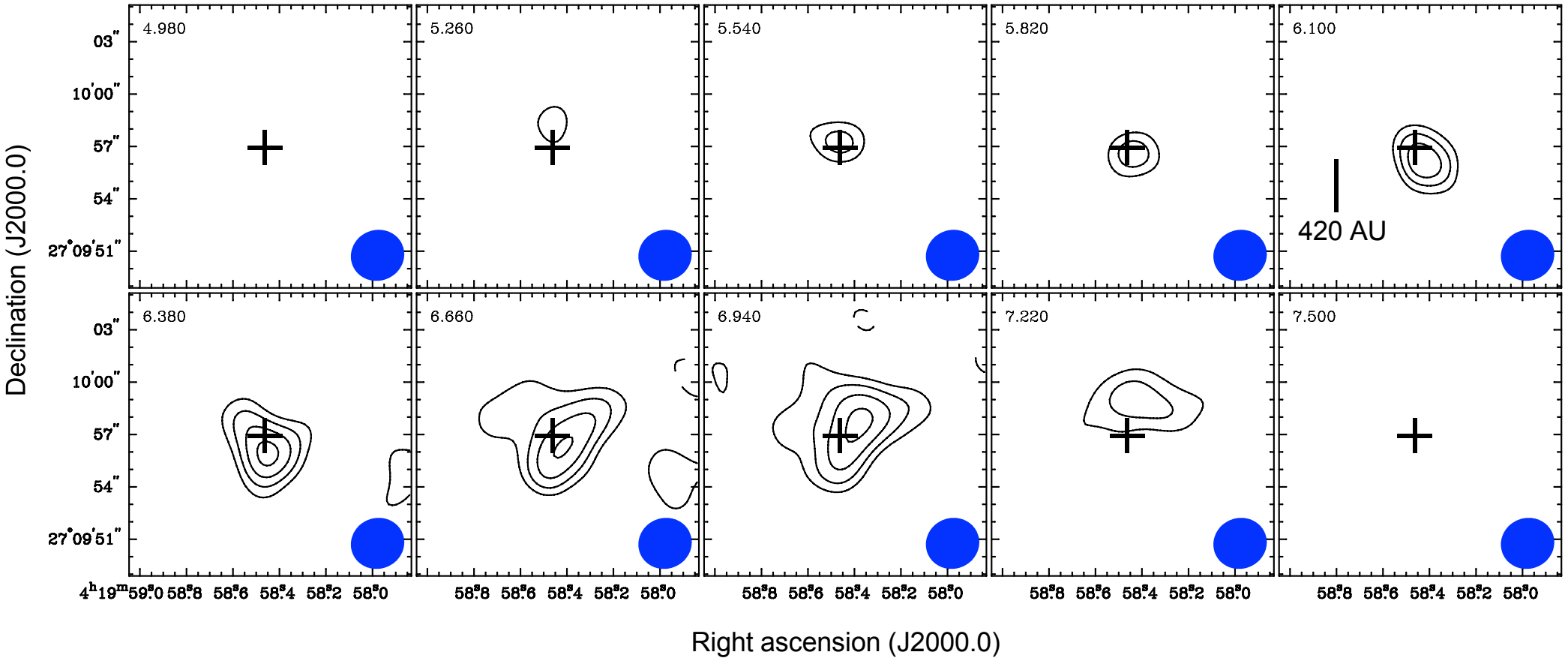
Velocity Gradient consistent with that of ^{13}CO (3-2)

—> Opposite to that of the $C^{18}O$ (1-0) Envelope.

SO is a tracer of the accretion shock (Yen et al. 2014)

—> The outermost ringlike region of the Disk ?

SMA $C^{18}O$ (2-1) Velocity Channel Maps



NW (Red)

r~400 AU scale inner Envelope

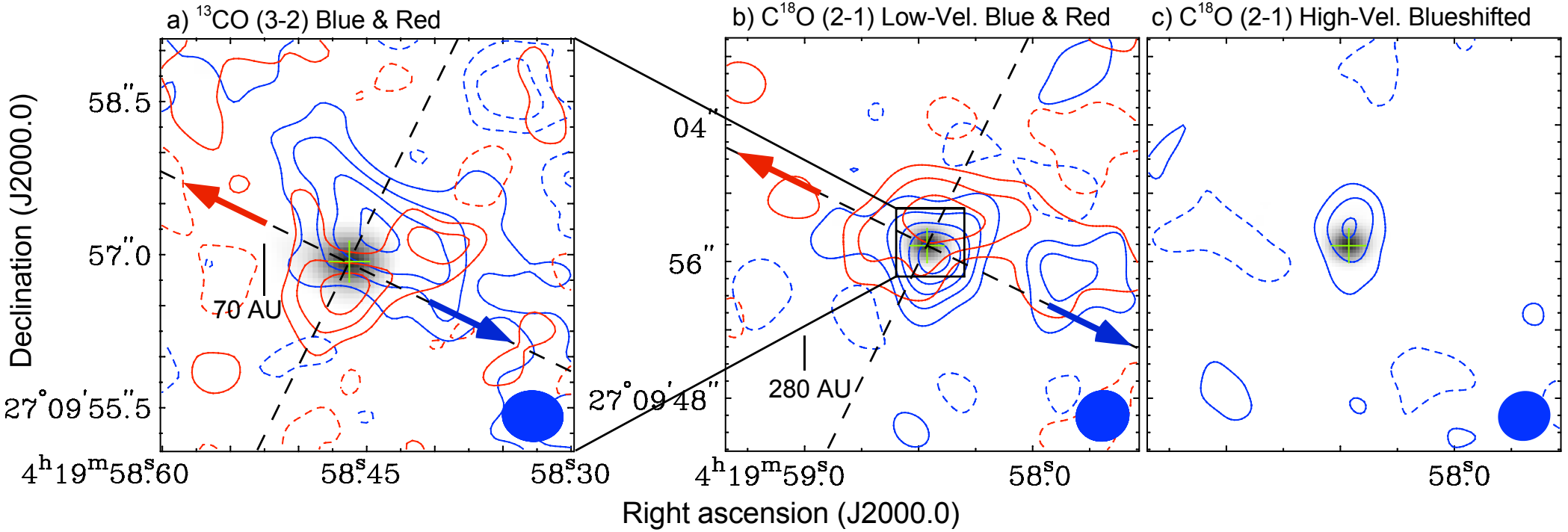
SE (Blue)

NW (Red)

r~1000 AU Envelope

SE (Blue)

SMA High-Reso. ^{13}CO (3-2) and Low-Reso. C^{18}O (2-1)

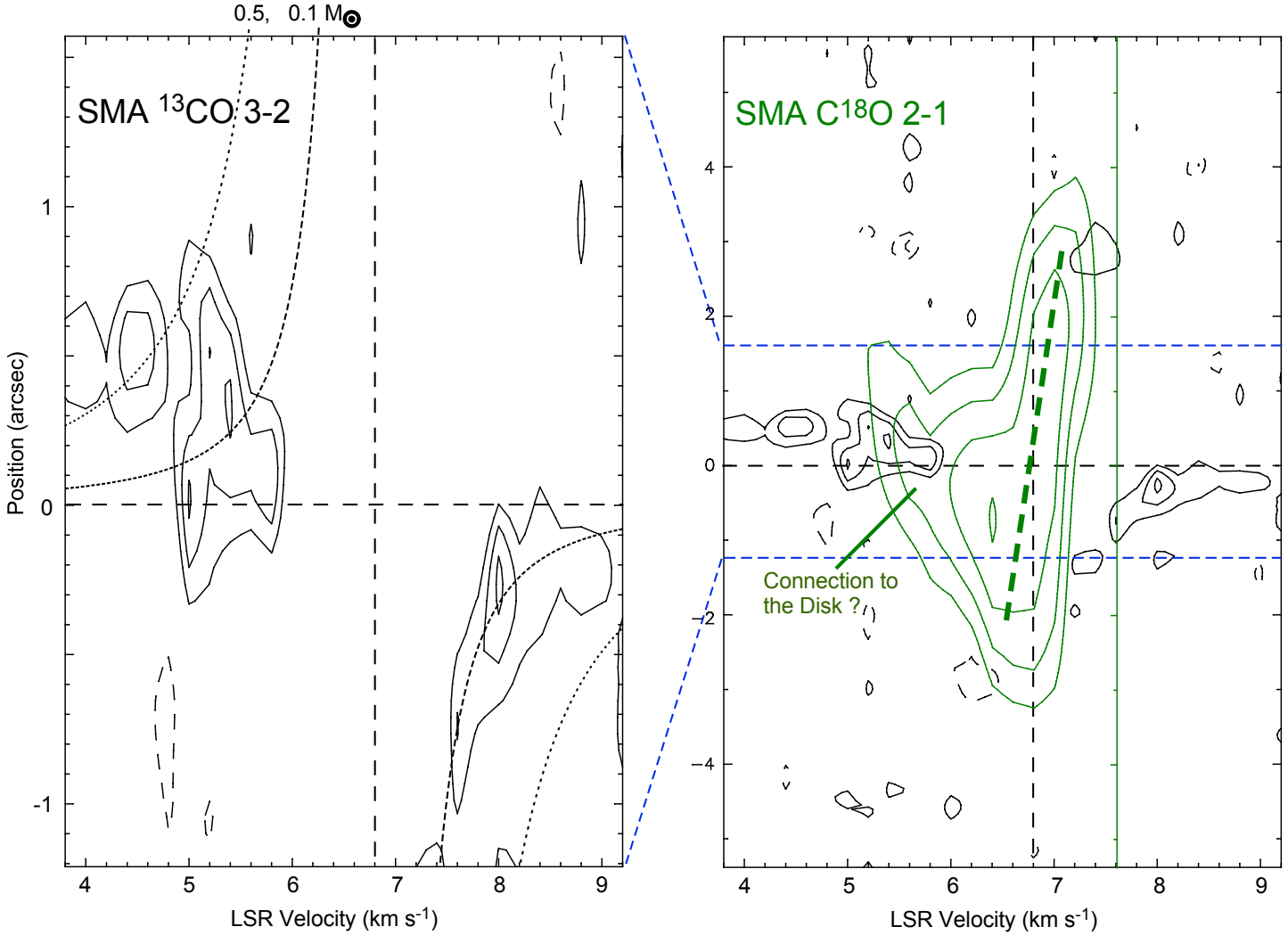


Along the major axis, r~100 AU ^{13}CO (SO as well)
and r~400 AU C^{18}O exhibit the Opposite Velocity Gradient.

High-Velocity Blueshifted C^{18}O 2-1 Emission
—> Same as the ^{13}CO component ?

C^{18}O also exhibit the NE-SW Velocity Gradient —> Infall

SMA P-Vs along the Major axis



^{13}CO can be r~100 AU Keplerian with 0.1 Msolar.

C^{18}O Envelope exhibits the opposite rotation, plus the Blueshifted Disk component.

Discussion

Inversion of the rotation occurs between r~100 and 400 AU.

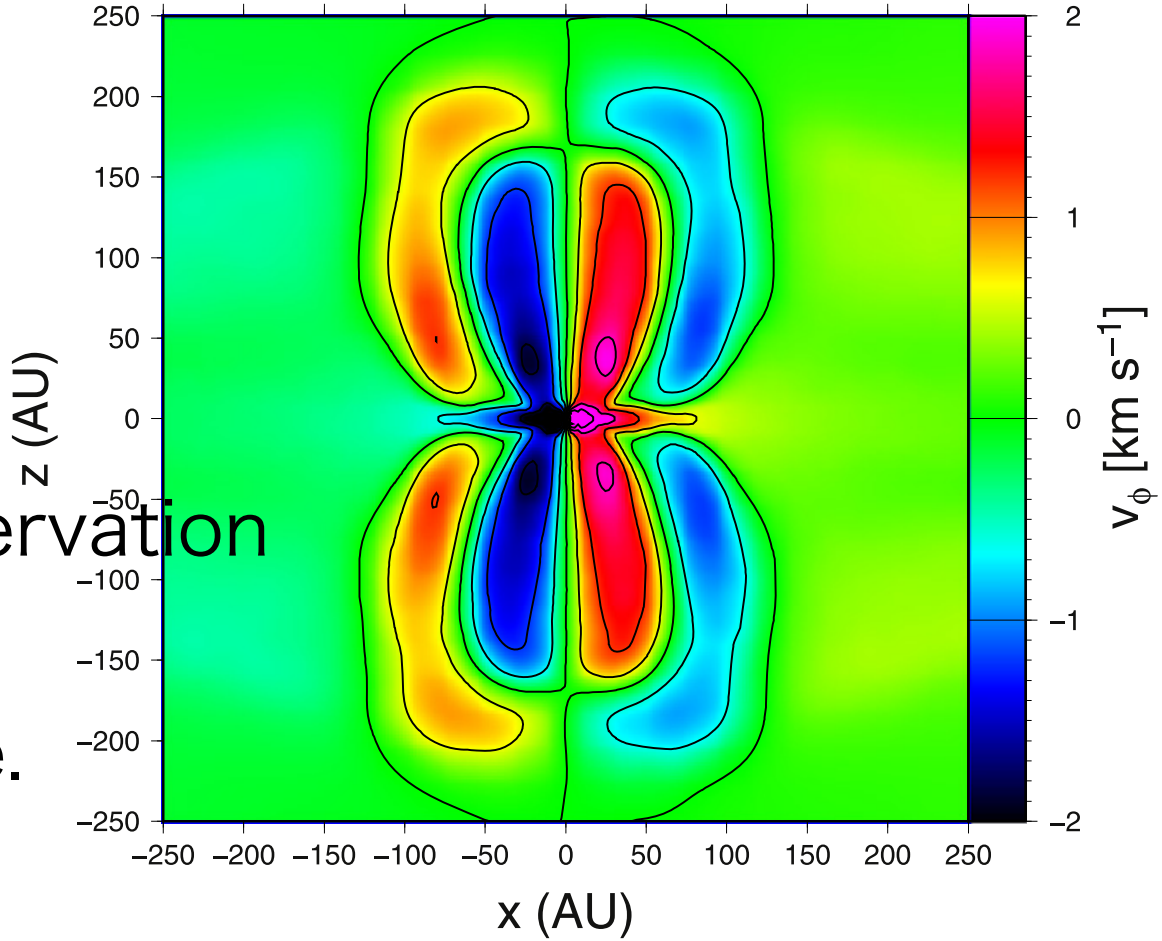
Cannot be explained with the simple dynamics.

—> Need to invoke Magnetic Fields!

Hall Effect accelerates disk rotation.

Angular momenta conservation

—> Counter Rotation in the outer envelope.



Tsukamoto et al. 2015

Summary

Possible Counter Rotation between
the r~100 AU scale Disk in ^{13}CO 3-2 and SO
and the r> 400 AU scale Envelope in $C^{18}O$ (1-0) and (2-1)

Observational Signature of the Effect of the magnetic field, “Hall Effect” ?

Counter rotation between protostellar envelopes and disk should be an unique measure to identify the effect of magnetic fields in disk formation.