SELF SIMILAR MAGNETIC MORPHOLOGICS IN A MASSIVE STAR FORMING REGION

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BIMODEL FILAMENT ORIENTATION WITH PRESENCE OF GRAVITY

Perpendicular

Nakaruma & Li (2008)

Li et.al. (2013)

Parallel

Stone et al. (1998)
MAGNETIC FIELDS OFTEN BIPOLAR IN INTERSTELLAR CLOUDS

G240.31+0.07 @ Qiu et al. (2014)

G11.11−0.12 @ Pillai et al. (2015)

G0.253+0.016 @ Pillai et al. (2015)

G240.31+0.07

G11.11−0.12

G0.253+0.016

@ Qiu et al. (2014)

@ Pillai et al. (2015)

Perpendicular

Parallel

Nakaruma & Li (2008)

G31.41+0.31 @ Girart et al. 2009

Stone et al. (1998)
BIPOLAR: EVEN COULDS IN GLOUD BELT

Li et al. (2013)
Questions:

1. Magnetic fields *inherited from the inter cloud medium* or *governed by cloud turbulence*?

2. **Role of magnetic fields** in clouds from 100pc to 0.1pc?

3. Relation between fields in cores and the surrounding medium?

4. Cloud Fragmentation and HMSF theory *DRIVEN BY magnetic field*?

Strong initial field, supporting the cloud at ~100pc level, e.g. Shu, Adams, Lizano, Li, ...

Turbulence fragmentation + Dynamo. e.g. Padoan, Nordlund, Federrath, …
CANDIDATE: NGC6334

- One of the closest clouds that
  a. Close enough (1.7kpc) to allow observer to observe star-light polarization
  b. Have massive star forming site
A FIRST MULTISCALE STUDY OF HIERARCHICAL MAGNETIC FIELDS IN NGC6334

Li, Yuen et al. (accepted by Nature, 2015)
NGC6334 IS SUBALFVENC

Li, Yuen et al.
(accepted by Nature, 2015)
SIMULATION: TRANS-CRITICAL B-N RELATION DEFLATES

\[ y = 0.41x - 0.68 \]

95% confidence bounds

<table>
<thead>
<tr>
<th>scale (parsec)</th>
<th>( B ) (mG) ( \pm )</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 ((a))</td>
<td>0.19 \pm 0.08</td>
</tr>
<tr>
<td>1</td>
<td>1.2 \pm 0.7</td>
</tr>
<tr>
<td>0.1 (IN)</td>
<td>13 \pm 10</td>
</tr>
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<td>0.1 (I)</td>
<td>11 \pm 7.5</td>
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CF method = 1.4

Li, Yuen et al.
(accepted by Nature, 2015)
SIMULATION: HOW FRAGMENTATION DRIVEN BY MAGNETIC FIELDS

Stone et al. (1998)

STRONG MAGNETIC FIELD $\beta=0.1$

Yuen et al. (In prep)
SIMULATION: HOW MAGNETIC FIELD ELONGATES DENSITY PROFILE

$t=0.05$

$t=0.15$

$t=0.25$

Yuen et al. (in prep)
MAGNETIC CRITICAL DENSITY MATCHS WITH THE GRAVITATIONAL CONTRACTION THRESHOLD
PROBING MAGNETIC FIELD STRENGTH IS LIMITED BY PROJECTION EFFECT

Plane of sky: Polarization data + grain alignment

Line of slight: Zeeman measurement

Lazarian (1994-2015, graphs from his review in 2008)

Plane of sky: Ion-neutral linewidth difference (with ambipolar diffusion)

Li and Houde (2008)
ESTIMATION OF 3D MAGNETIC FIELD STRENGTH FROM POS DATA

Force balances in dual-core system

Point-by-point estimation on one set of data

Magnetic tension balance turbulence (CF Method)

Gravity balance magnetic pressure + tension
Koch et al. (2012), Zhang et al. (2014)

Li, Yuen et al. (accepted by Nature, 2015)

One estimation on one set of data

Magnetic correlation (HH method, Houde et al 2009)

CAN THIS GO RIGHT?
PRELIMINARY RESULT: FORCE BALANCE AROUND CORES

Yuen, Law et al. (in prep)

CF method = 1.4

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1. SELF SIMILAR MAGNETIC FIELD FROM 10PC TO 0.1PC
2. DIRECTION OF FIELD DOES NOT CHANGE SIGNIFICANTLY OVER ENTIRE SCALES
3. SUB-ALFVENIC-TRANS-CRITICAL SCENARIO ELONGLATES THE CLOUD TO BE PERPENDICULAR TO MEAN FIELD DIRECTION
4. MAGNETIC FIELDS FAVLOR MASSIVE STAR FORMATION AND CLOUD FRAGMENTATION
5. BETTER ESTIMATION OF MAGNETIC FIELD ENABLES US GETTING MORE MAGNETIC INFO FROM THE MAP

MAGNETIC FIELDS PLAY A CRUCIAL ROLE FOR CLOUD FRAGMENTATION (AT LEAST IN NGC6334)