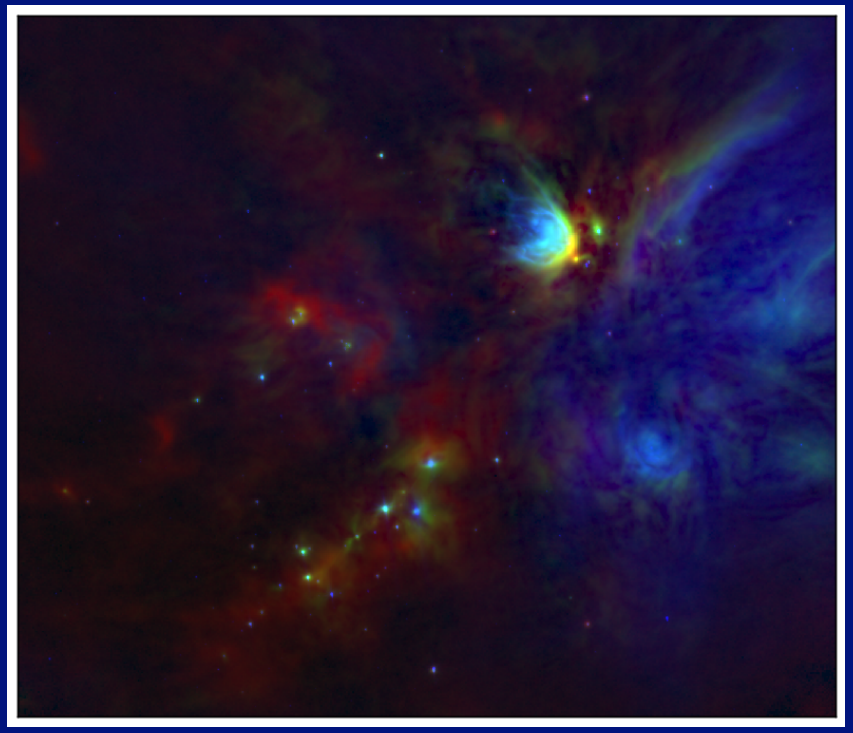
The wonders of B-fields in star-forming regions



Pattle et al., 2015,
MNRAS, 450, 1094

Derek Ward-Thompson
Jeremiah Horrocks Institute, University of Central Lancashire

Wonders of Star Formation, Edinburgh, 2018

Pierre Bastien
Mike Chen
Simon Coudé
James Di Francesco
Jason Fiege
Erica Franzmann
Rachel Friesen
Doug Johnstone
Martin Houde
Kevin Lacaille
Quang Nguyen-Luong
Brenda Matthews
Andy Pon, Steve Mairs
Gerald Schieven

Tao-Chung Ching
Qilao Gu
Dalei Li
Di Li
Hua-bai Li
Hong-Li Liu
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Keping Qiu
Hongchi Wang
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Jianjun Zhou

Lei Zhu

Doris Arzoumanian
Yasuo Doi, Ray Furuya
Tetsuo Hasegawa
Saeko Hayashi , Tsuyoshi Inoue , Shu-ichiro Inutsuka
Kazunari Iwasaki
Yoshihiro Kanamori
Akimasa Kataoka
Koji Kawabata
Gwanjeong Kim
Masato Kobayashi
Takayoshi Kusune
Jungmi Kwon
Masafumi Matsumura
Tetsuya Nagata
Fumitaka Nakamura
Hiroyuki Nakanishi
Nagayoshi Ohashi
Takashi Onaka ,Tae-Soo Pyo
Hiro Saito, Masumichi Seta
Hiroko Shinnaga
Motohide Tamura
Kohji Tomisaka,Yusuke

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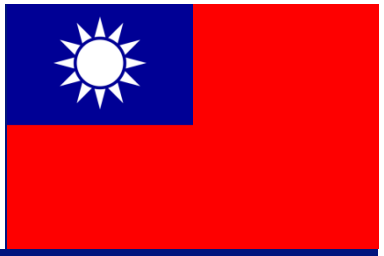
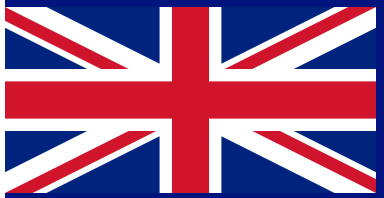
Miju Kang
Sung-ju Kang
Jongsoo Kim
Kee-Tae Kim
Kyoung Hee Kim
Mi-Ryang Kim
Shinyoung Kim
Woojin Kwon
Chang Won Lee
Jeong-Eun Lee
Sang-Sung Lee
Young-Hee Lee
Tie Liu
Aran Lyo
Archana Soam

Hyunju Yoo



Vivien Chen
Wen Ping Chen
Eswaraiah Chakali
Ciska Kemper
Patrick Koch
Shih-Ping Lai
Sheng-Yuan Liu
Kate Pattle
Ramprasad Rao
Ya-Wen Tang
Jia-Wei Wang

Hsi-Wei Yen



Antonio Chrysostomou
Emily Drabek-Maunder
Gary Fuller
Tim Gledhill
Jane Greaves
Matt Griffin
Jennifer Hatchell

Jason Kirk
Ilse de Looze
Nicolas Peretto
Brendan Retter
John Richer
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Giorgio Savini
Anna Scaife
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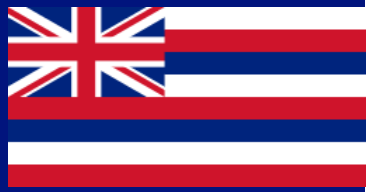
Derek Ward-Thompson
Anthony Whitworth



David Berry
Per Friberg
Sarah Graves
Steve Mairs
Harriet Parsons
Mark Rawlings

Diep Pham Ngoc
Dung Mai Thuy

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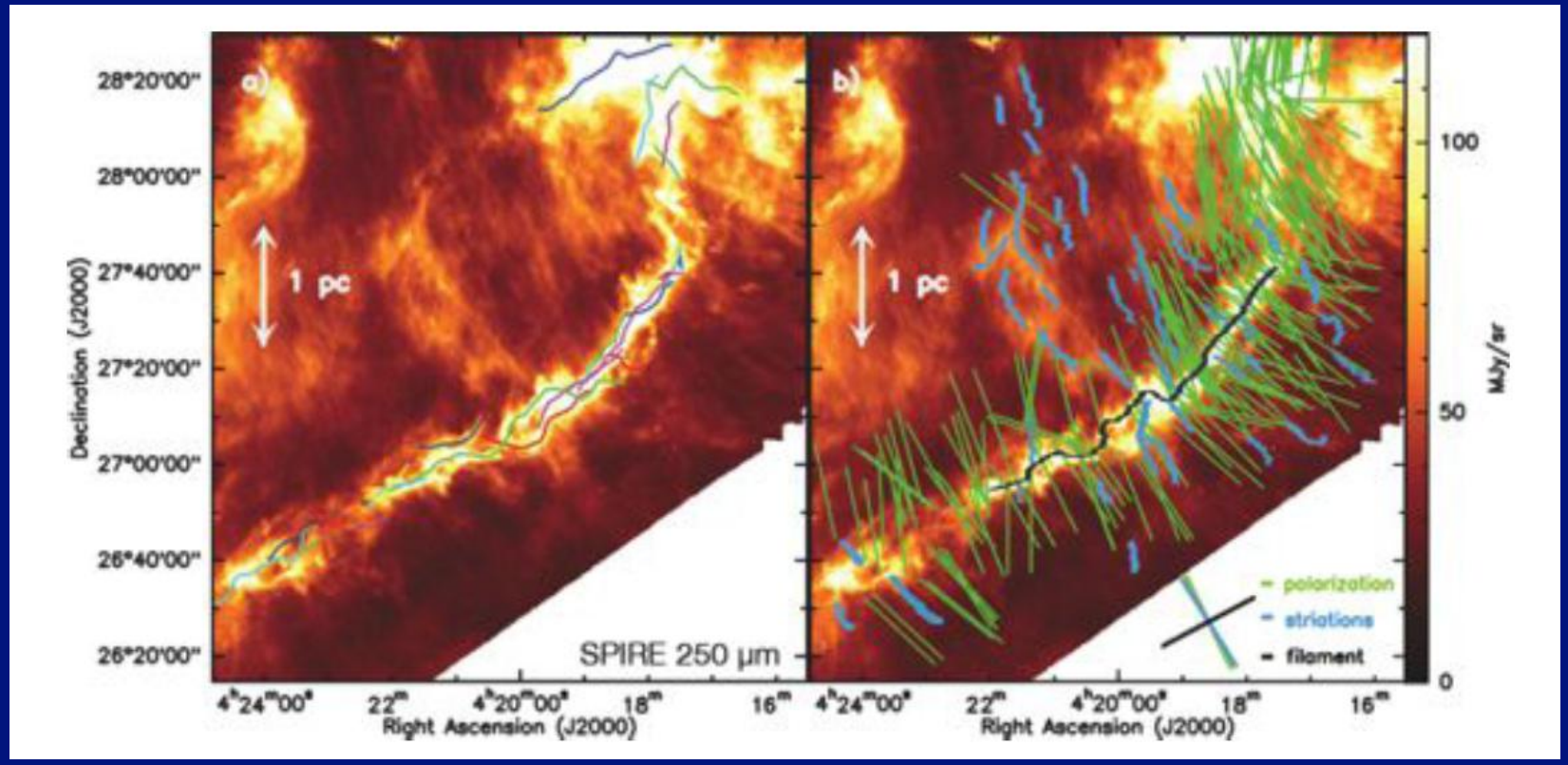
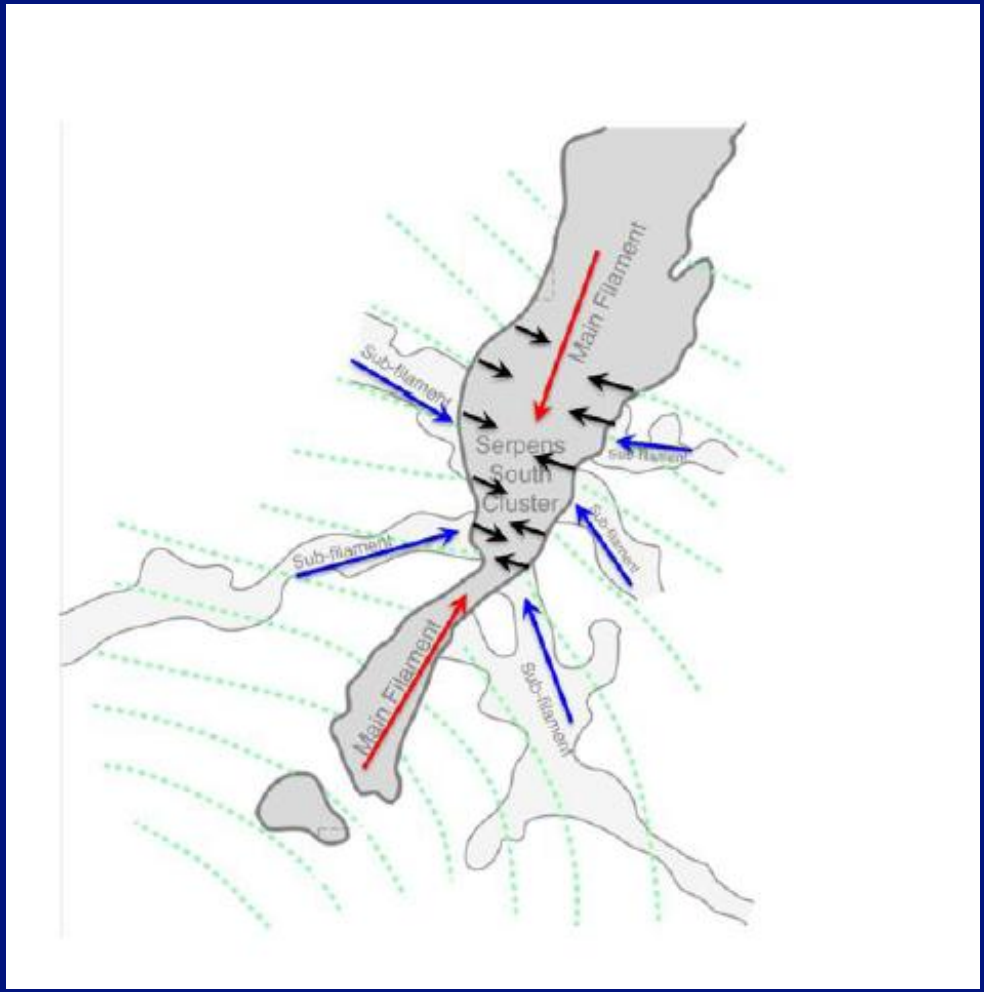
Filament growth



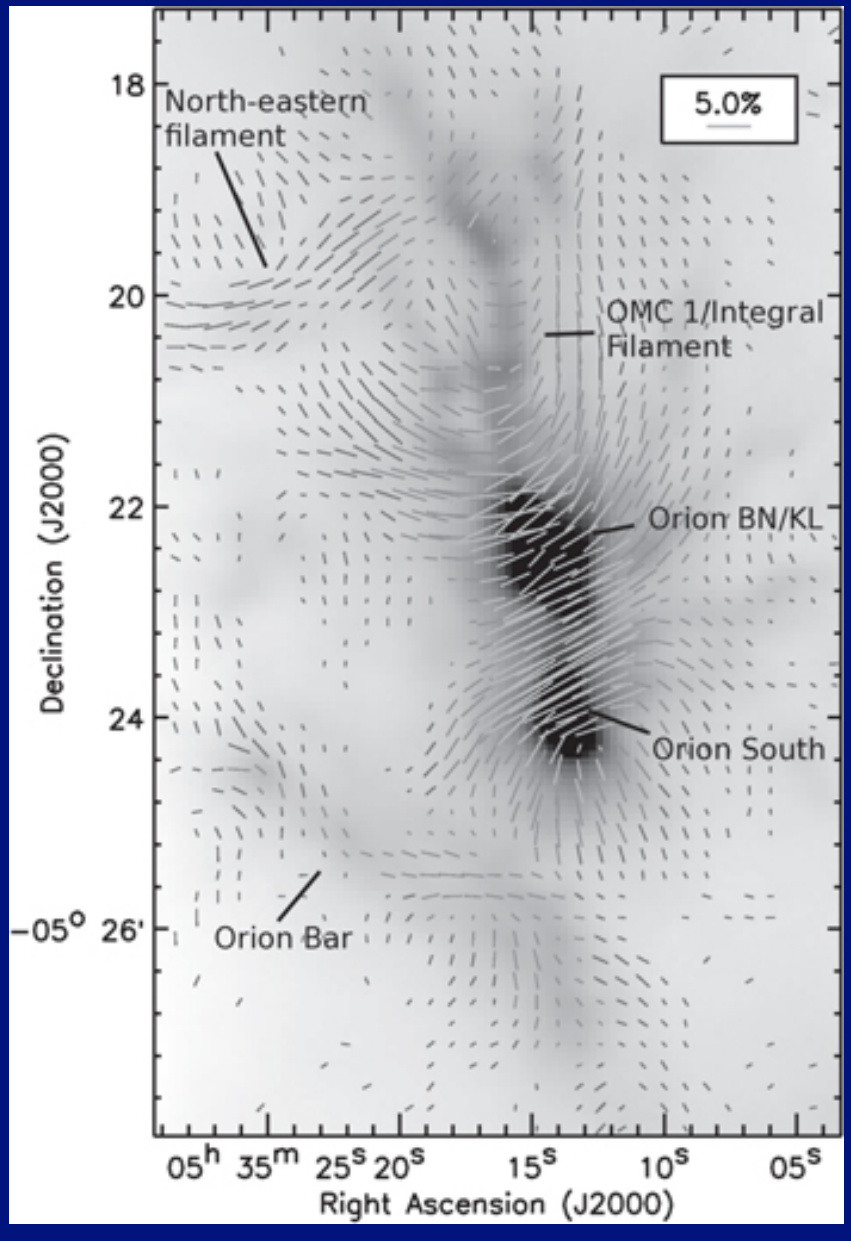
Palmeirim et al., 2013, A&A, 550, A38

Cores form on filaments



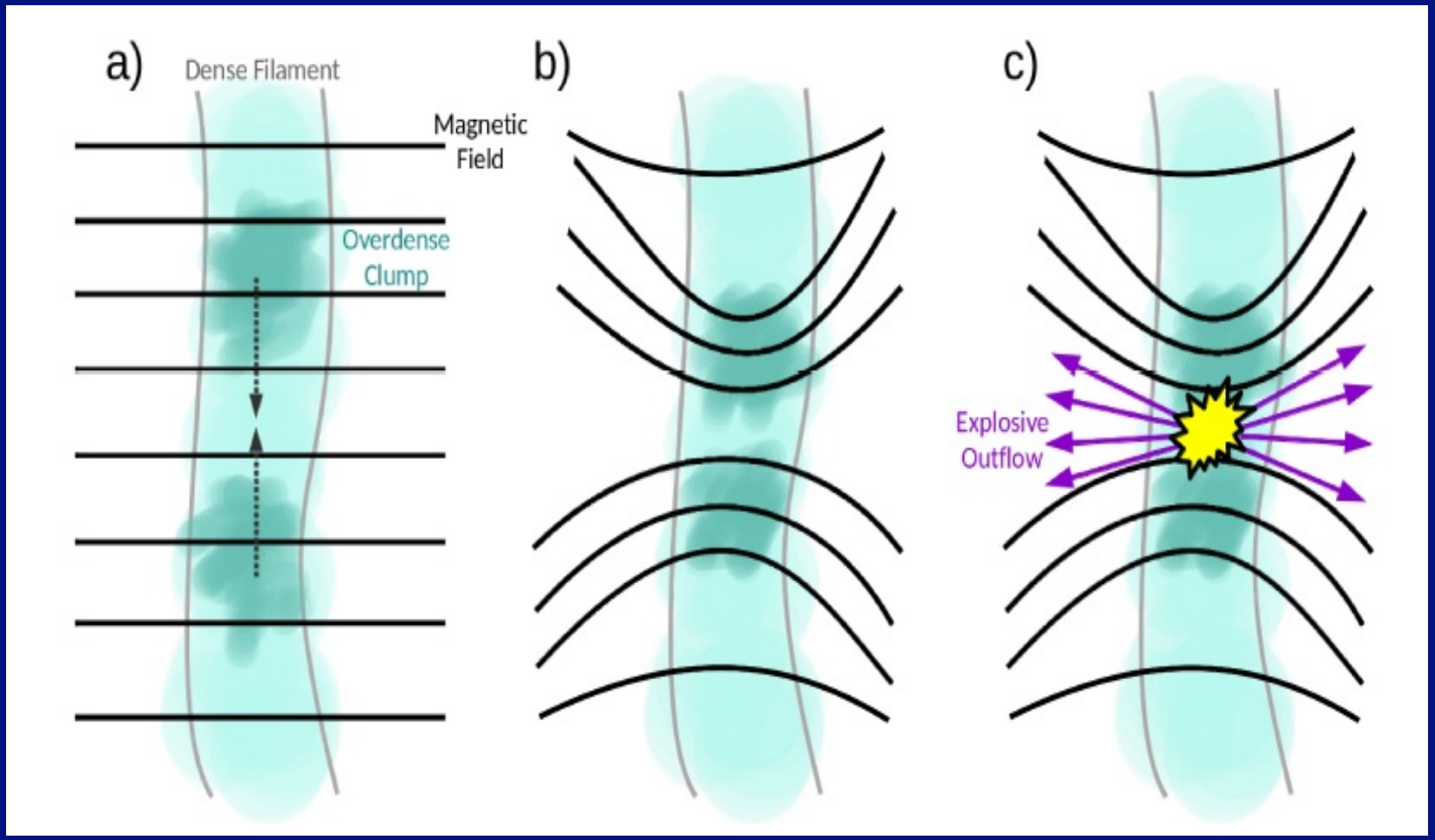
Andre et al., 2014, PPVI, pp.27-51

Orion A



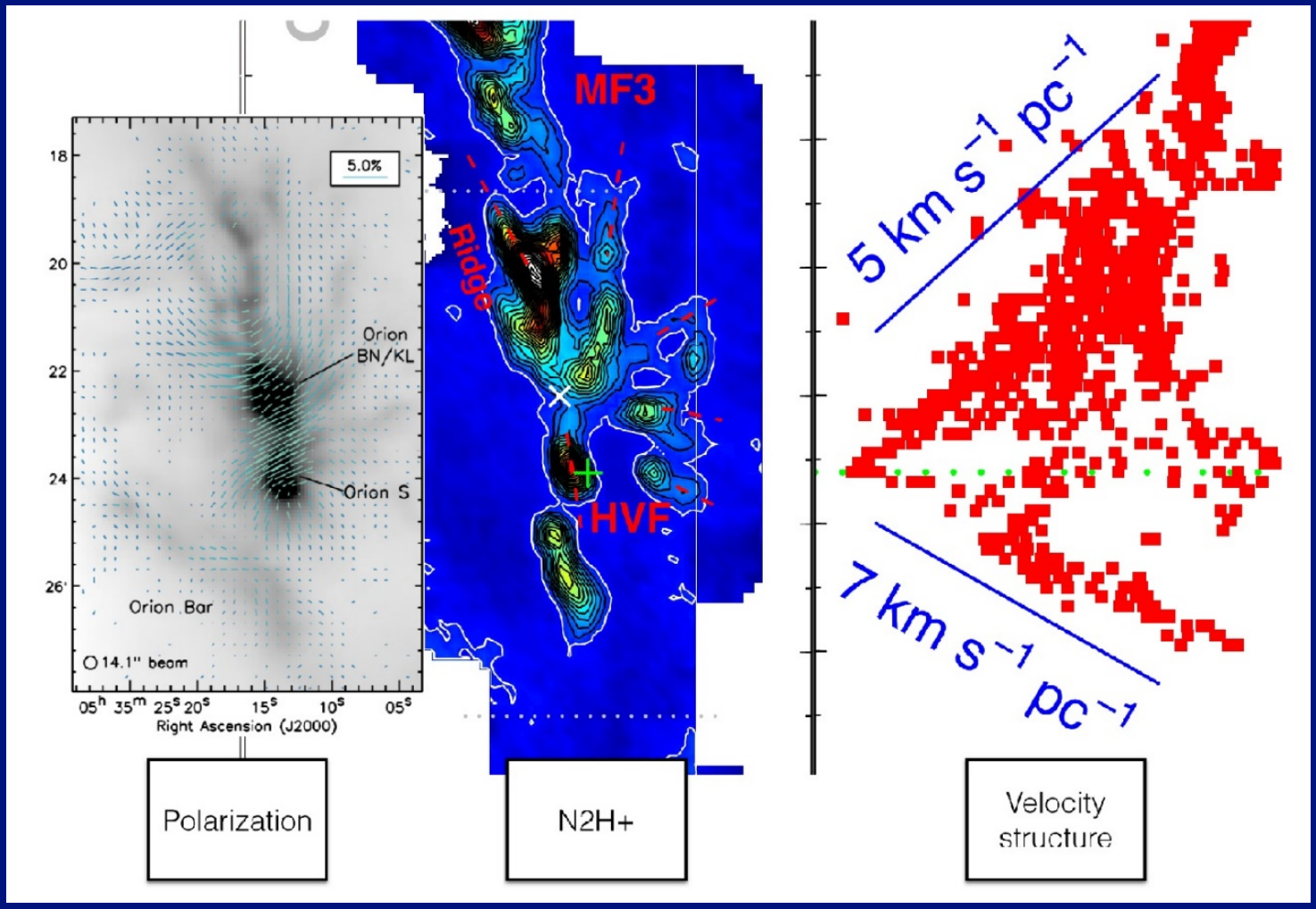
Ward-Thompson et al 2017
ApJ 842, 66

A magnetic ‘spring’



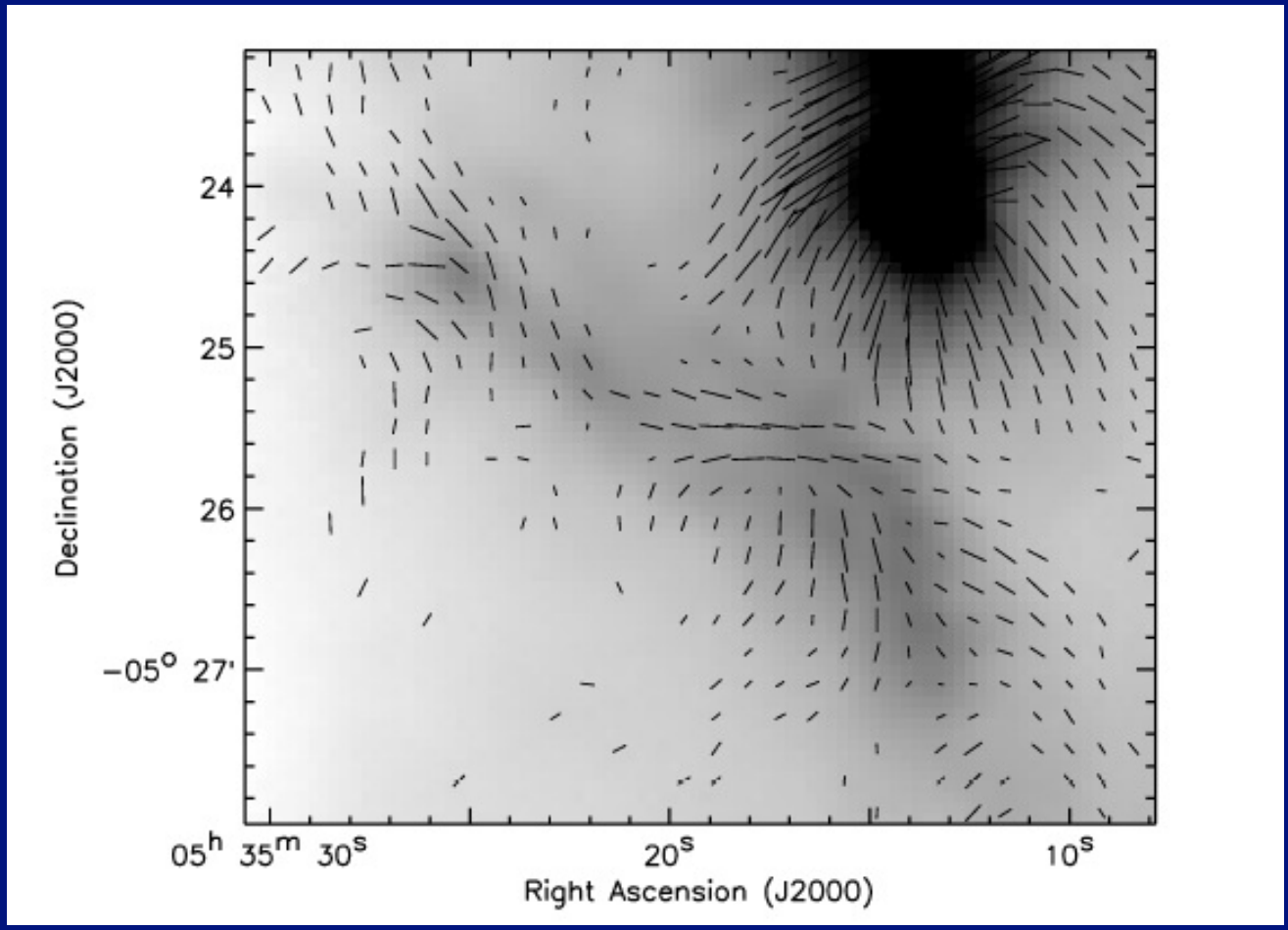
Pattle et al 2017, ApJ, 846, 122

Observed velocities



Hacar 2018 (priv comm); Hacar et al 2017 A&A 602, L2

Orion Bar

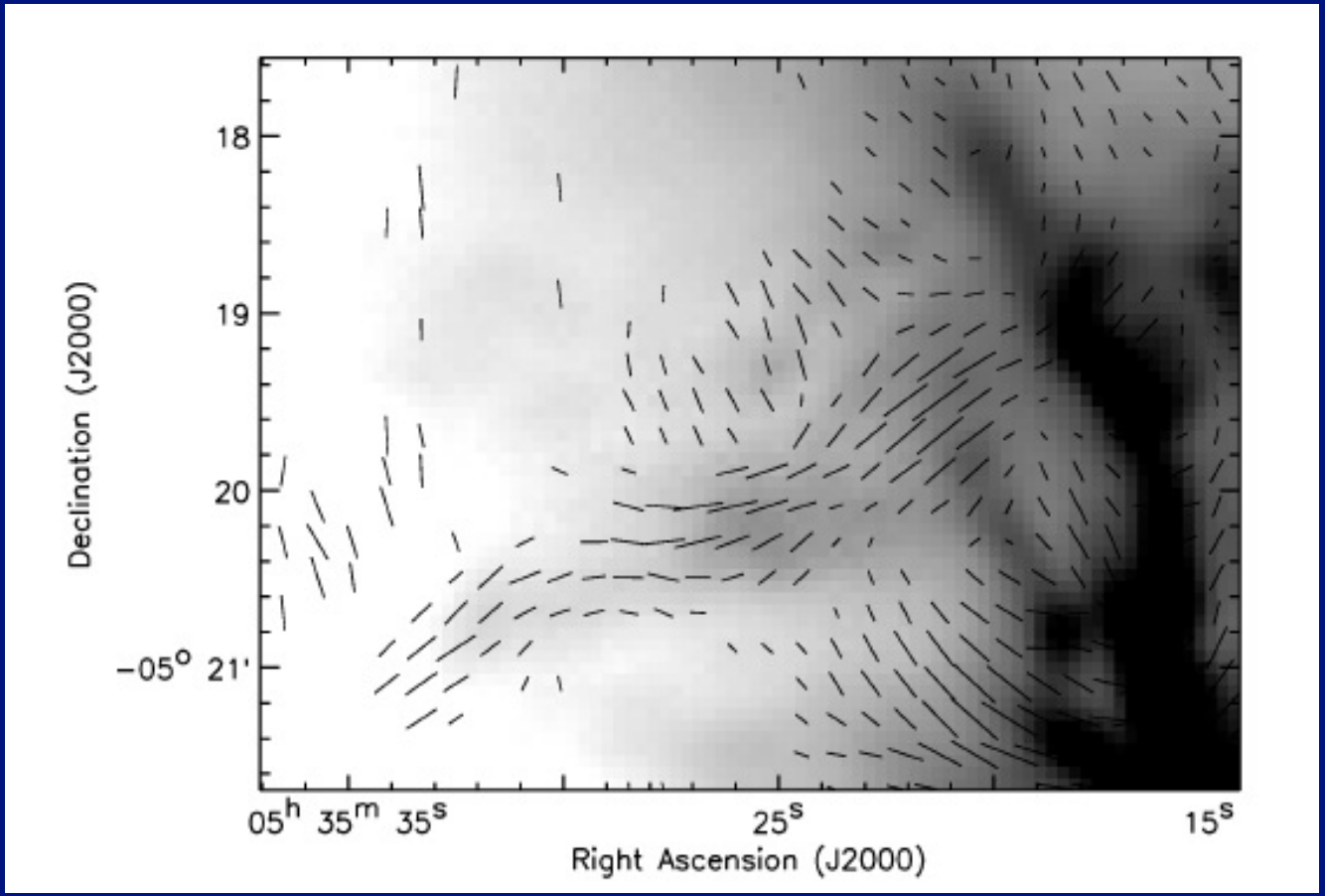


Ward-Thompson et al 2017 ApJ 842, 66

N-E filament

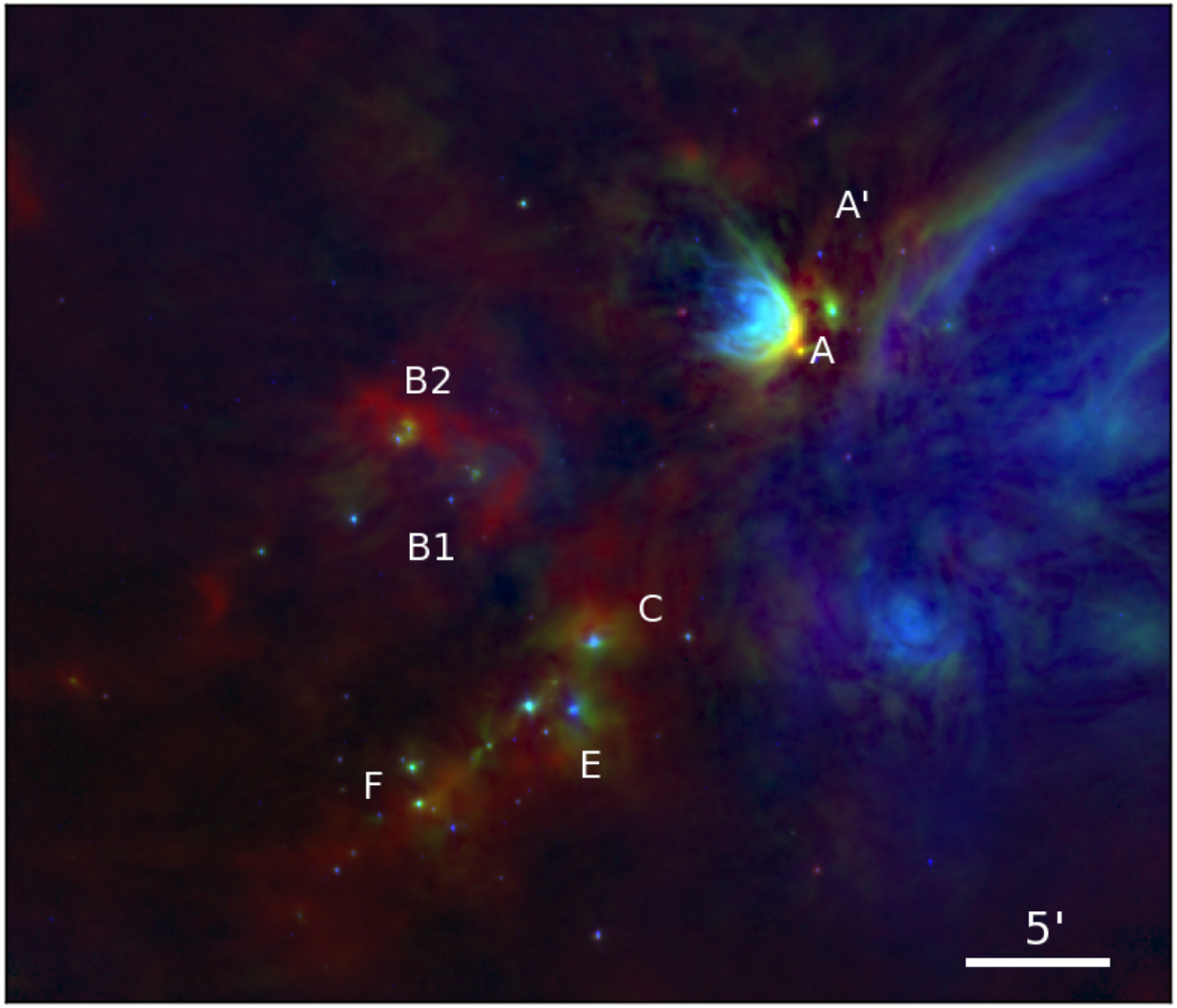
Self-gravitating vs Non-self-gravitating filaments

(cf Ostriker et al 2001)



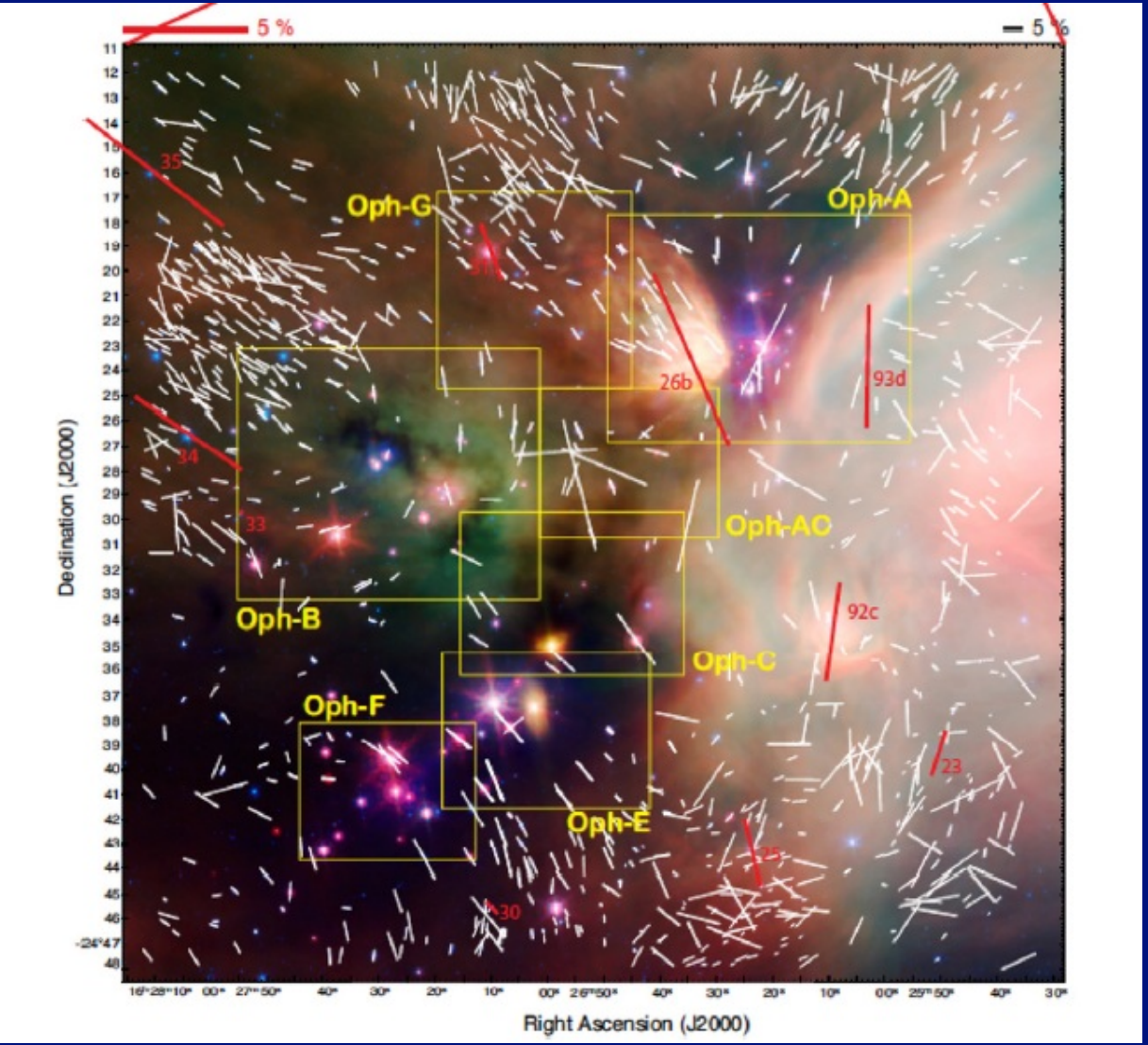
Ward-Thompson et al 2017 ApJ 842, 66

Ophiuchus – L1688



Pattle et al. 2015, MNRAS, 450, 1094

NIR Polarisation

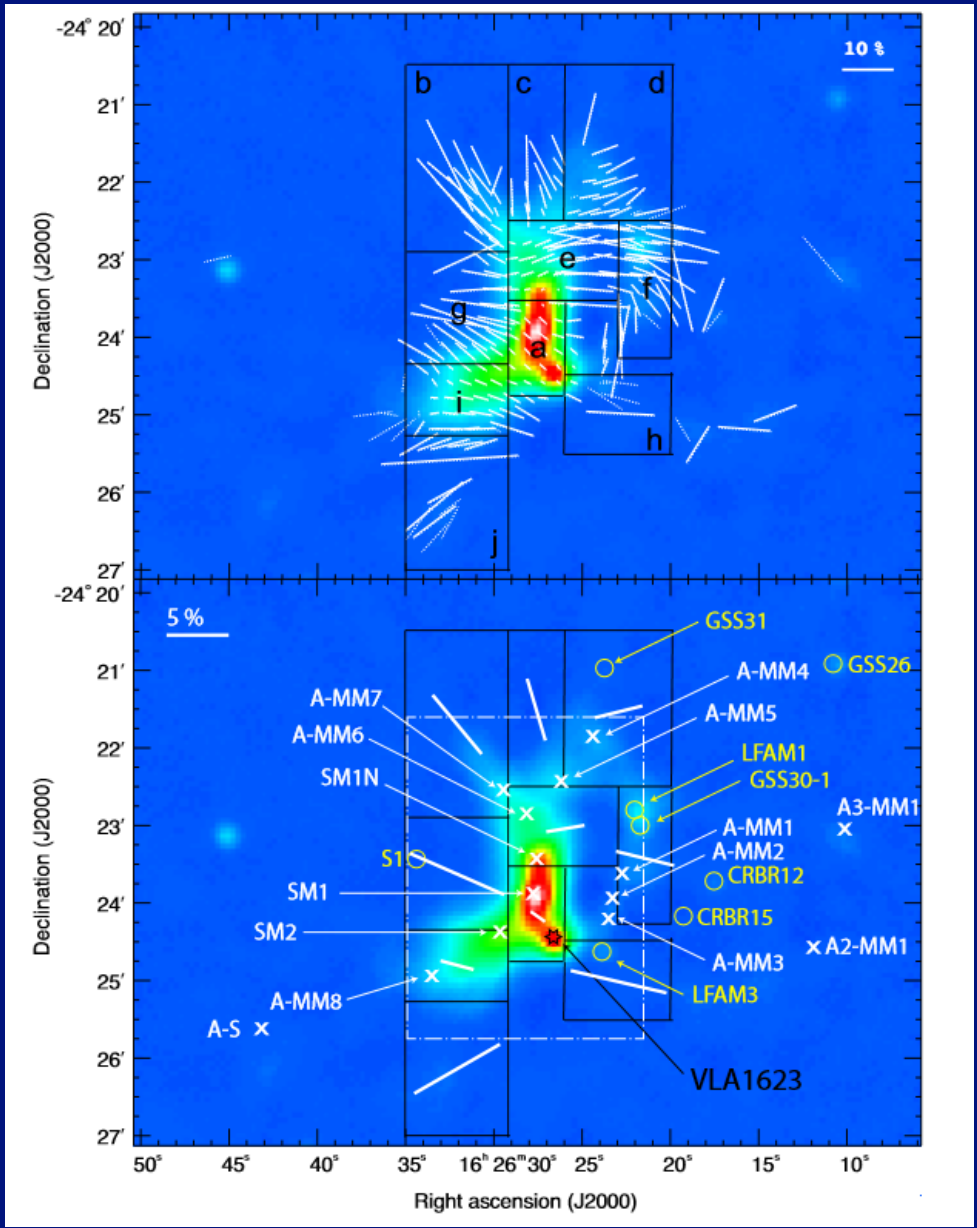


Kwon et al 2015, ApJS, 220, 17

Oph A

B-field in low density gas is parallel to ambient, but more complex in high density gas

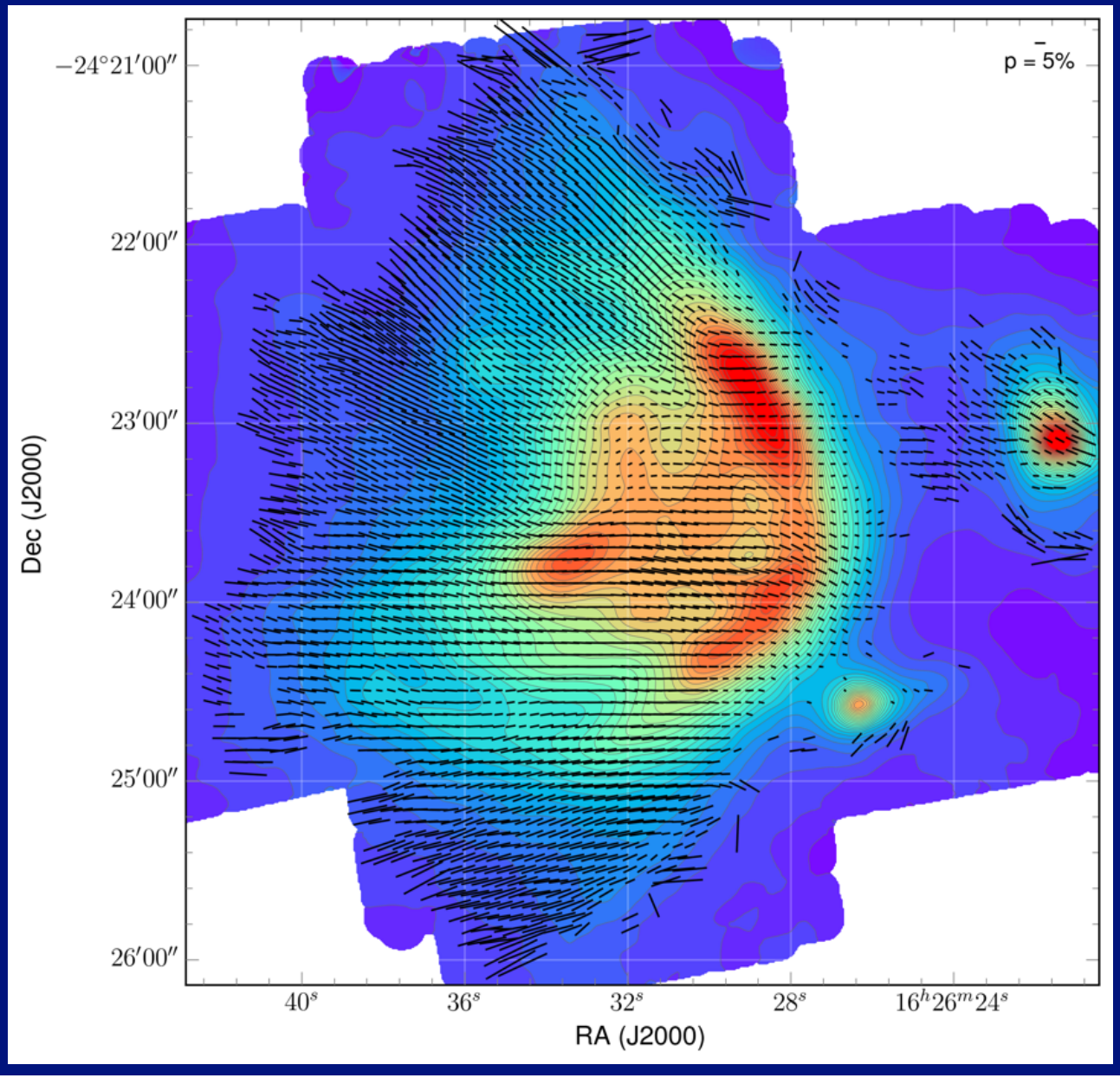
Kwon et al., 2018, ApJ, 859, 4



HAWC+ on SOFIA

Field similar to BISTRO observations, but 'bubble' around HII region is now seen.

Santos et al., 2018, AAS 231, 130.04



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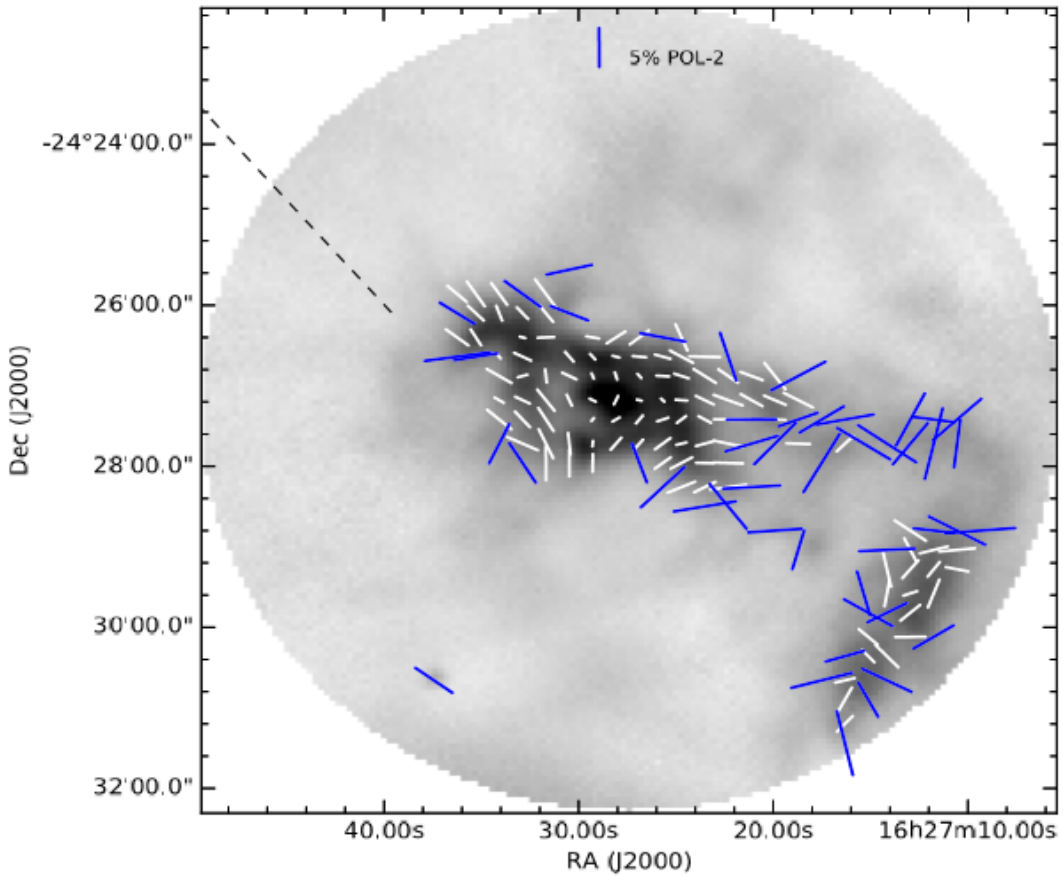
Oph B

Field more disordered, but parallel to ambient in east, orthogonal in west

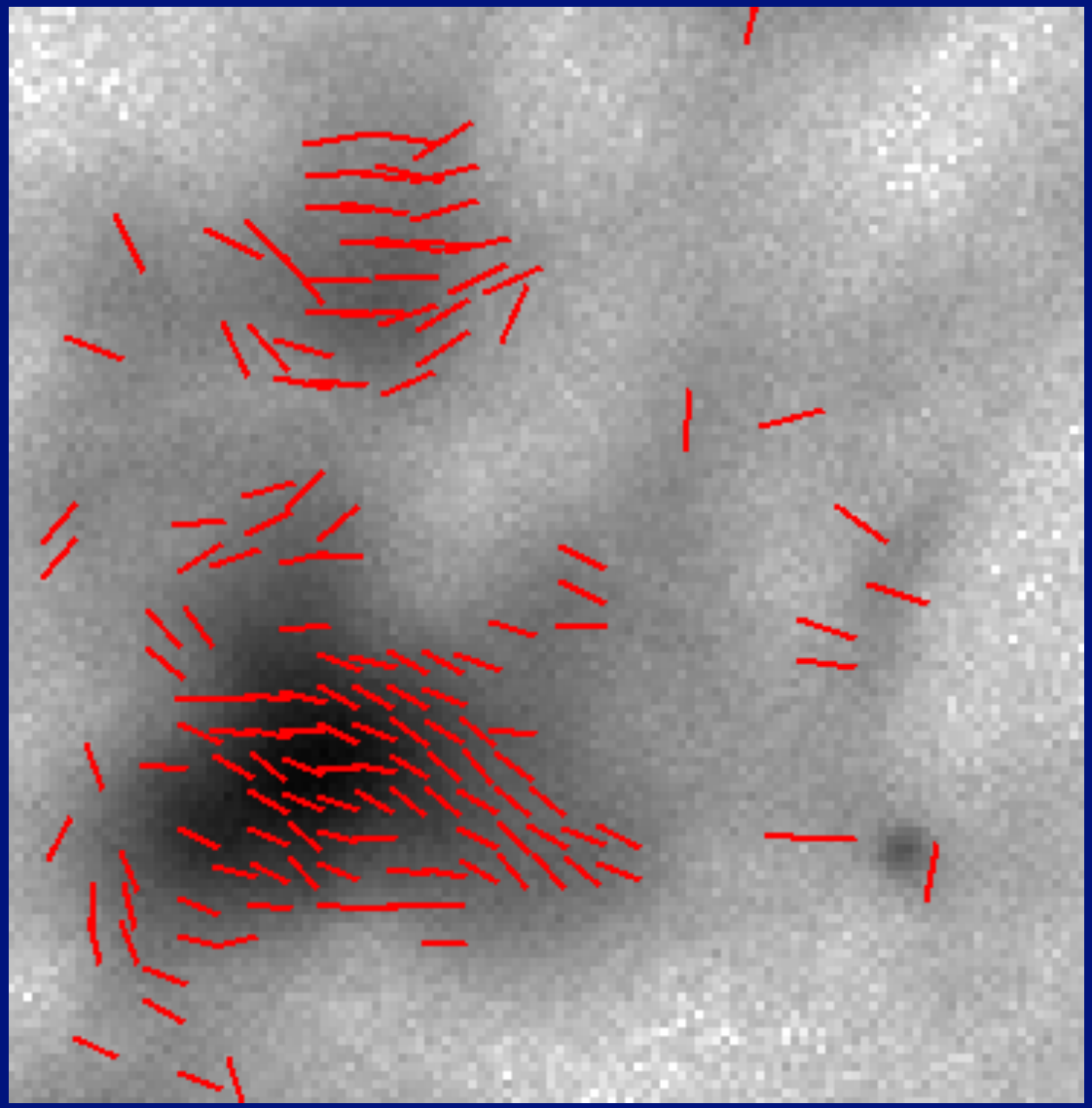
Soam et al., 2018, ApJ, 861, 65



Oph C

Field parallel to ambient in south, rotated in north

Qiu et al 2018 in prep

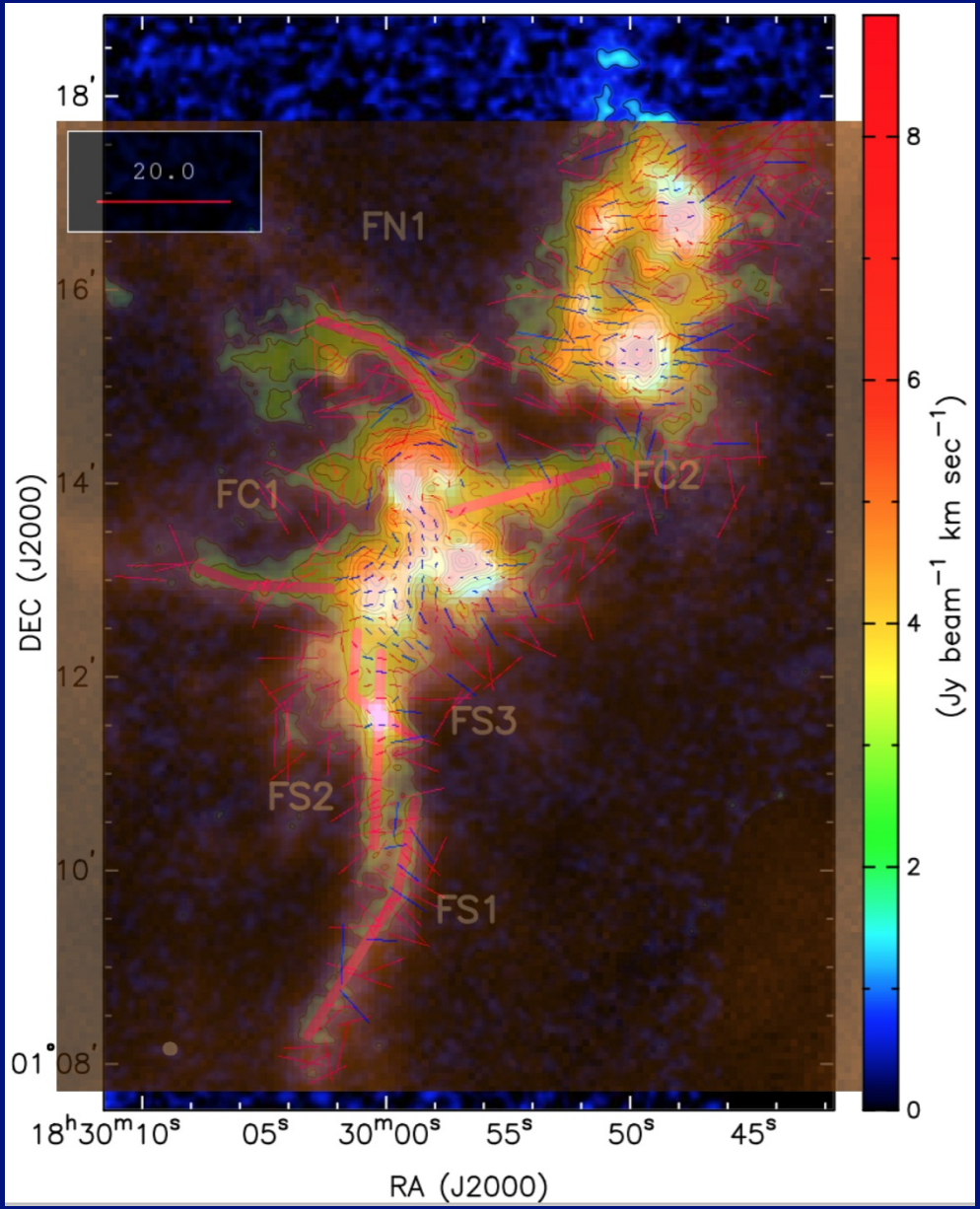


Serpens Main

Vectors show field (blue>3σ red>2σ)

Field perp to filaments

%age pol. reduces in high density regions



W Kwon et al., 2018 in prep

N2H+ CARMA image from Lee, Kwon et al., 2014

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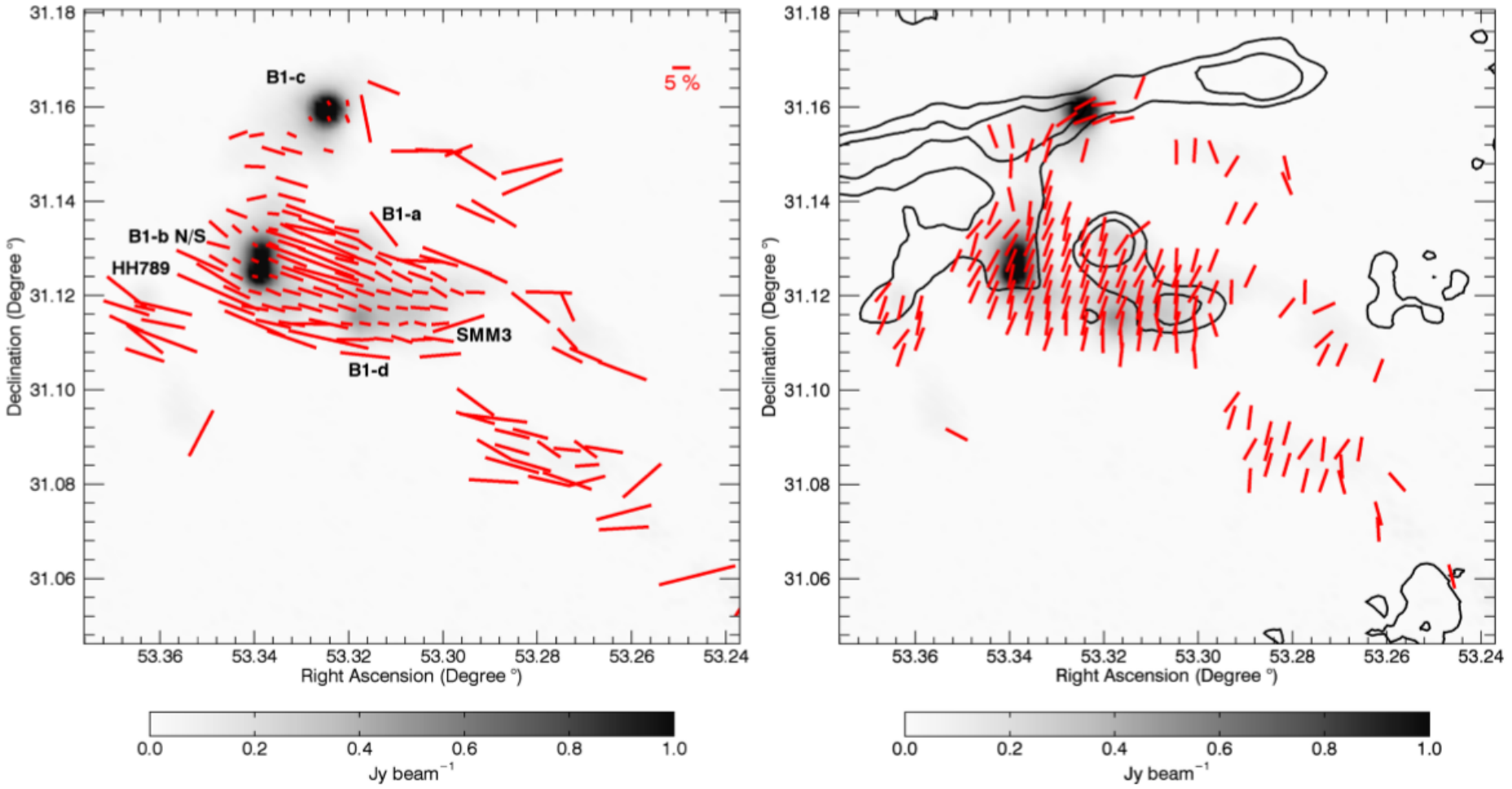
Perseus B1



Coudé et al, 2018, ApJ, submitted

B-field ~ 120+/-60uG

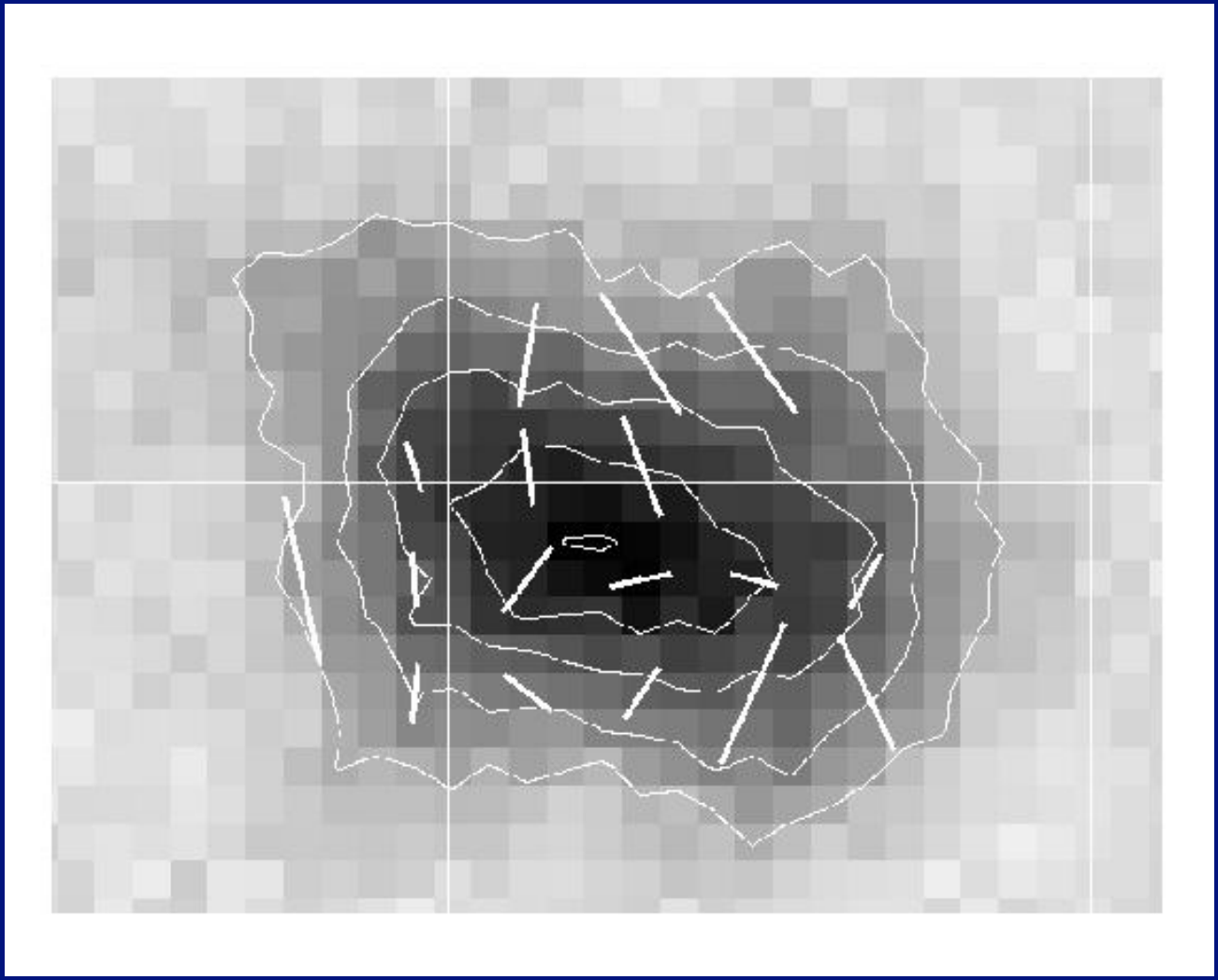
L1689B

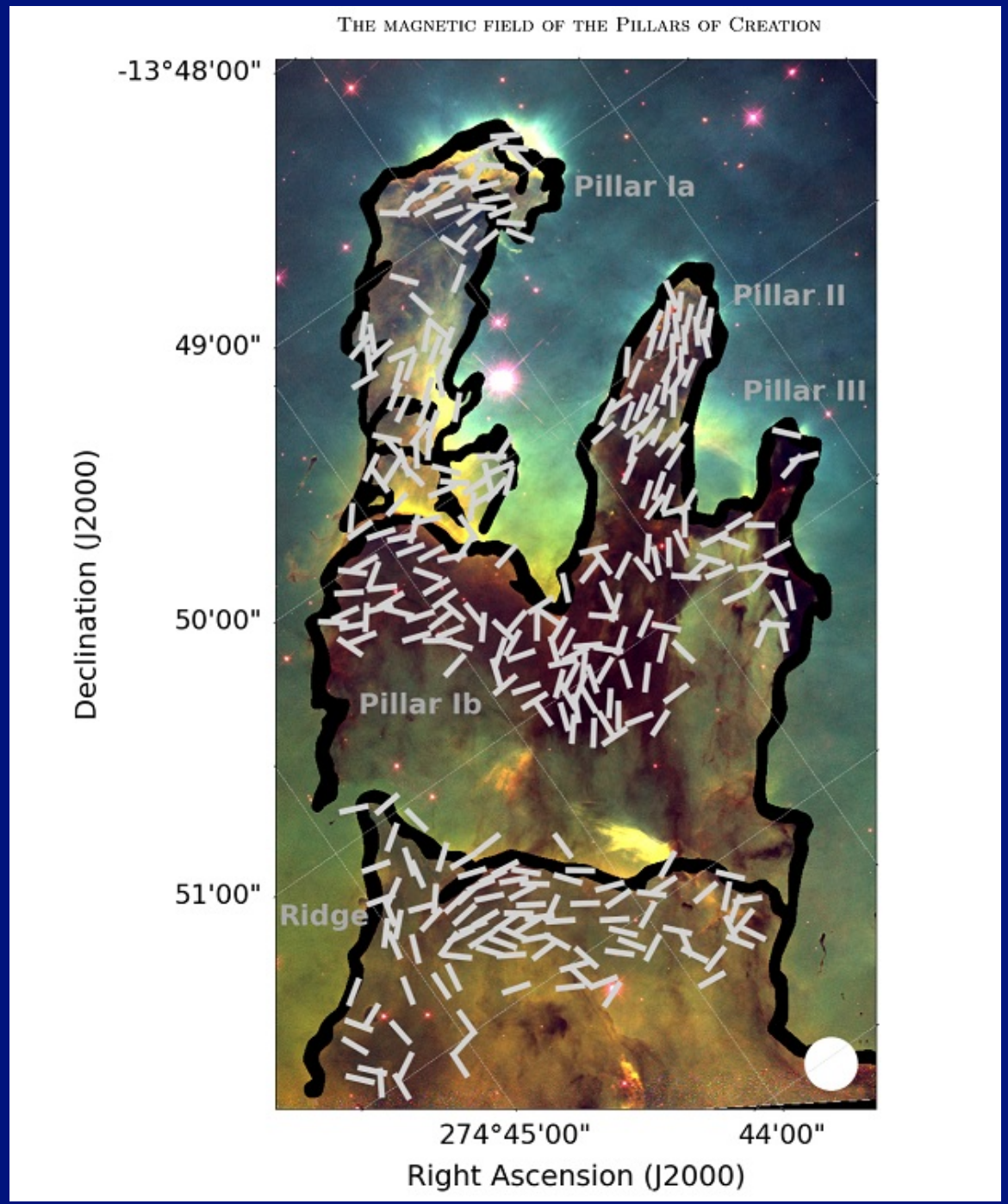
Faintest object so far observed.

Field roughly north-south, rotates in centre.

Perp. to core/filament.

Ward-Thompson et al., 2018 in prep





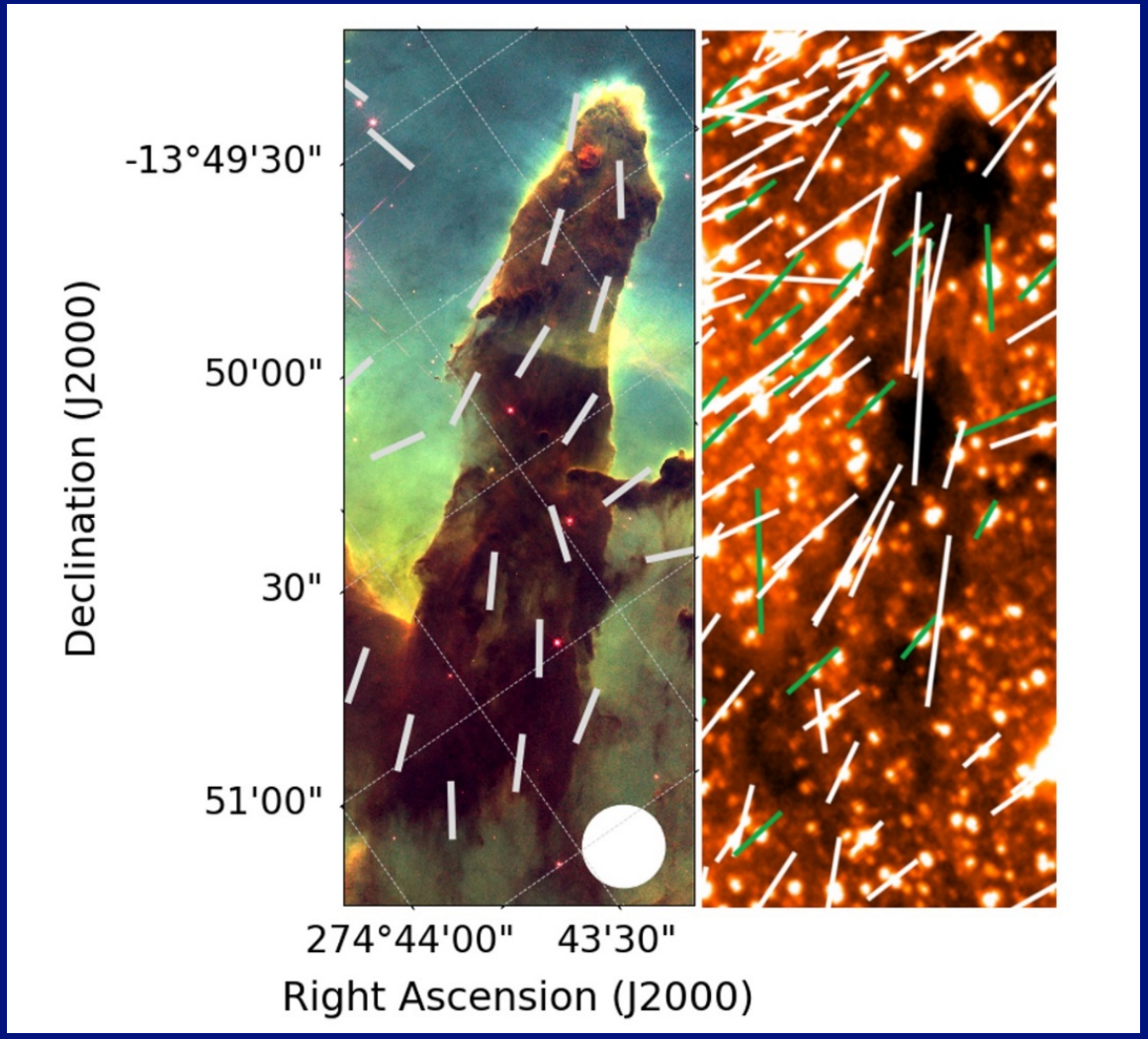
B-fields in the 'Pillars of Creation' of M16

Pattle et al., 2018, ApJL, 860, L6

B-field detail in Pillar II

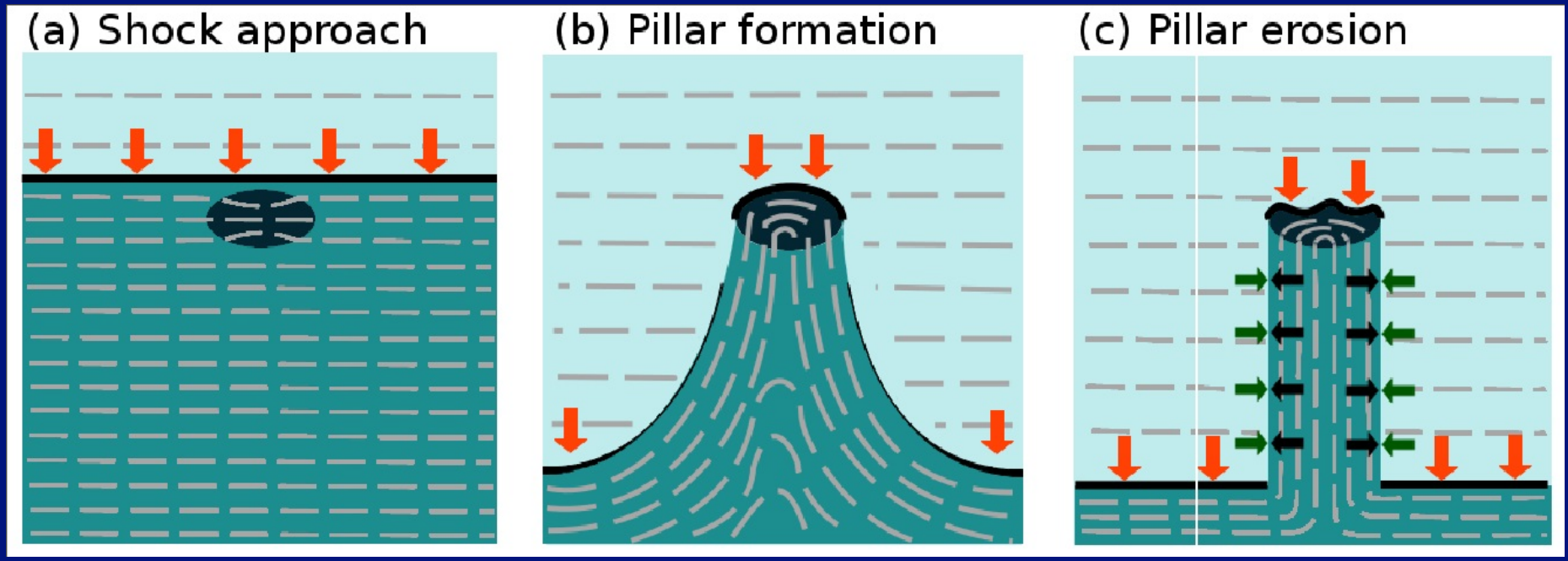
Field strength ~200-300 uG

Contributes significantly to pillar support



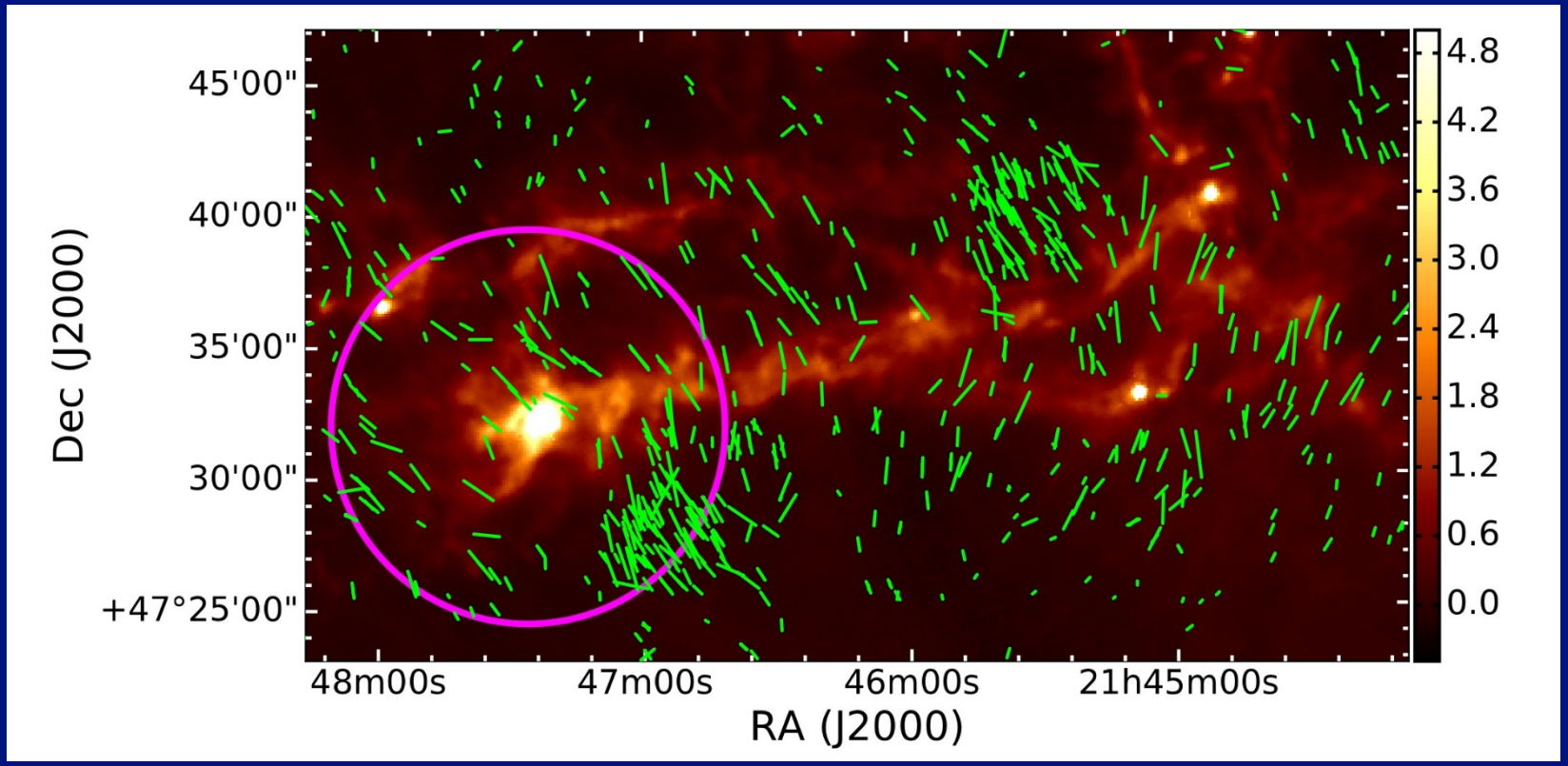
Pattle et al., 2018, ApJL, 860, L6

Pillar evolution



Pattle et al, 2018, ApJL, 860, L6
cf: Williams et al., 2001, MN, 327, 788

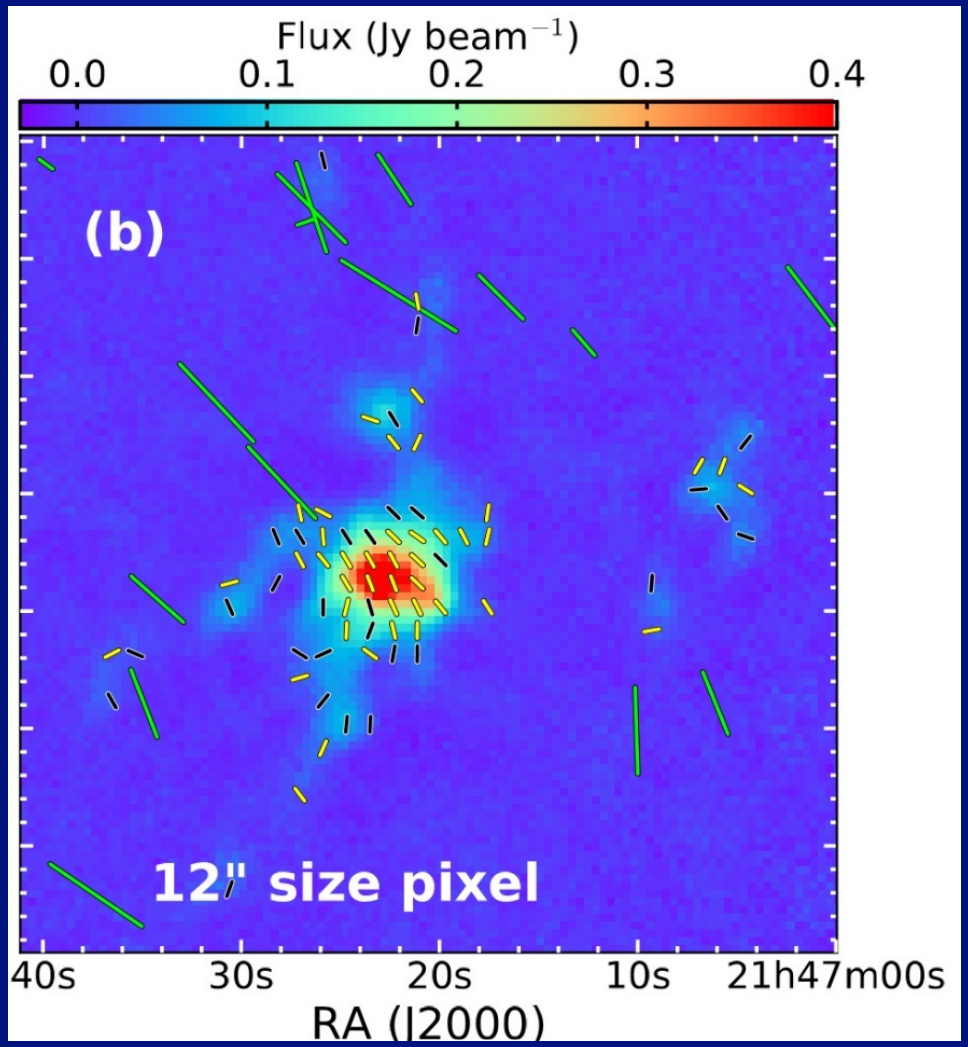
IC5146 – Another filament



IR poln. – Wang et al., 2018, in prep

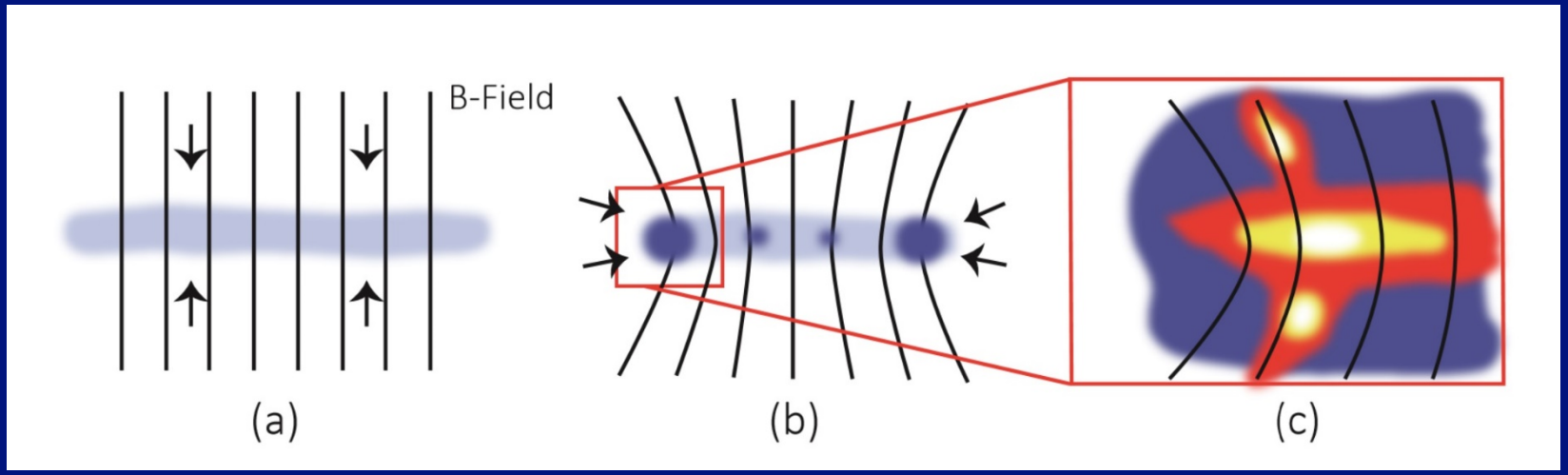
IC5146 – Hub

A hint of a turn in centre of Hub

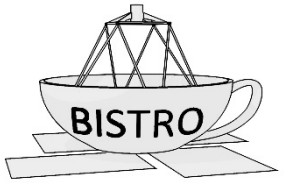


Wang et al., 2018, in prep.

Cartoon of IC 5146



Is IC 5146 like the Orion filament? (Wang et al., 2018, in prep)



Summary

- The story before BISTRO:
  - Inter-stellar clouds rapidly become filamentary
  - Filaments form cores
  - Cores form stars
  - B-fields could be responsible for ‘funnelling’
  - Outflows affect B-fields
- BISTRO goals:
  - What role do B-fields play inside filaments & cores?
  - Are B-fields dominant?

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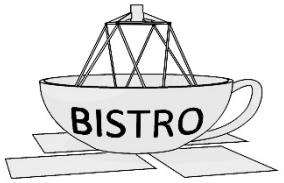

BISTRO Papers:

- Ward-Thompson et al., 2017, ApJ, 842, 66 - Orion A
- Pattle et al., 2017, ApJ, 846, 122 - DCF analysis of Orion A
- J. Kwon et al., 2018, ApJ, 859, 4 - Oph A
- Soam et al., 2018, ApJ, 861, 65 - Oph B
- Pattle et al., 2018, ApJL, 860, L6 – M16
- Qiu et al., in prep. – Oph C
- Wang et al., in prep. - IC5146
- Coudé et al., ApJ, submitted - Perseus B1
- Ward-Thompson et al., in prep. - L1689B
- Tang et al., in prep. - Serpens Main NW
- W. Kwon et al., in prep. - Serpens Main SE
- Pattle et al., in prep. – Dust grain analysis in Oph
- Lyo et al., in prep. - Orion B
- Ching et al., in prep. - DR21

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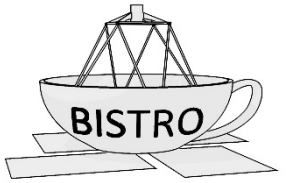

BISTRO-1: Overview

- Aims to map Gould Belt star-forming regions in polarised light
- Awarded 224 hours of Band 2 observing time
- 122 survey members across 7 partner countries/regions, EAO & associates
- P.I.s: Derek Ward-Thompson (UK), Keping Qiu (China), Tetsuo Hasegawa (Japan), Woojin Kwon (Korea), Shih-Ping Li (Taiwan), Pierre Bastien (Canada)
- DR team incudes 3 members from each partner region
- We aim to map the high-column-density regions of:

Ophiuchus, Orion A & B, Perseus, Serpens, Taurus L1495/B211, Auriga, IC5146
all regions for which we have both SCUBA2 & HARP-B data

Currently ~ 80% complete

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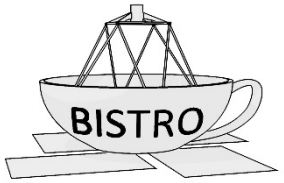

BISTRO-2: Another 224hrs

- 16 more fields
- The same ~120 members
- Now to include some higher mass regions
- Also 450 micron observations in selected fields
- Sample ‘mass axis’ of star formation models
- Preliminary studies of wavelength dependence
- More experiments in mosaic-ing
- Sources around the sky
- Currently ~20% complete

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