Stability of polarimetry in Kanata/HONIR observations and recent result of polarimetric survey of a starless core's ambient A03 110

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Abstract

We are promoting multi-messenger astronomy using the Kanata 1.5m telescope, and its dedicated instruments HONIR. HONIR is capable of imaging, spectroscopy, imaging-polarimetry, spectro-polarimetry modes in both optical and NIR channels simultaneously. In the first half of poster, we report on the results of the long-term observation of the polarimetric standard stars, including observation through wire-grid.

In the second half of this poster, we show the magnetic field structure of starless core by polarization survey of ambient core. Magnetic field is about twice as large as those in typical clouds. We use virial analysis with each energy, gravitational contraction is suppressed by strong magnetic pressure, and it is consistent to no signs of star forming.

Kanata telescope & HONIR

Kanata Telescope

1.5m main mirror (5th largest in Japan)

Rotating speed : 6 degree/sec (azimuth)

3 degree/sec (altitude)

→Merit in high response observation (e.g. GRBs, GW)

FoV : 15 arcmin diameter

Usable 1 Cassegrain focus and 2 Nasmyth foci

Kanata Telescope & HONIR

HONIR (Akitaya+ 2014)

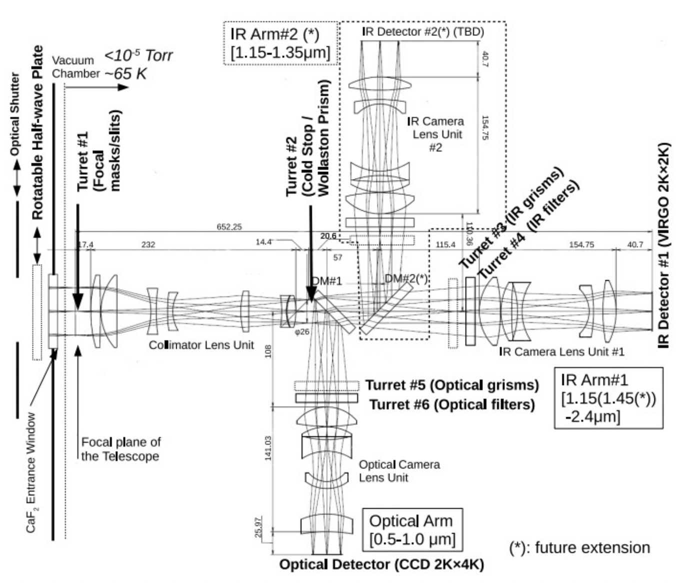
Mounted on Cassegrain focus

Mode : Imaging, Spectroscopy, Imaging-Polarimetry, Spectro-Polarimetry

FoV : 10' × 10'

Opt : HPK 2k4k CCD; B, V, Rc, Ic, Y

NIR : Raytheon 2k2k HgCdTe; Y, J, H, Ks



Optical Design of HONIR

We can observe simultaneously in 2 channels (Opt & NIR) !

We are planning to introduce another 1 NIR channel (i.e., 3rd channel) for HONIR

Polarimetric Calibration of HONIR

We evaluate the stability of HONIR polarimetry from the long-term results of unpolarized and strongly polarized stars

Instrumental polarization calibration

Polarization emerged within the telescope and instrument

→ Observe unpolarized star and subtract its polarization from target ones

Instrumental polarization is negligibly small and stable

object	date	Q_{inst}(%)	Q_{error}(%)	U_{inst}(%)	U_{error}(%)
BD32d+373	2024/07/17	0.08	0.06	0.01	0.04
	2022/04/04	-0.04	0.04	0.005	0.02

Example of observed unpolarized star status by HONIR (R-band)

Offset of position angle

Difference of position angle of polarization of the instrument from that in the celestial coordinate

object	date	P(%)	P_{error}(%)	θ(deg)	$θ_{error}$(deg)
BD64d+106	2024/10/11	5.33	0.03	63.1	0.2
	2022/11/02	5.31	0.04	62.4	0.2
HD 204827	2024/09/28	5.03	0.03	25.4	0.2
		5.03	0.02	24.3	0.1

Example of observed strong polarized star status by HONIR (R-band)

→ Compile the past results of strongly polarized standards (Schmidt+ 1992)

Offset angle is stably 34.1±0.6 degree

Wire-grid

Wire-grid plate : Producing nominal 100% polarization

→ We correct for the instrumental depolarization using the results with wire-grid.

2024/05/14	B	V	R	I	J	H
P(%)	98.3±0.06	98.9±0.03	99.1±0.03	99.2±0.09	99.8±0.05	99.8±0.10

Result of wiregrid observation by HONIR

Magnetic field structure of starless core

Star formation process with magnetic field

Molecular cloud → Core → Protostar

Not just gravity but turbulence and magnetic field affects formation process

Starless core

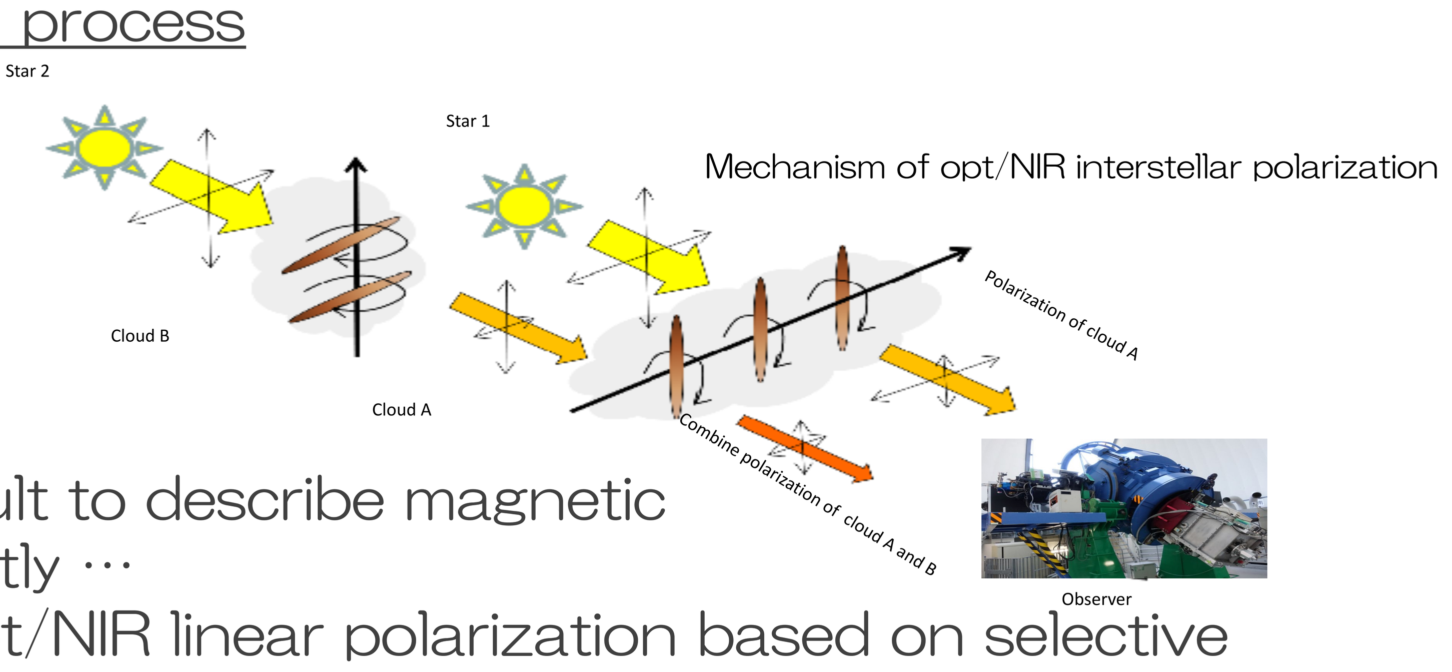
Having no protostar and no signs of star formation

Core just before

or

Core which cannot contract with something reasons like strong magnetic field

→ Structure of magnetic field of starless core is key to star formation process



Mechanism of opt/NIR interstellar polarization

It is difficult to describe magnetic field directly …

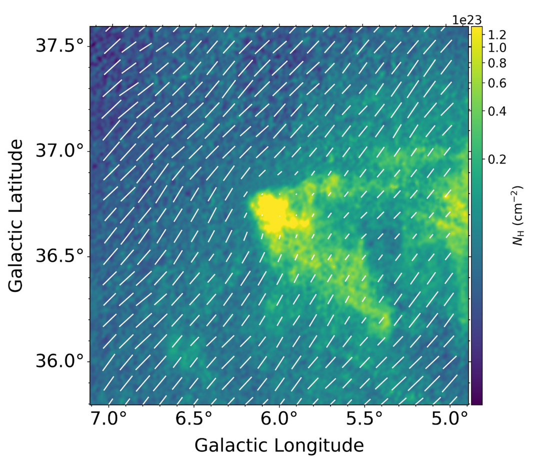
→ Use opt/NIR linear polarization based on selective absorption by aligned non-spherical dust

MBM 37 / L 183

• High galactic longitude cloud including evolved starless core L 183

Distance ~121pc (Schlafly + 2014)

• Opt & NIR polarimetry in preceding study, but sample density is rough



Planck 353GHz magnetic field map (0.1° step)
Background : $N_h$map (Akari)

Observation

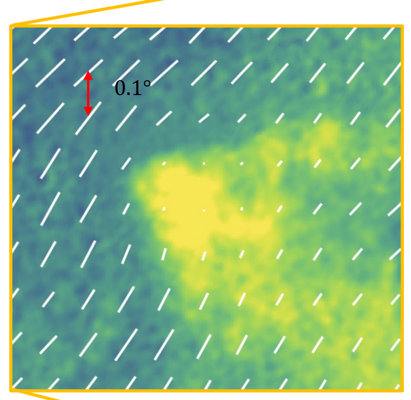
Epoch : May 2023 – September 2023 (7 regions)

Exposure time about 1 region

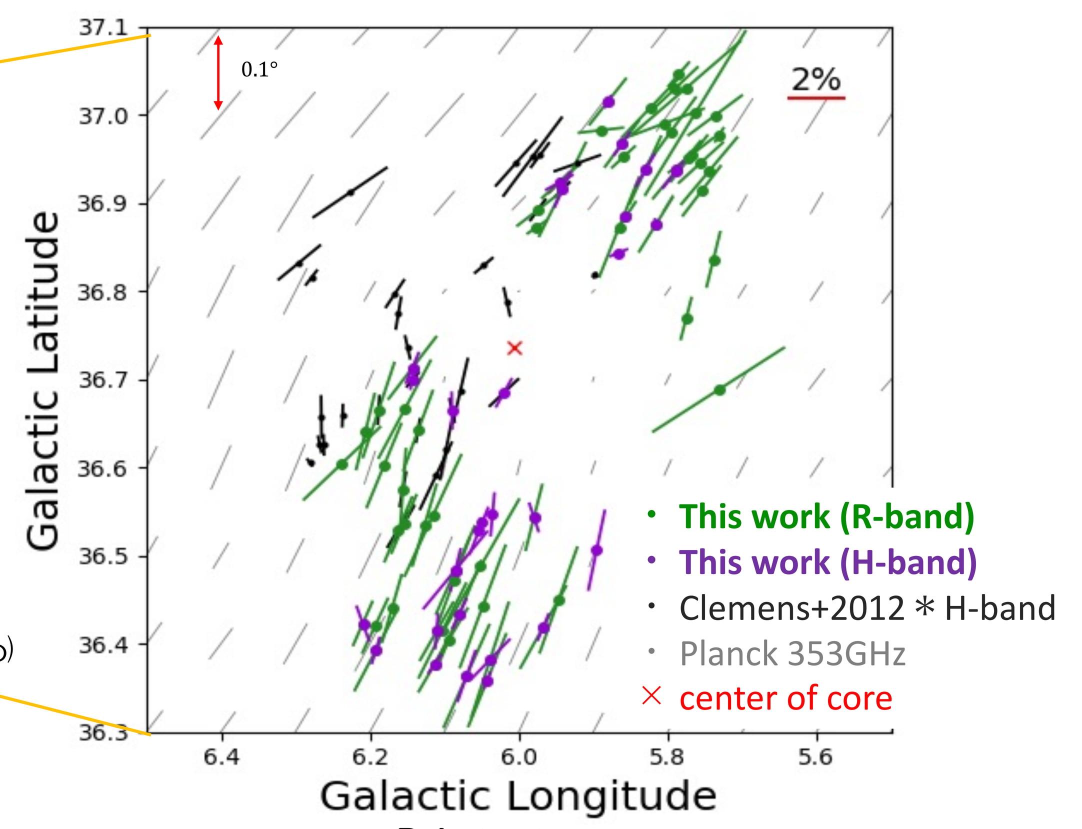
R-band(75s×4 wave-length plates PA×9 dithers),

H-band(60s×4 wave-length plates PA×9 dithers)

Result



Planck 353GHz magnetic field map (0.1° step)
Background : $N_h$map (Akari)



Polarization map

Core's ambient magnetic field is well consistent with Planck map
→Upper right region (interface of core) is aligned with a little shift
→Magnetic field is bended by molecular cloud or turbulence?

• Magnetic field strength is about 20~40 μG

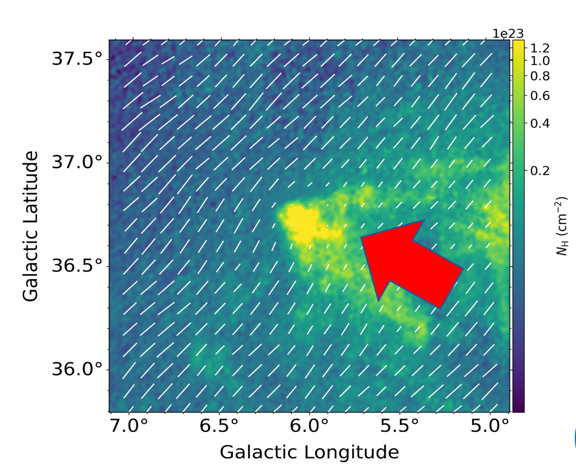
→Stronger magnetic field than same type (Neha+ 2018)

• Virial ratio (ratio of kinetic, magnetic and potential energy) about 10

→ In case of below 2, star formation go ahead by gravitational contraction

→ Consistent to no signs of star formation

Shape of cloud is like moving red arrow direction?
→ Ram pressure role



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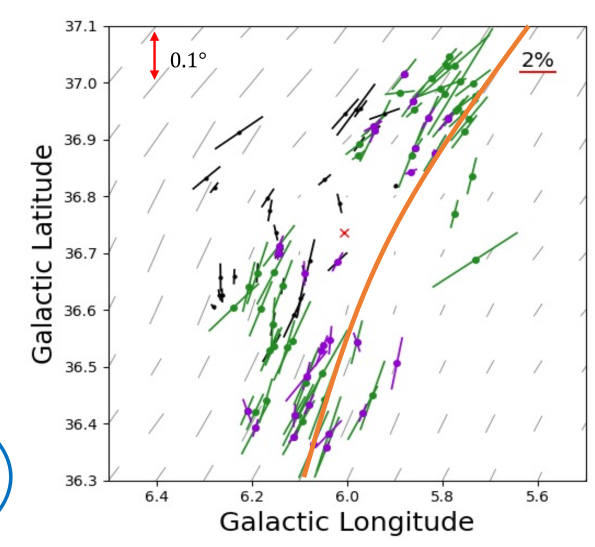
Balanced

Global distortion of magnetic field
→ Magnetic tension role



Estimated moving velocity is ~0.8 km/s
(ambient gas velocity is ~1.2 km/s Laureijs + 1995)