Relationship between filamentary morphology and B-field

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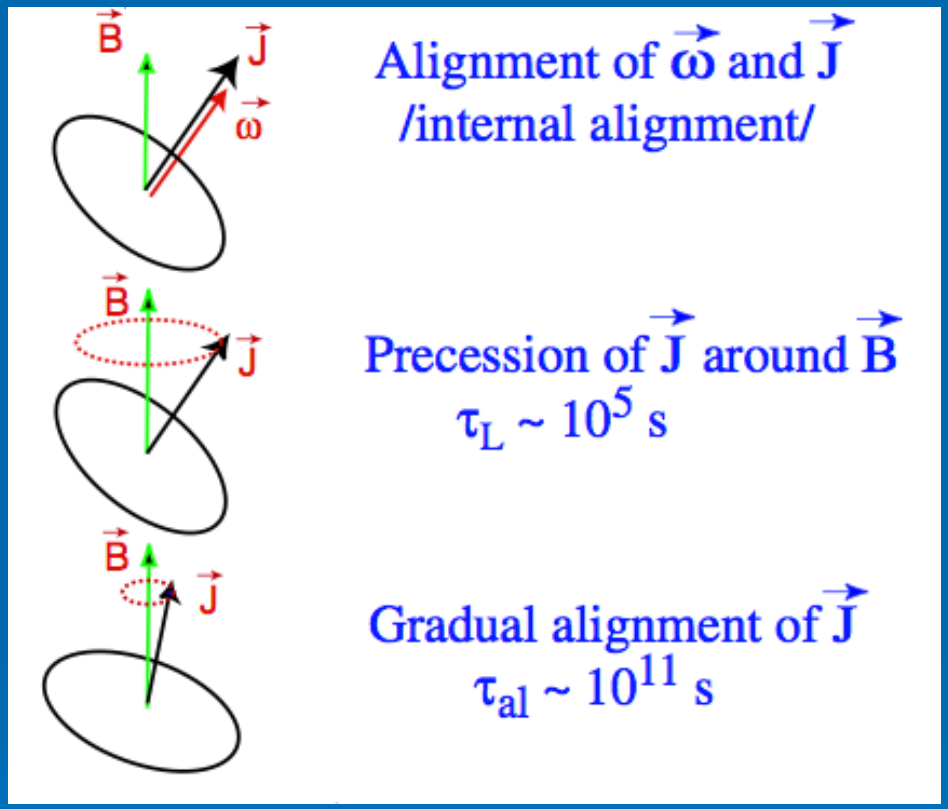
C I E R A

radiative torques (RATs) – the most promising mechanism for magnetic grain alignment



e.g., Lazarian ’07; Hoang & Lazarian ’09

-- grains must have helicity

-- incident radiation field must be anisotropic

-- grains spin about short axes

-- precession due to μ x B torque enforces *some* kind of alignment with respect to B-field

-- small values of precession cone angle are more stable against RAT *alignment* torques

observational tests of grain alignment theory

size dependence – small grains not aligned

(e.g., Kim & Martin ’95)

dependence on A_V – well shielded grains not aligned

(e.g., Goodman+ ’92)

dependence on T – emission from hot regions more polarized

(Vaillancourt & Matthews ’12)

dependence on angle between RAT and B-field

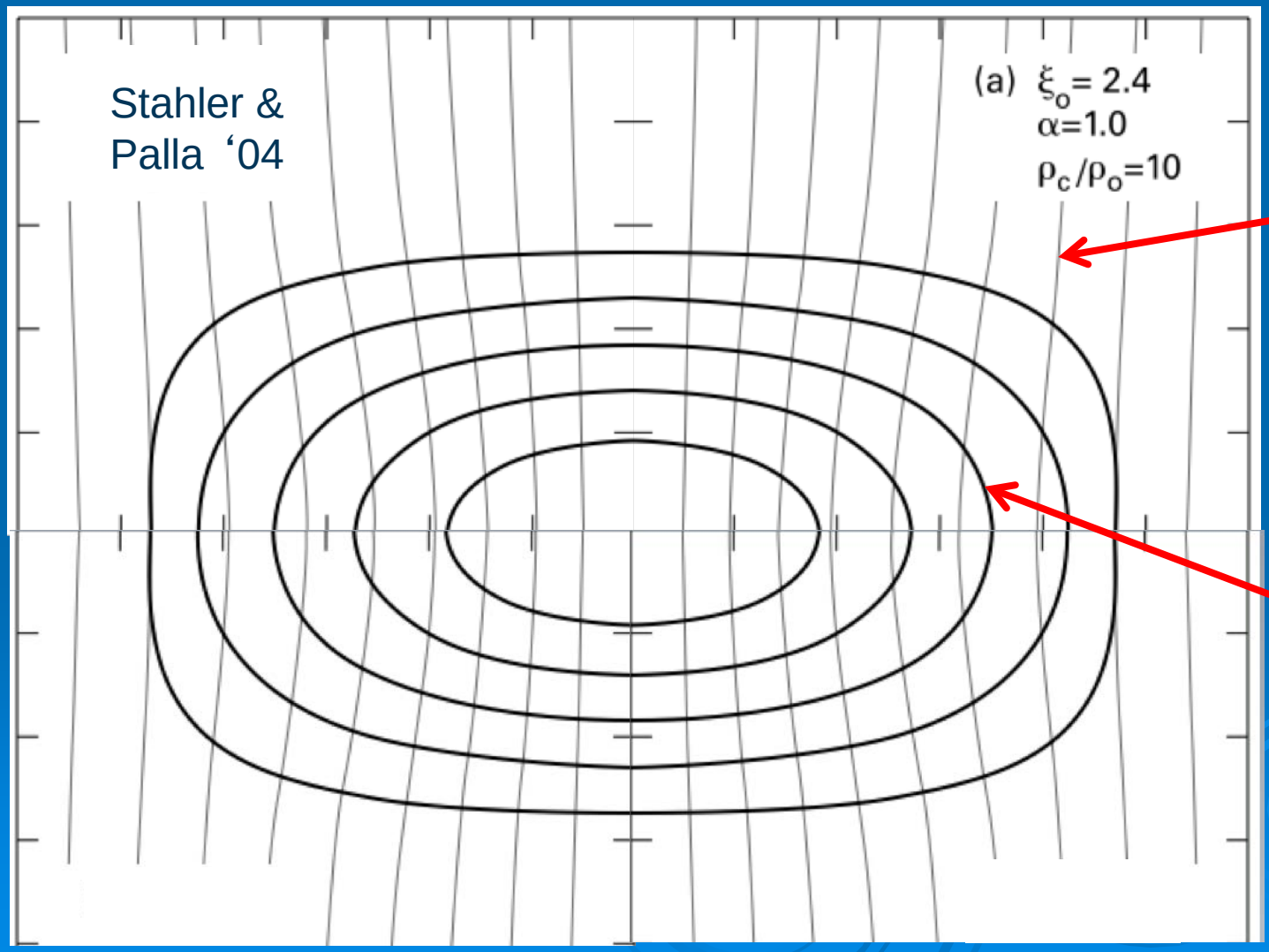
(Andersson+ ’11)

submm polarization spectrum vs. cloud environment

(e.g., Hildebrand+ ’99; Zeng+ ’13)

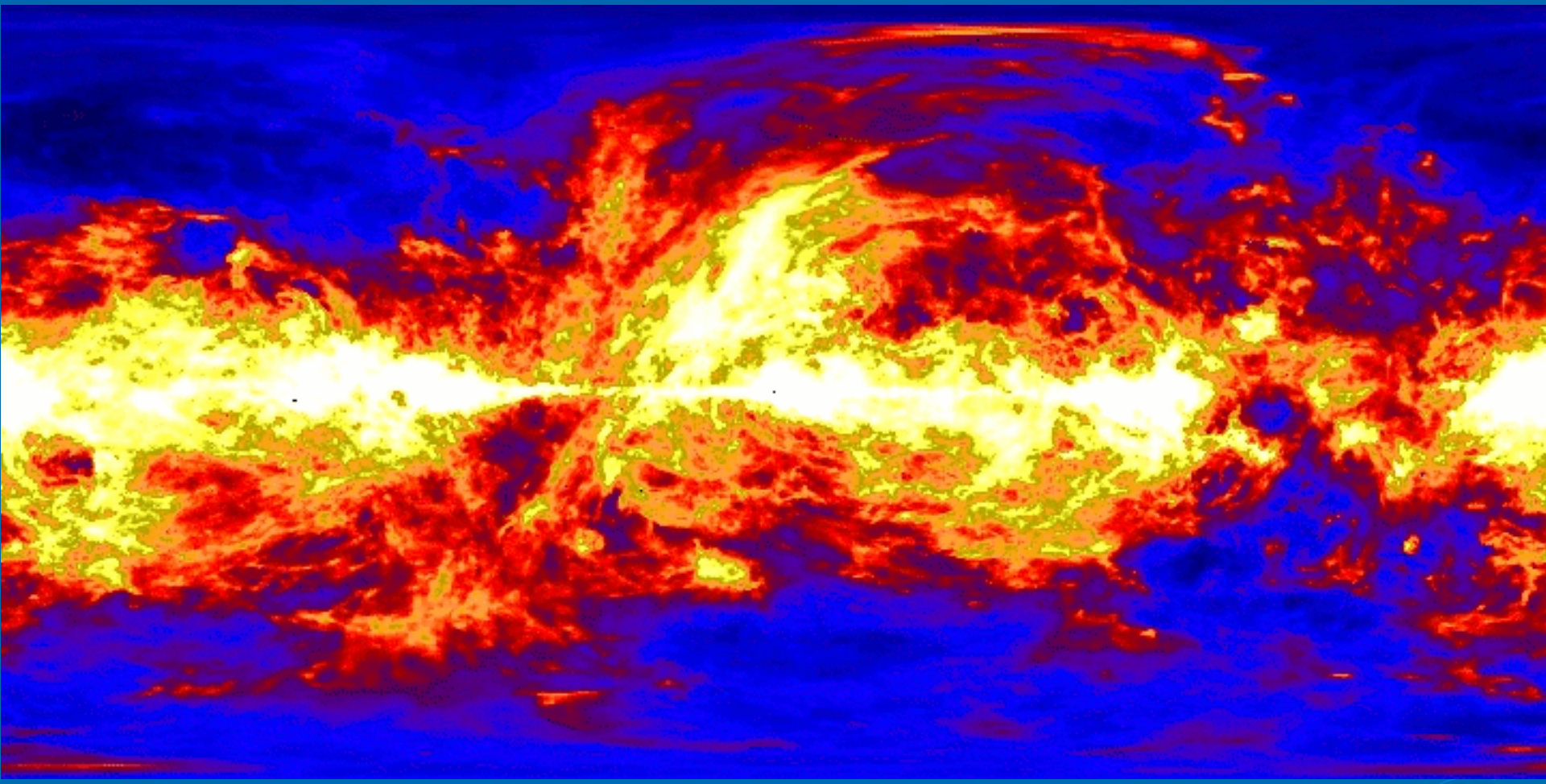
(see also Andersson 2012)

equilibrium solutions for self-gravitating magnetized gas clouds; includes effects of external pressure



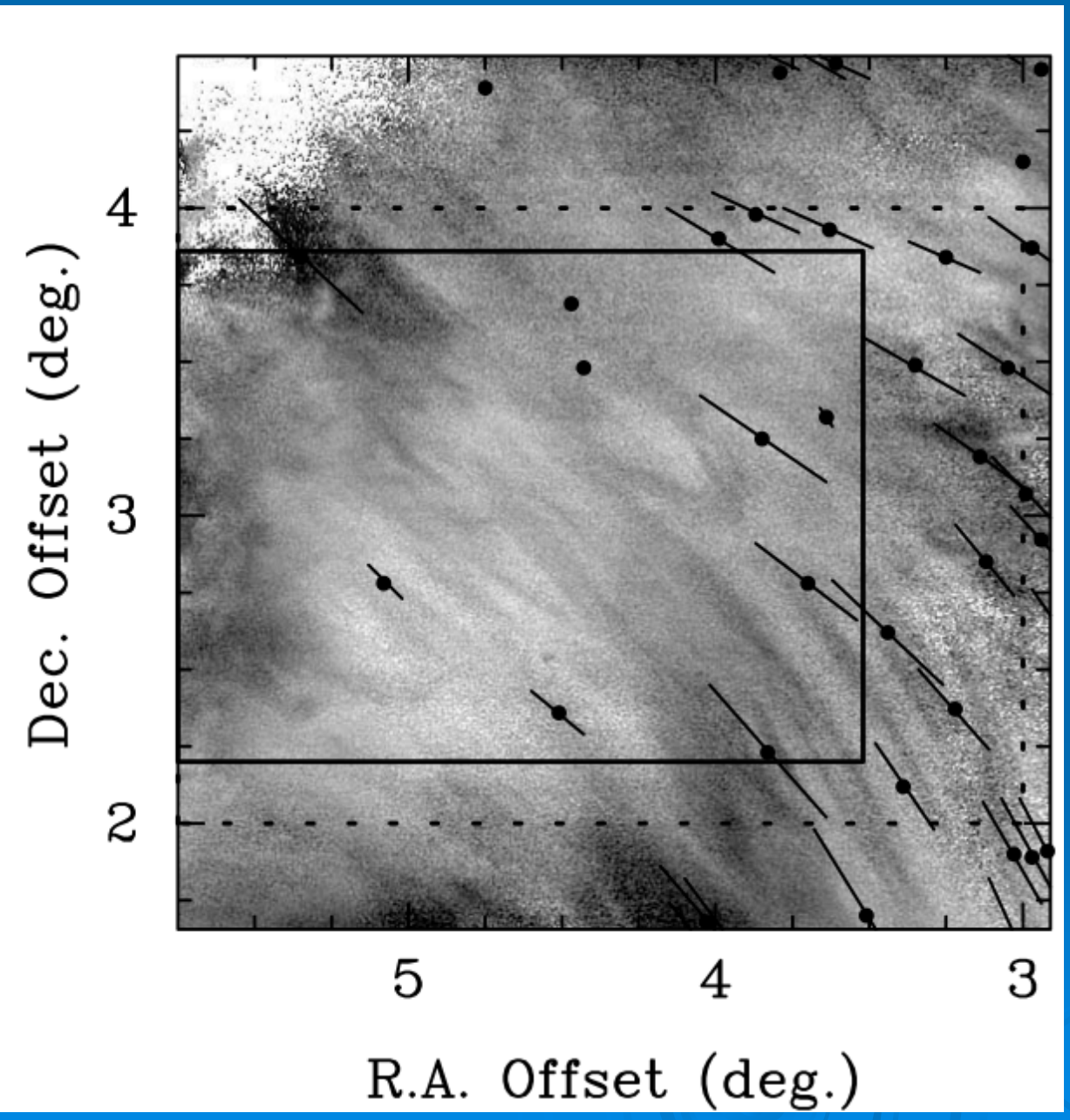
magnetic field lines

iso-density contours



B-field from optical polarimetry of starlight traces filamentary structure seen in 21 cm atomic hydrogen emission (e.g. “supershells”)

slide courtesy of Carl Heiles



what about molecular clouds?

Goodman+ ’90 :

… no clear alignment for dark clouds

Heyer+ ’08 and Goldsmith+ ’08 :

… diffuse striations follow B-field

velocity centroids in grayscale

submm polarimetry: comparing core/cloud elongation with B-field:

Tassis+ ’09 :

… preference for B-field perpendicular to elongation

… 0.05 – 1.0 pc scales

… 99% confidence

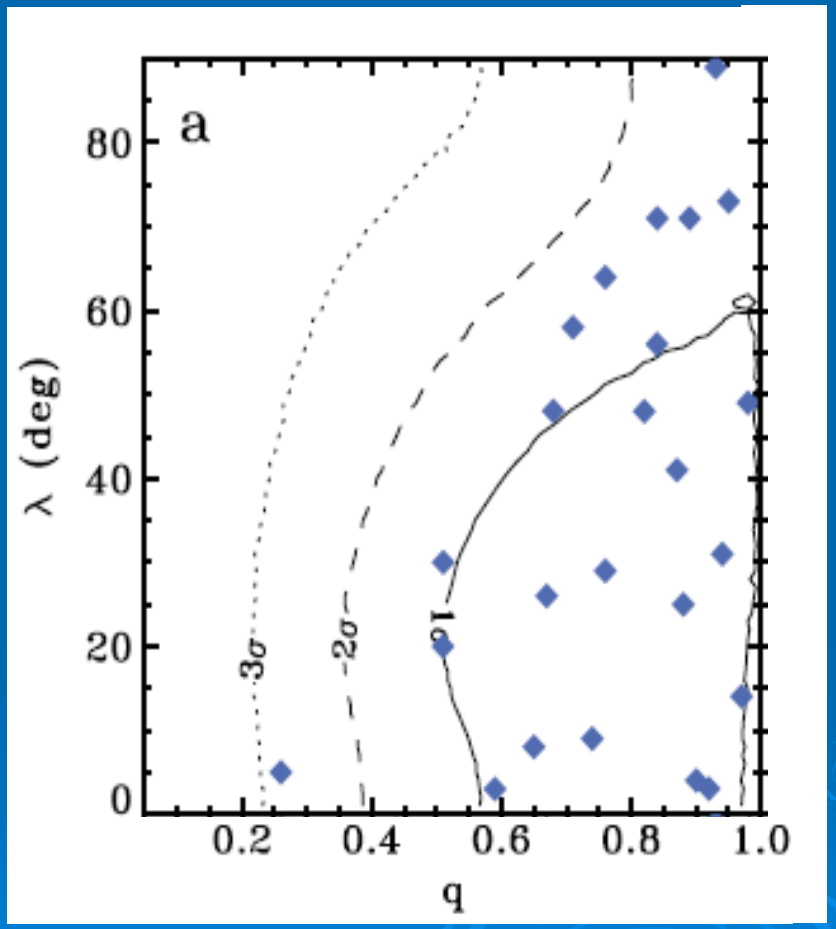
see also :

Ward-Thompson+ ’09

Sugitani+ ’11

Palmeirim+ ’13

Matthews+ ’14



more elongated

rounder

Planck result on *astro-ph*
(Planck XXXII; corresponding author A. Bracco)

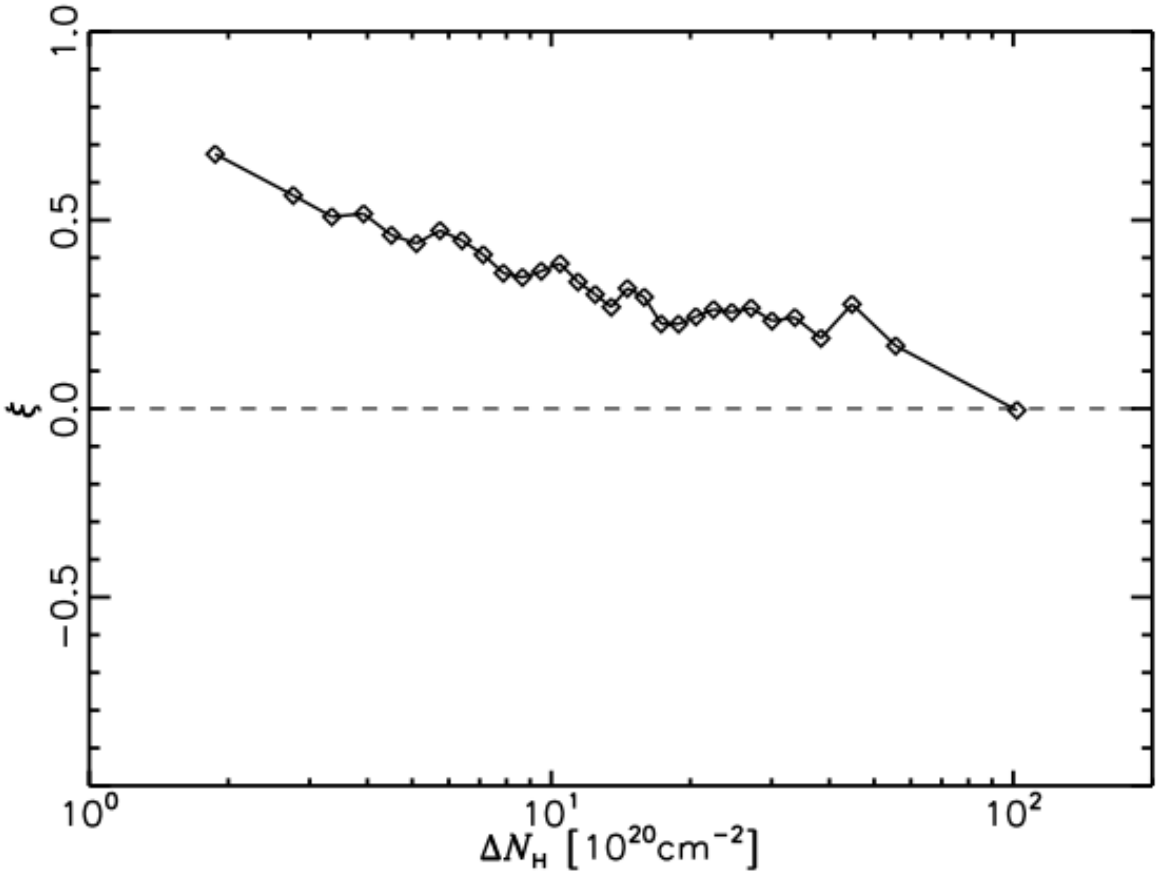
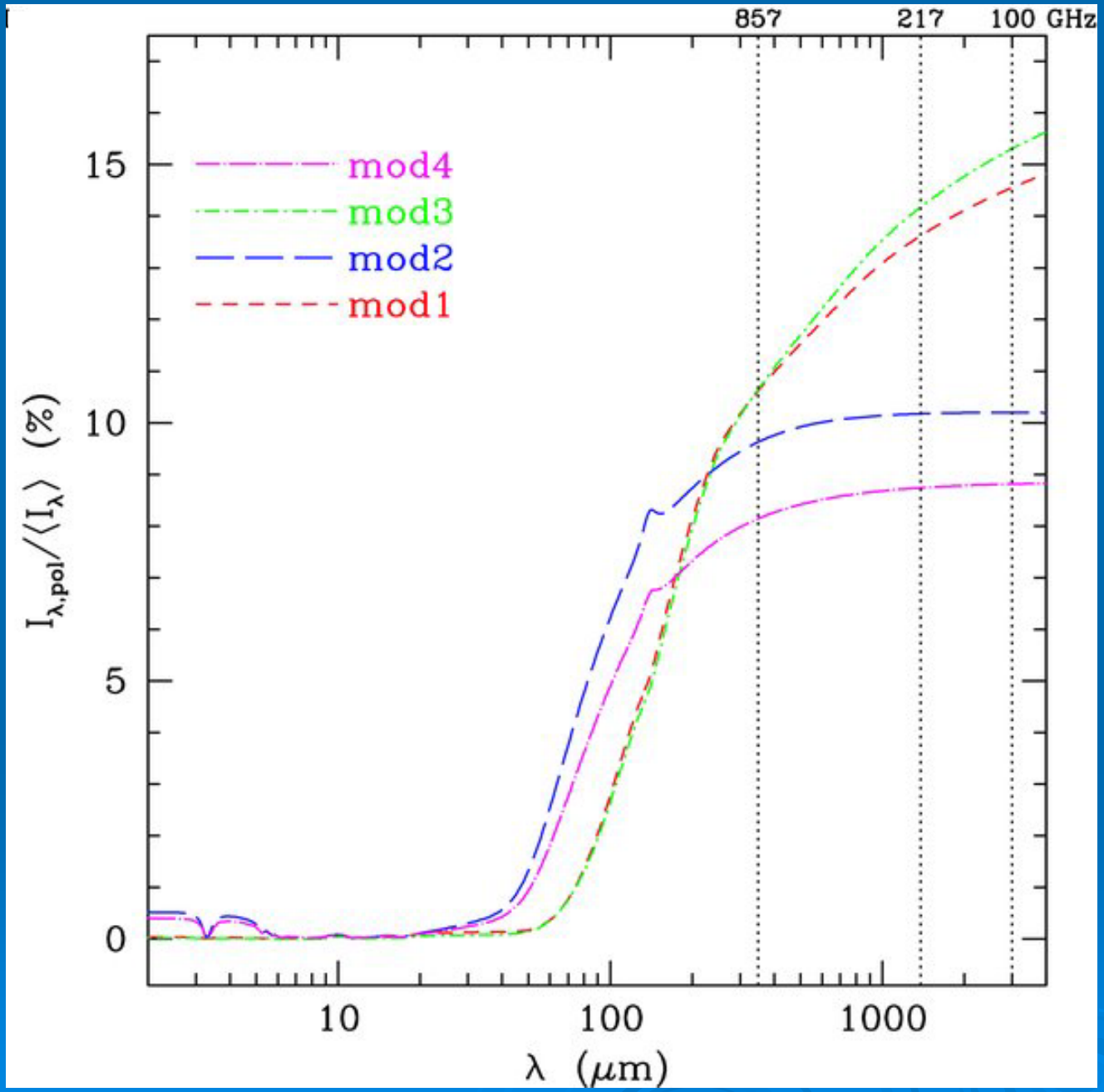


Fig. 15. Variation of the degree of alignment, ξ, as a function of the excess column density, $\Delta N_{\rm H}$, for the selected pixels. The de-

magnitude of submm polarization vs. N_H and T

Image of preliminary BLAST-pol results has been removed (these data have not yet been released by the collaboration)

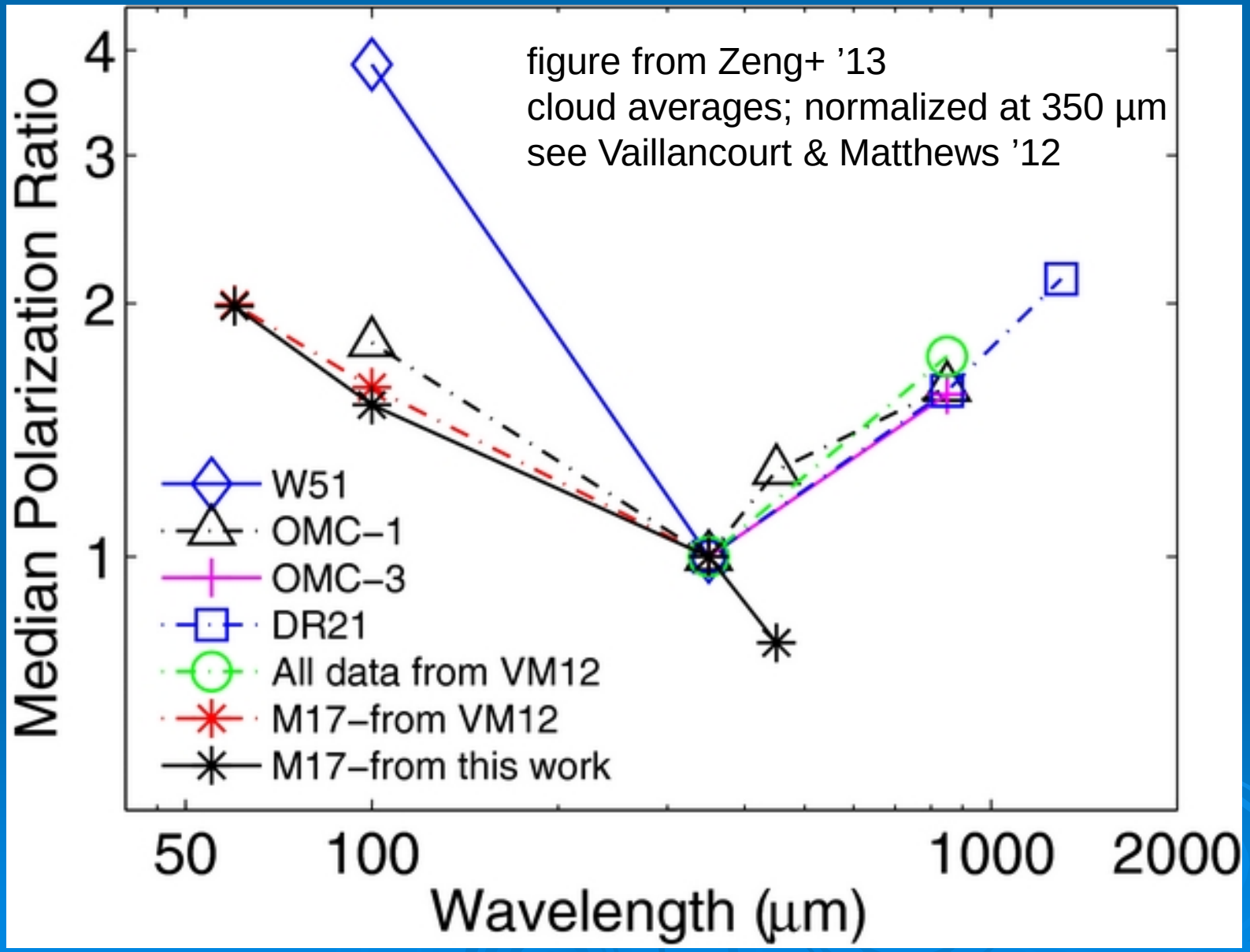


theoretical predictions: far-IR/submm polarization spectra

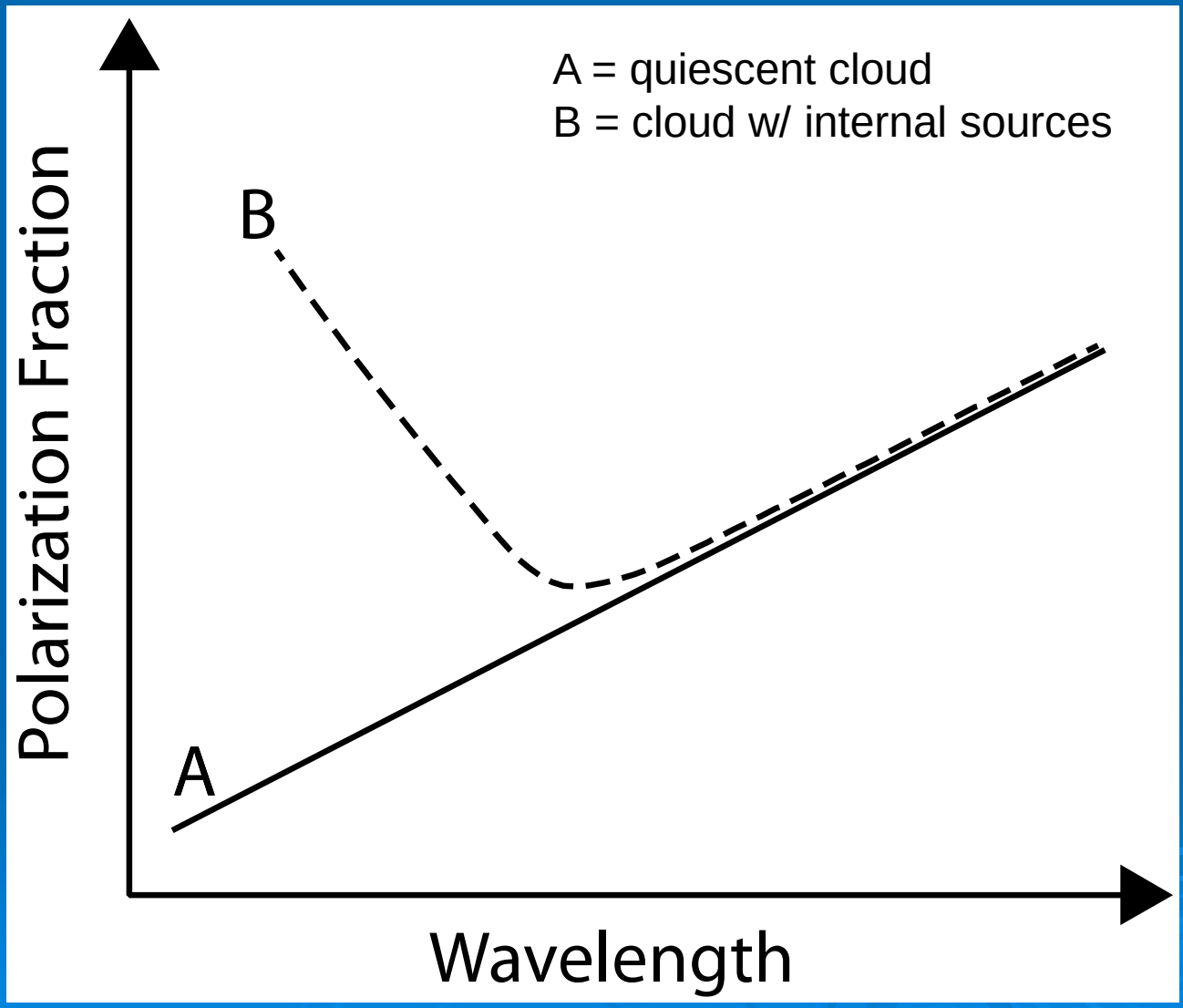
shown at left is Draine & Fraisse ’09 (diffuse emission)

see also Bethell+ ’07 (molecular clouds)

observed far-IR/submm pol. spectra



qualitative explanation proposed by Zeng+ ’13



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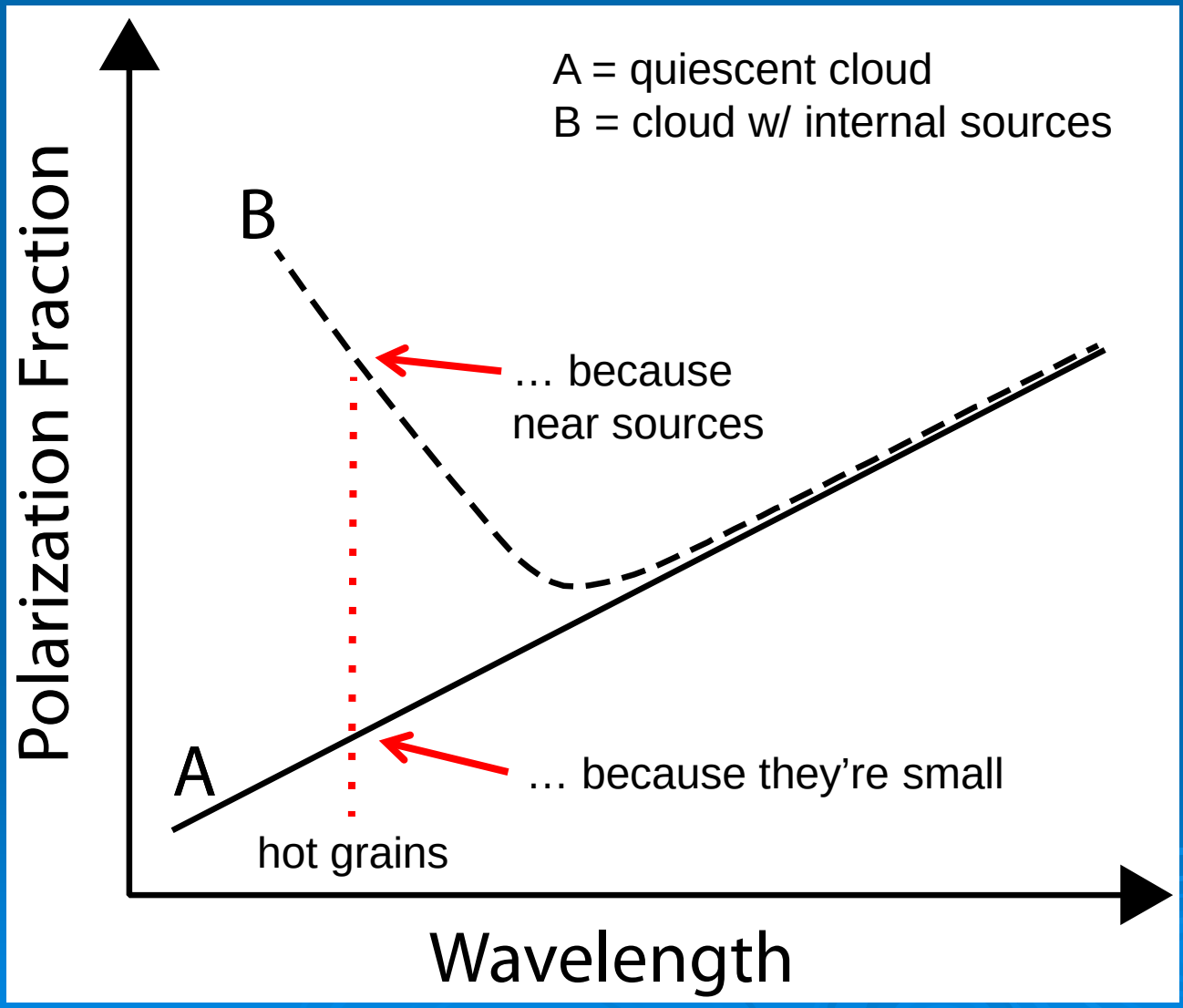

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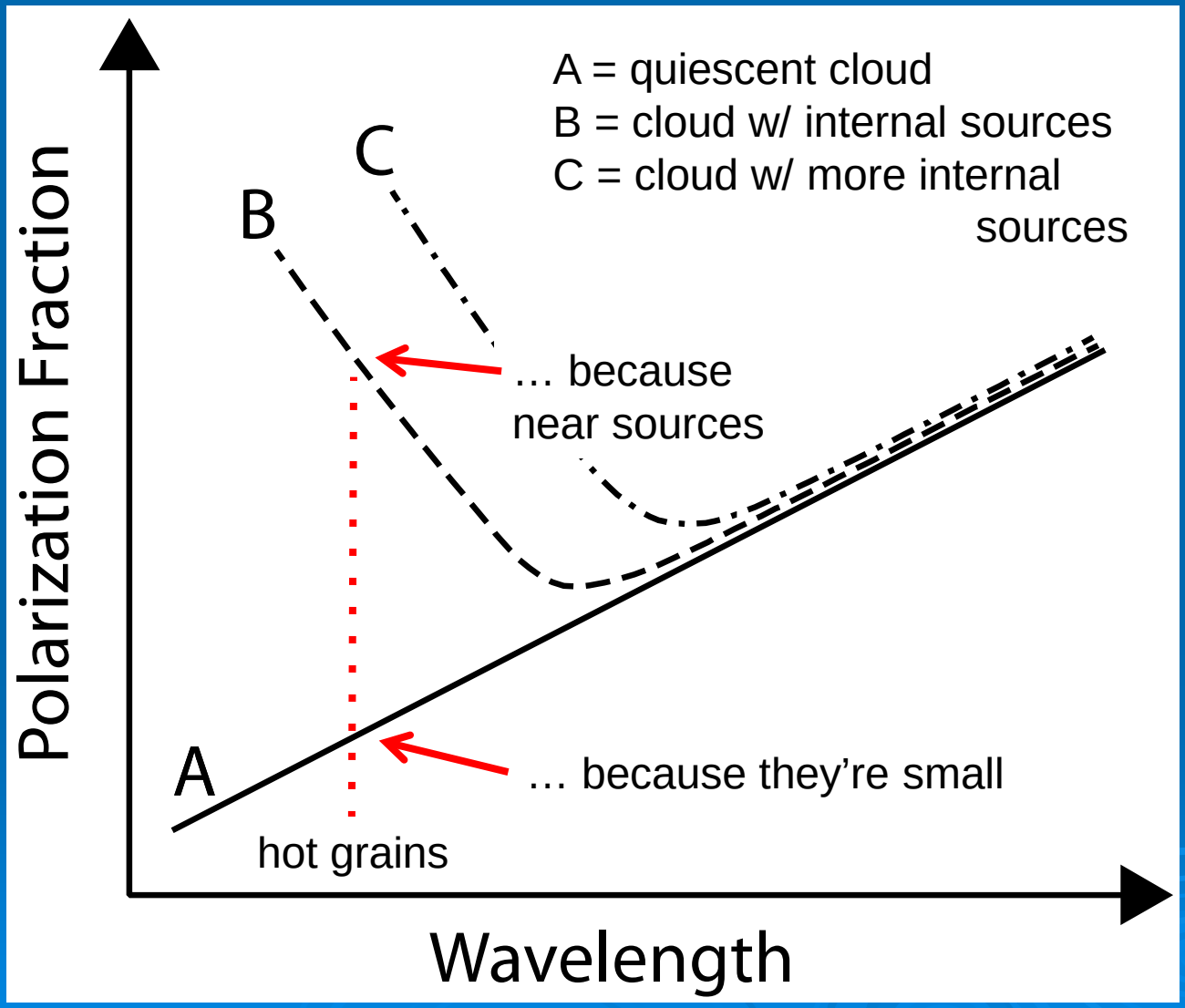

slope of polarization spectrum vs. T
(for three N_H bins)

Image of preliminary BLAST-pol results has been removed (these data have not yet been released by the collaboration)

ongoing and future research

1. ESA's *Planck* mission is correlating B-fields with filamentary structure, and follow-up submm polarimetry at scales ~ 0.1 pc and below can better match filament scales
2. For example, the upgraded BLAST experiment will generate 500,000 vectors per flight (2016 flight)
3. Quantitative comparisons between observations and theoretical simulations require grain alignment prescriptions
4. HAWC+/SOFIA & BLAST will provide eight spectral bands shortward of 850 μm (where ASTE, APEX, and JCMT operate) providing polarization spectra for a wide range of cloud conditions, with unprecedented statistics

thanks to:

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