Observational Constraints on Interstellar Grain Alignment

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Why do we care?

- Optical/NIR ISM polarization arises due to dicroic extinction by aligned, asymmetric, dust grains
  - Discovered in 1949, still not well understood!
  - FIR polarimetry from emission by aligned grains
- Polarimetry can be used to
  - Trace magnetic field structure
  - Measure field strength through Chandrasekhar-Fermi analysis
  - Grain micro-physics
- But if we don’t know which grains we are probing, we don’t know what it means!

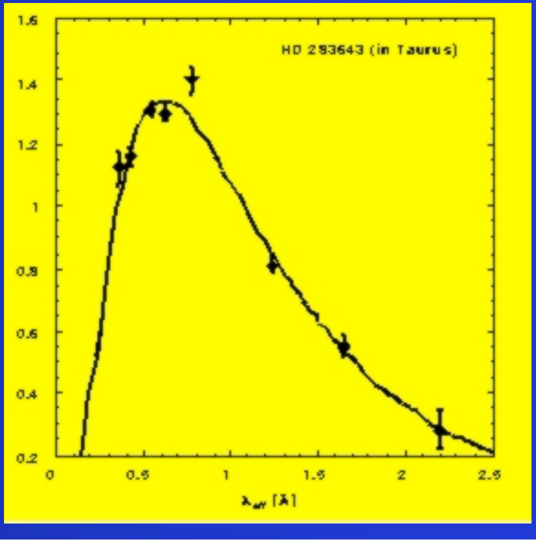
Modern theory favors RATs

- An asymmetric grain will have a differential right-hand/left-hand helicity ("basis vector decomposition")
- The helicity of the grain "absorbs" torques from the circular polarization in an asymmetric radiation field.
- Alignment should depend (amongst other) on:
  - Radiation field strength
  - Radiation field colour (λ/a)
- Pin-wheel torques ("quasi Purcell") might enhance the Radiative Alignment Torques alignment
- See Lazarian & Hoang 2007, MNRAS, 378, 910

How do we measure grain alignment?

- Fraction of aligned grains
  - p/A_V
  - Sensitive to l.o.s. turbulence/field topology
    - (polarization is a vector!)
- Relative alignment of different grain sizes
  - Measure λ_{max}
  - Requires multi-band data

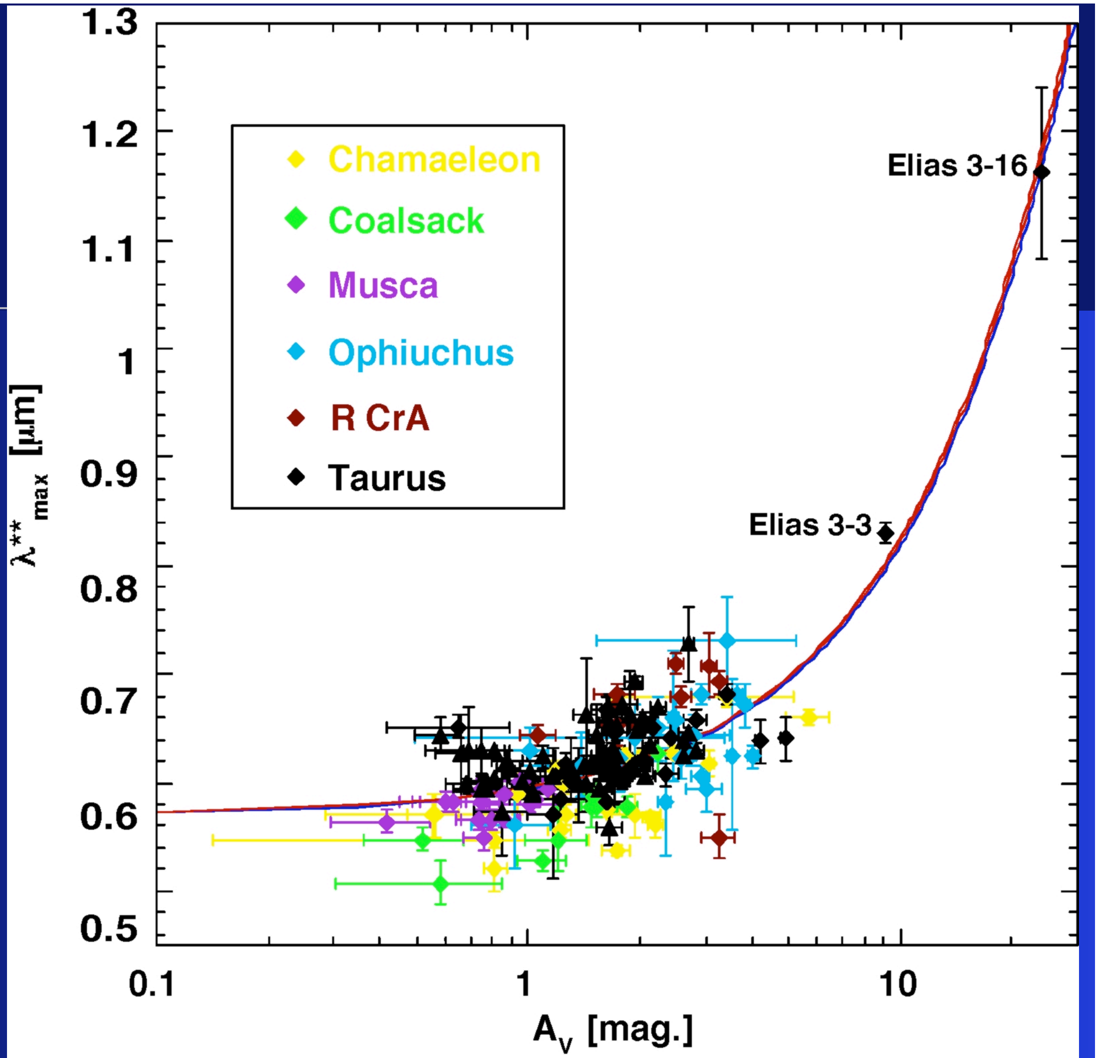
$$p(\lambda) = p_{\max} e^{-\left[K \ln^2(\lambda_{\max}/\lambda)\right]}$$



When observational biases:

- Anomalous sightlines
- Near-by bright stars
- Cloud-to-cloud differences in grains size

are corrected for:



Universal relation:

$\lambda_{max}=(0.157\pm0.002)<R_V>+(0.0252\pm0.004)A_V$

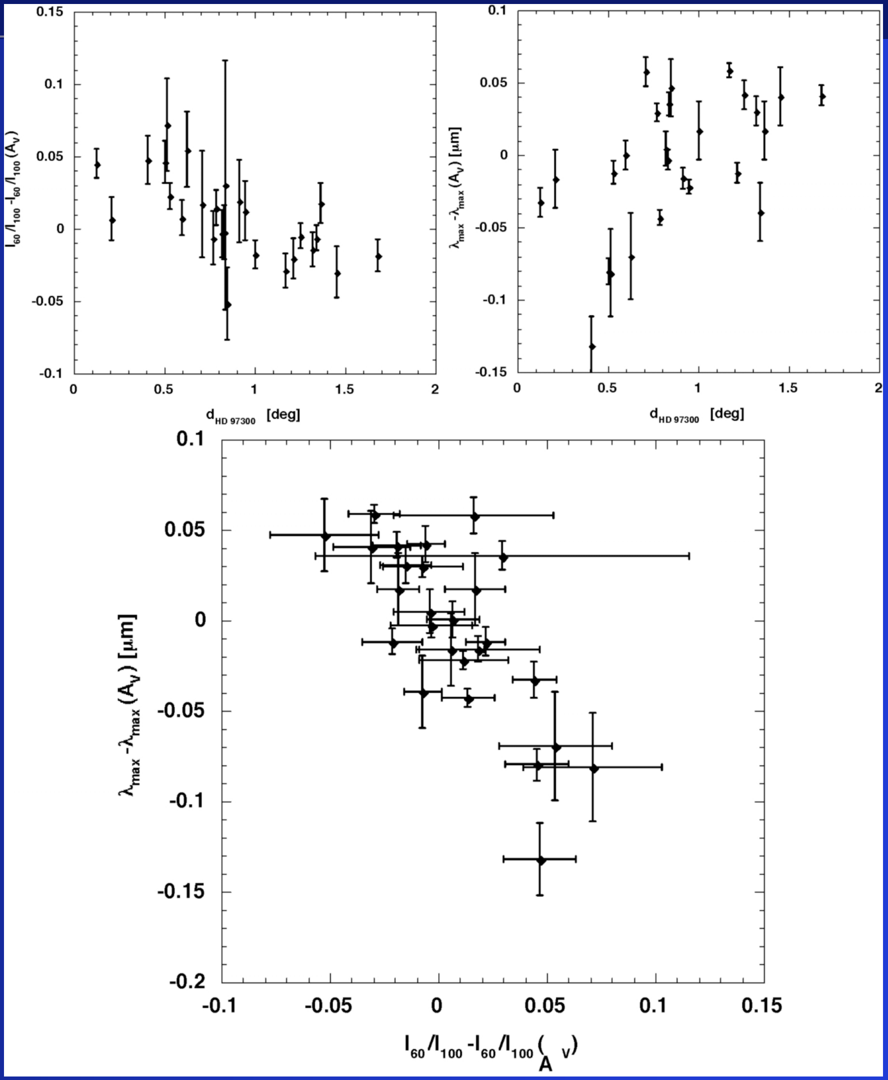
Supports radiative grain alignment

Can be used to probe for secondary effects

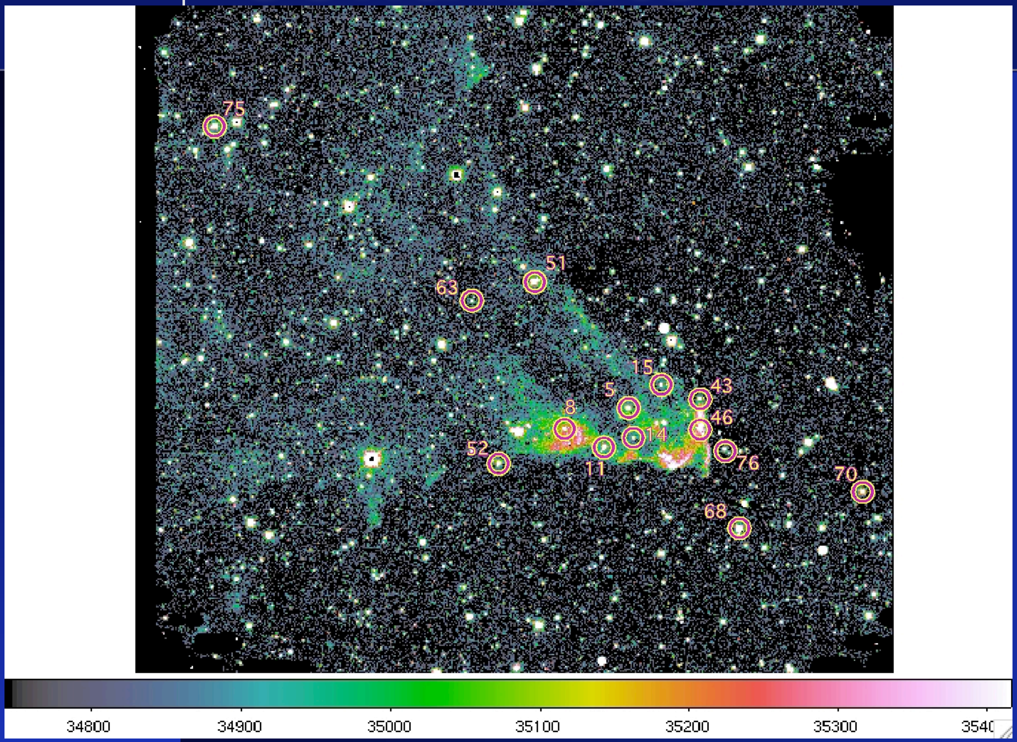
(see Andersson & Potter 2007, ApJ, 665, 369)

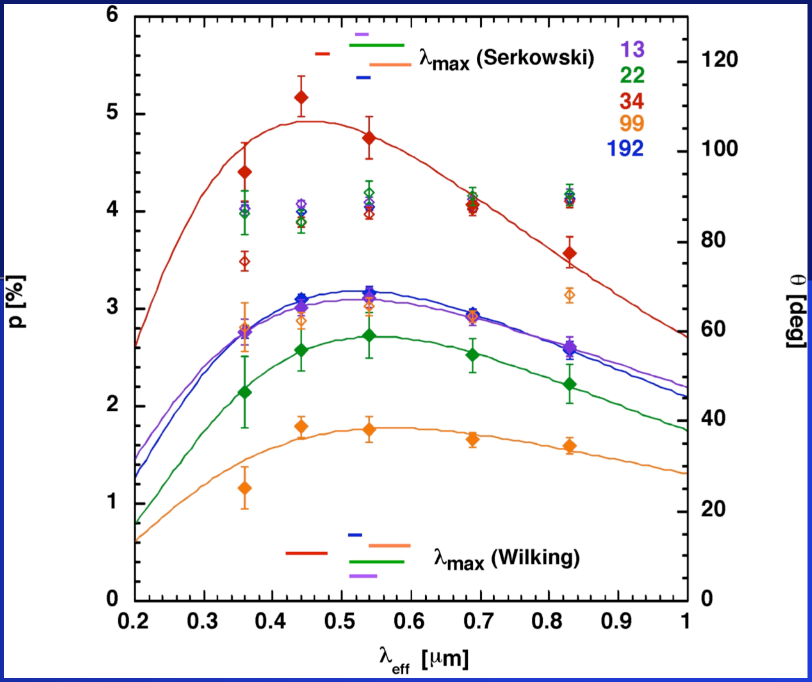
Alignment is enhanced close to a bright star

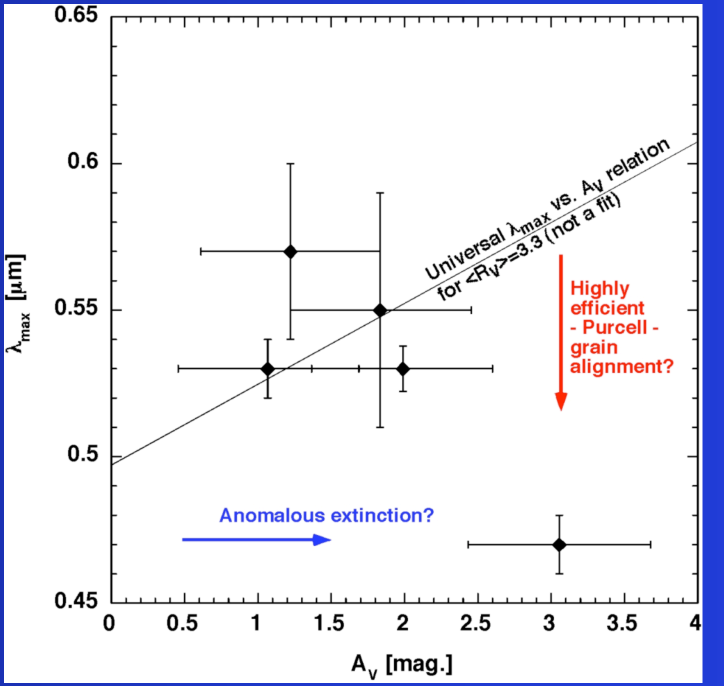
- Measure the differentials of I_{60}/I_{100} and λ_{max} vs. the nominal relations as functions of A_V, close to HD 97300 in Chamaeleon.
  Additional radiation => additional alignment



Do pin-wheel torques contribute?







- Deep H_2 1-0 S(1) imaging
- 15 sightlines with NOT/ALFOSC
- H_2 formation seems to enhance the alignment
- If true: Grains are not super-paramagnetic

Conclusions

- A quantitative theory of grain alignment has recently been developed, based on direct radiative effects
- We have observationally shown that:
  - λ_{max} correlates with A_V
  - Alignment enhanced close to bright star
  - Alignment seems to be enhanced by H_2 formation
- Supporting radiative alignment theory.
- A 60 year old problem is being solved!