Hot stars and scintillators: a new result from ATESE

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(Manly Astrophysics)

Overview

- Why is radio-wave propagation interesting?
- The ATESE project: who and what
- Discovery of Intra-Day Variability in PKS1322-110
  - Right next to Spica!
- Another look at IDV in PKS1257-326 and J1819+3845
  - Association with local, hot stars
- Inferences about the circumstellar medium

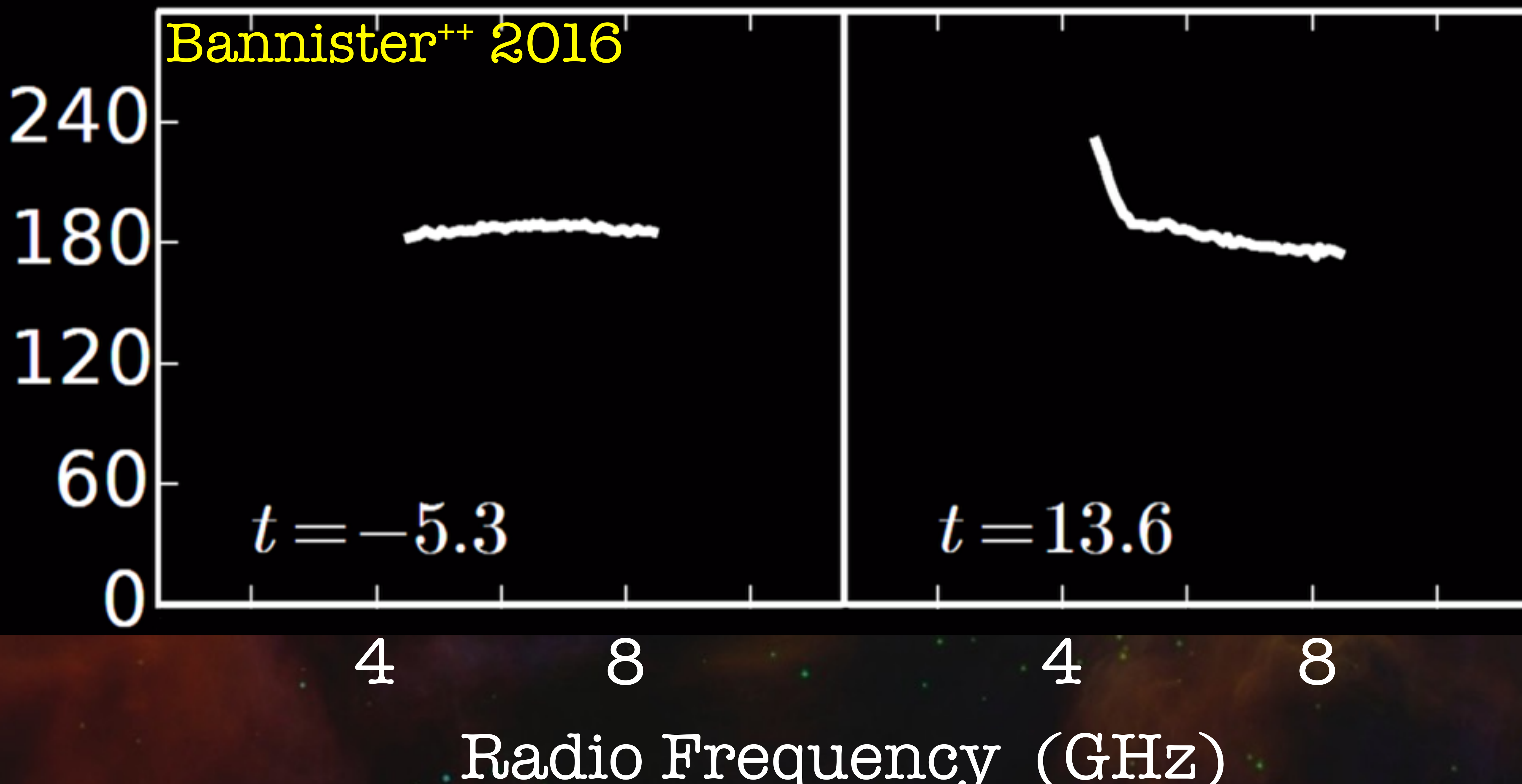
Why scintillation is interesting

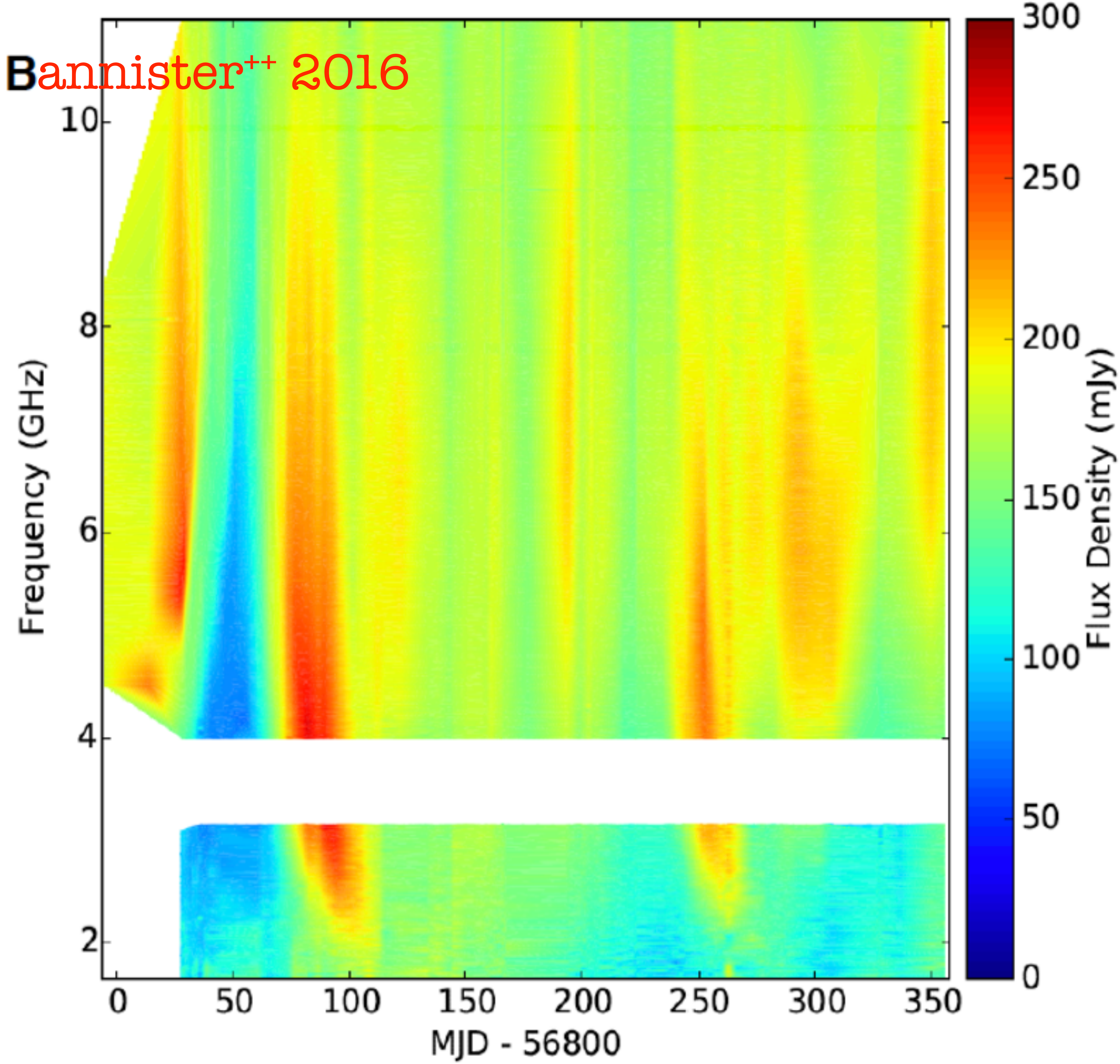
- A powerful "microscope" for the ionised ISM
  - "Resolution" ~ 10^{11} cm
  - "Sensitivity" ~ 10^{11} cm^{-2}
- Usually see low-level flux variations of radio quasars
  - Distributed turbulence throughout Galactic ISM (?)
- Sometimes see large and/or rapid flux variations
  - Extreme Scattering Events (ESEs) - plasma lensing
  - Intra-Day Variability (IDV) - scattering by plasma microstructure (highly anisotropic)
  - ESEs/IDV suggest numerous small regions ($10^{1\pm1}$ AU) that are over-pressured ($n_e \sim 10^{2\pm1}$ cm^{-3})

ATESE: ATCA survey for Extreme Scattering Events

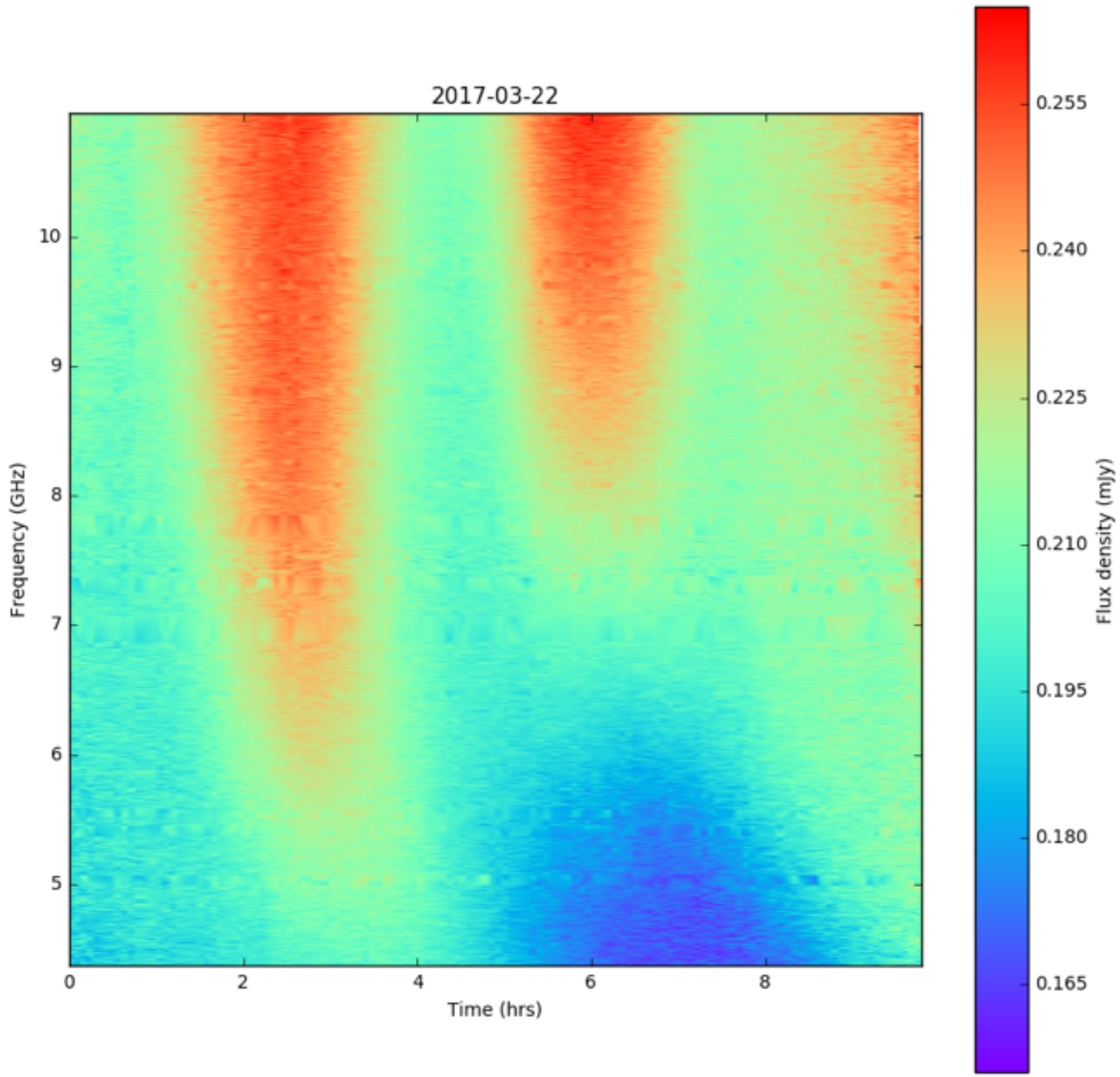
- Keith Bannister (PI), Jamie Stevens, Simon Johnston, Hayley Bignall, Cormac Reynolds (CSIRO) - radio obs. Artem Tuntsov & MW (Manly) - theory
- Vikram Ravi (Caltech) - optical follow-up
- Running since April 2014
- Monthly observations of 10^3 compact radio quasars
  - Wide-band spectra (4 - 8 GHz)
- Intensive follow-up of interesting sources
  - Mainly triggering on weird spectra

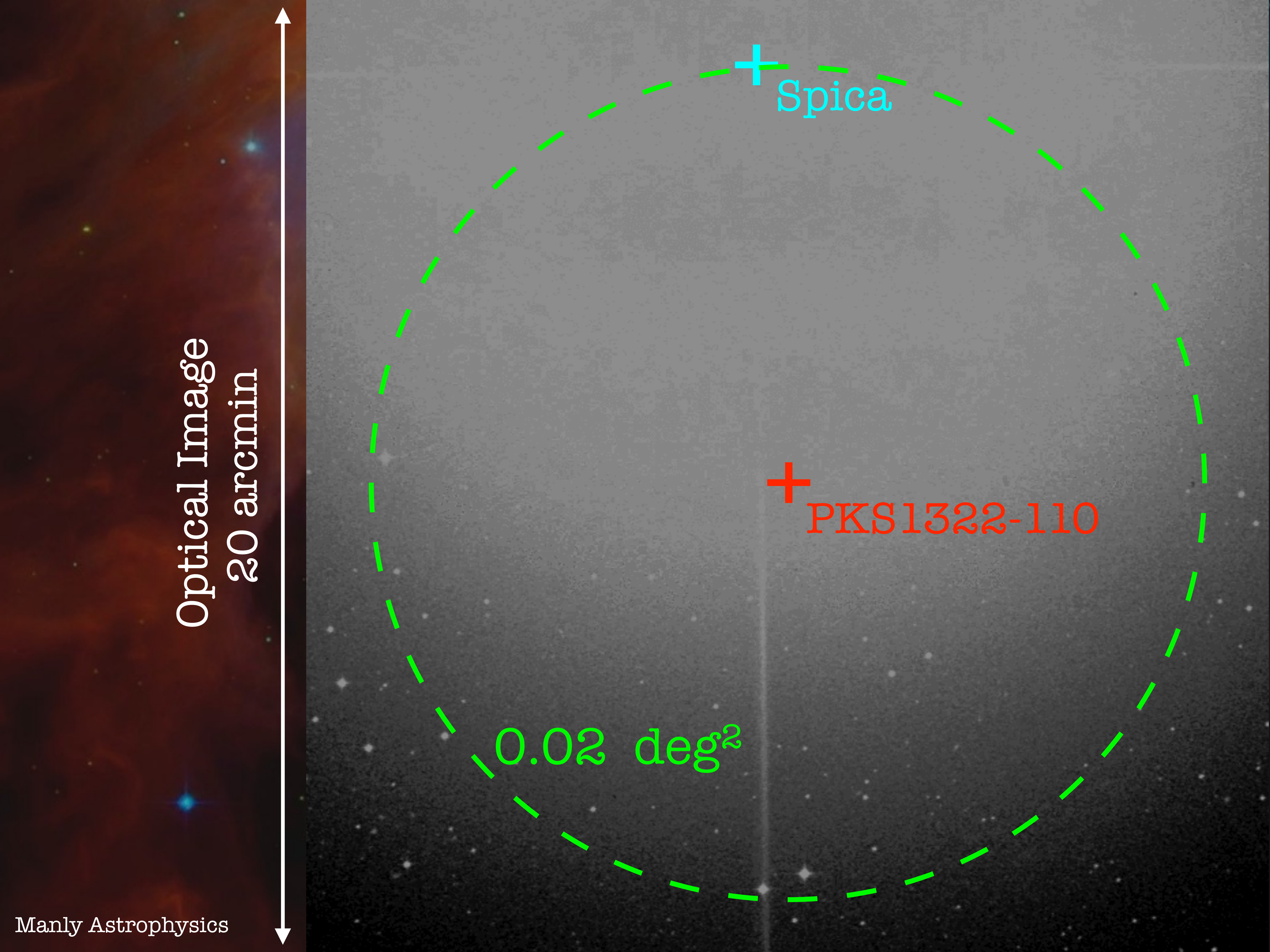
First Event: PKS1939-315




Bannister++ 2016
Frequency (GHz)
10
8
6
4
2
0
50
100
150
200
250
300
350
MJD - 56800
Flux Density (mJy)
300
250
200
150
100
50
0

PKS 1322-110 : a new IDV




Optical Image
20 arcmin
Spica
PKS1322-110
0.02 deg²
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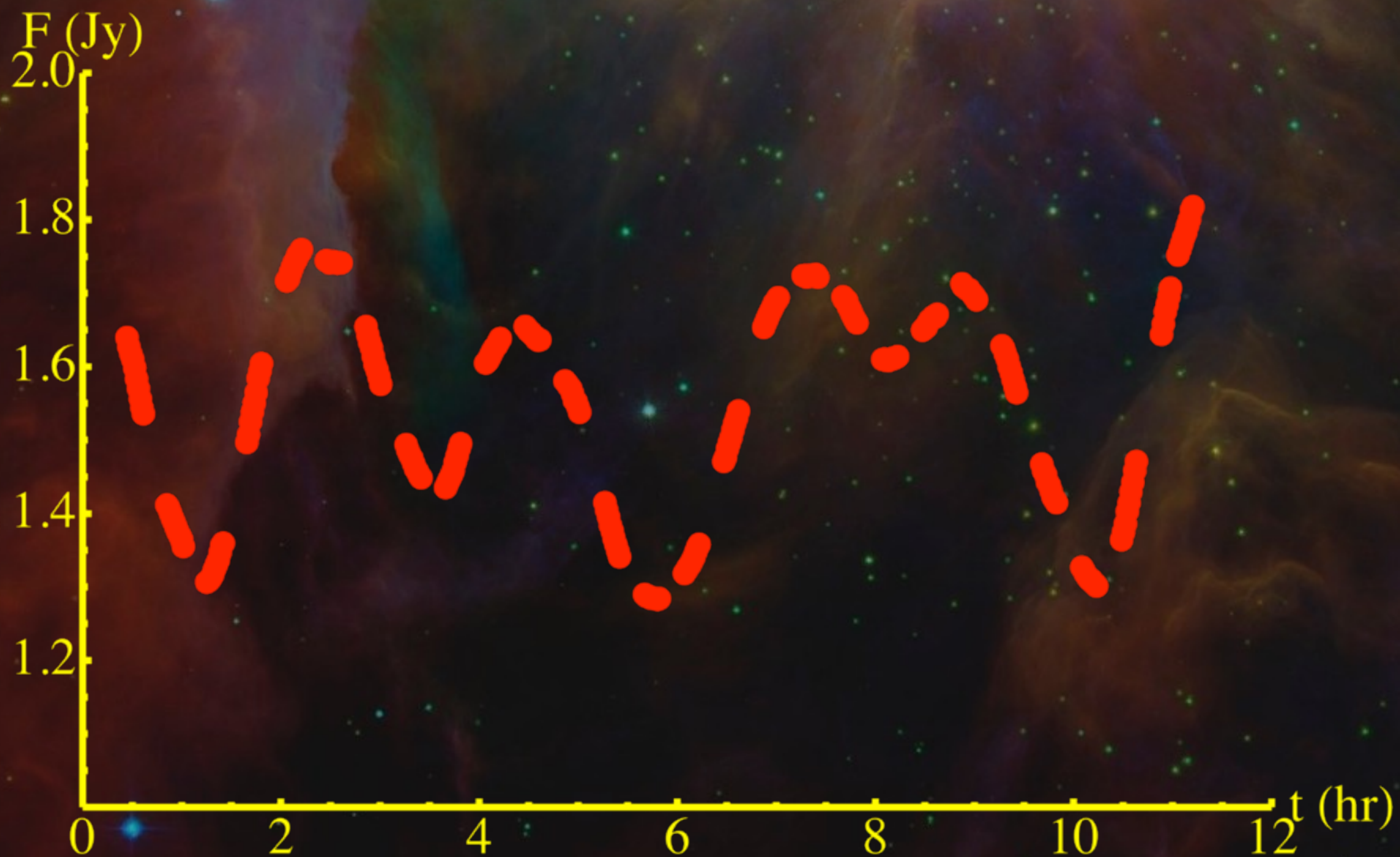
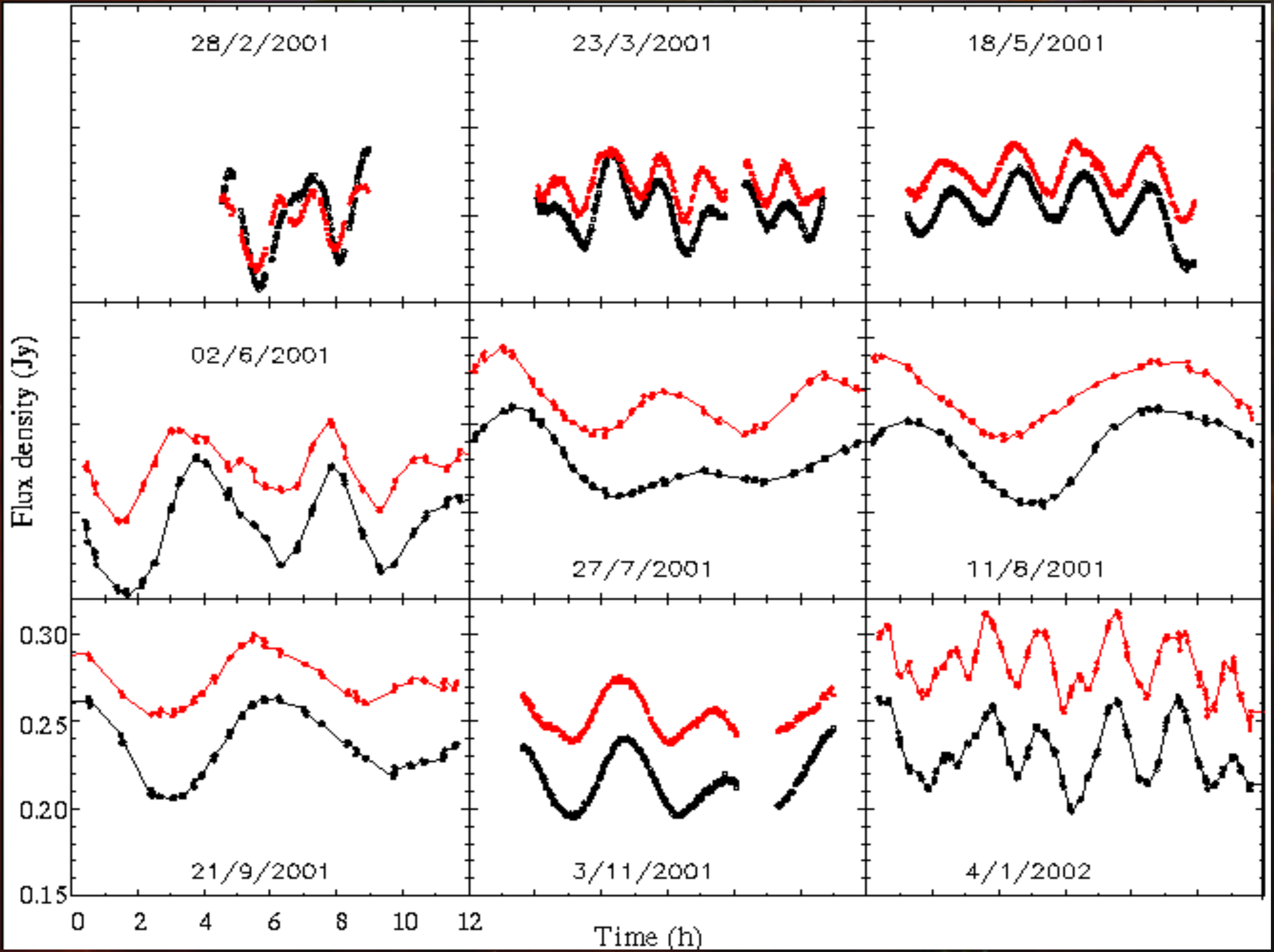
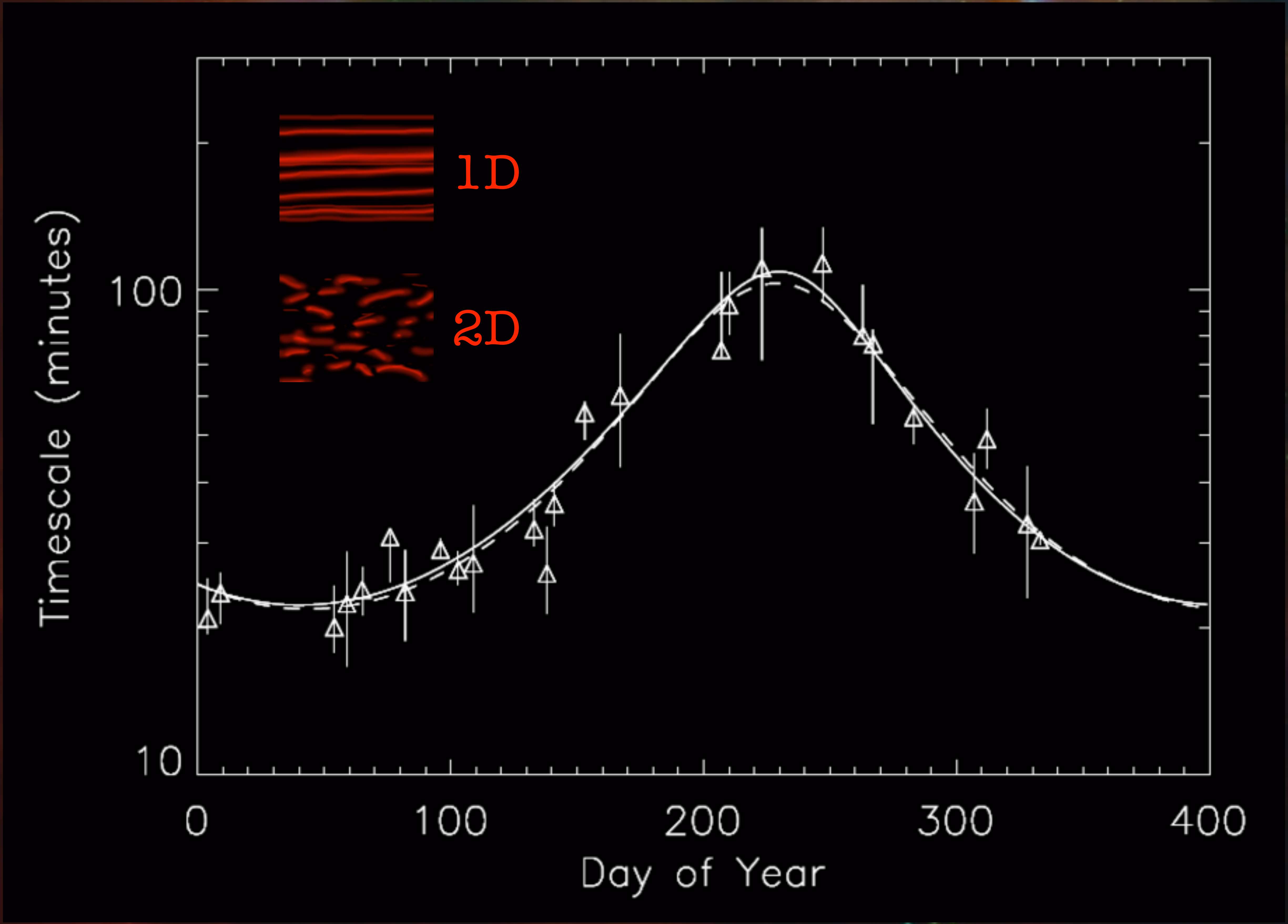
PKS0405-385 (Lucyna's source)



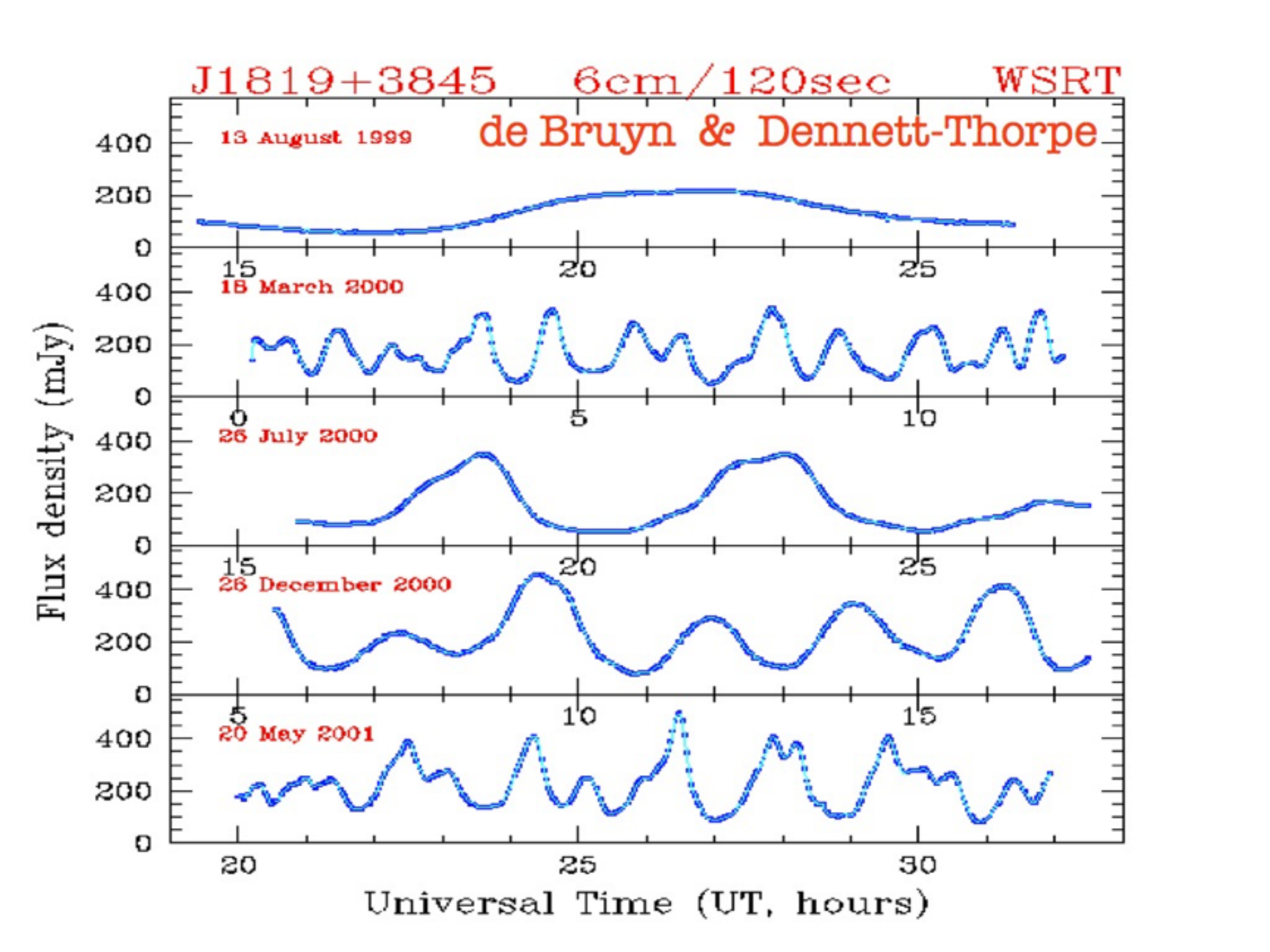
PKS1257-326 (Hayley's source)



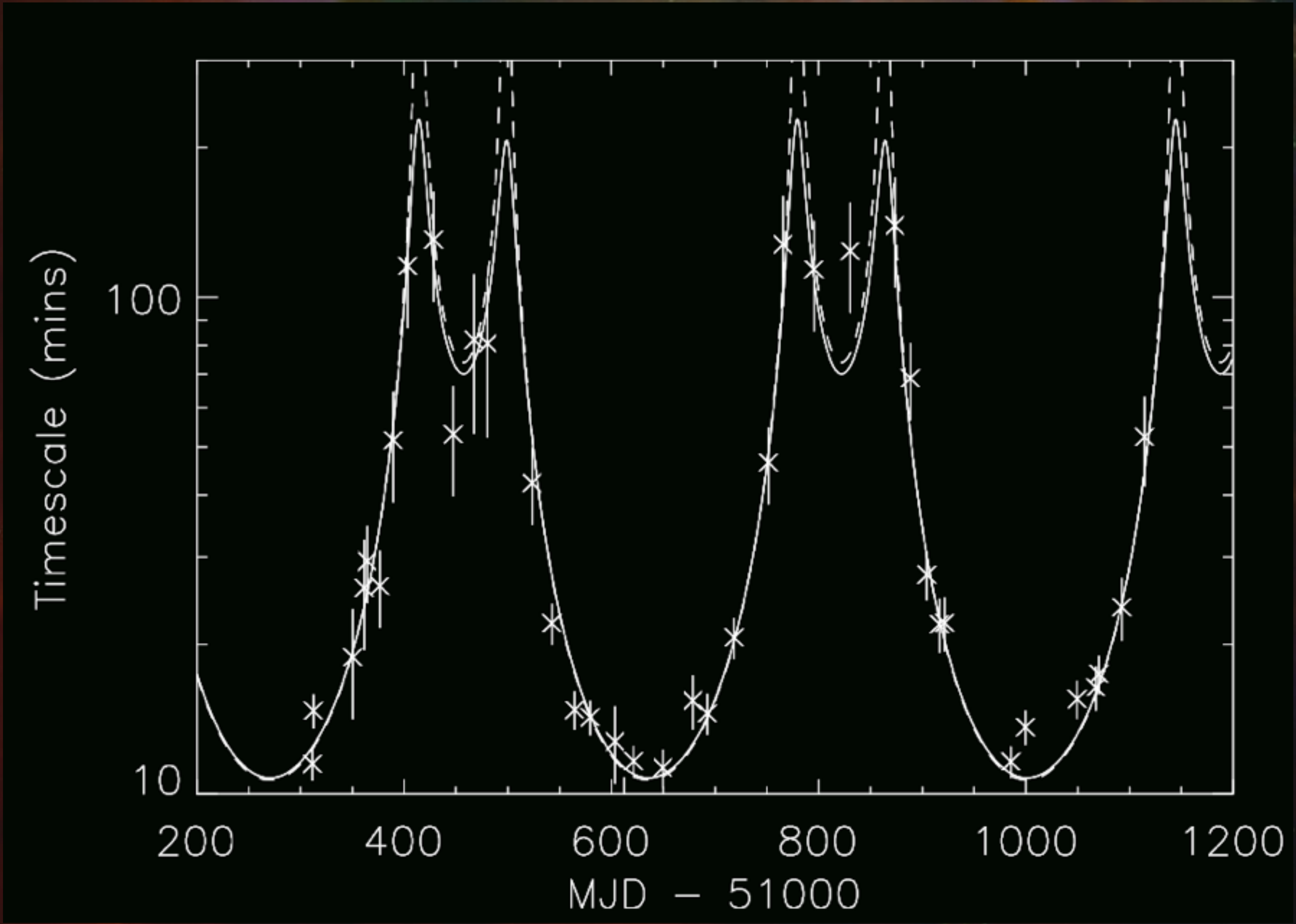
PKS1257-326 (Hayley's source)



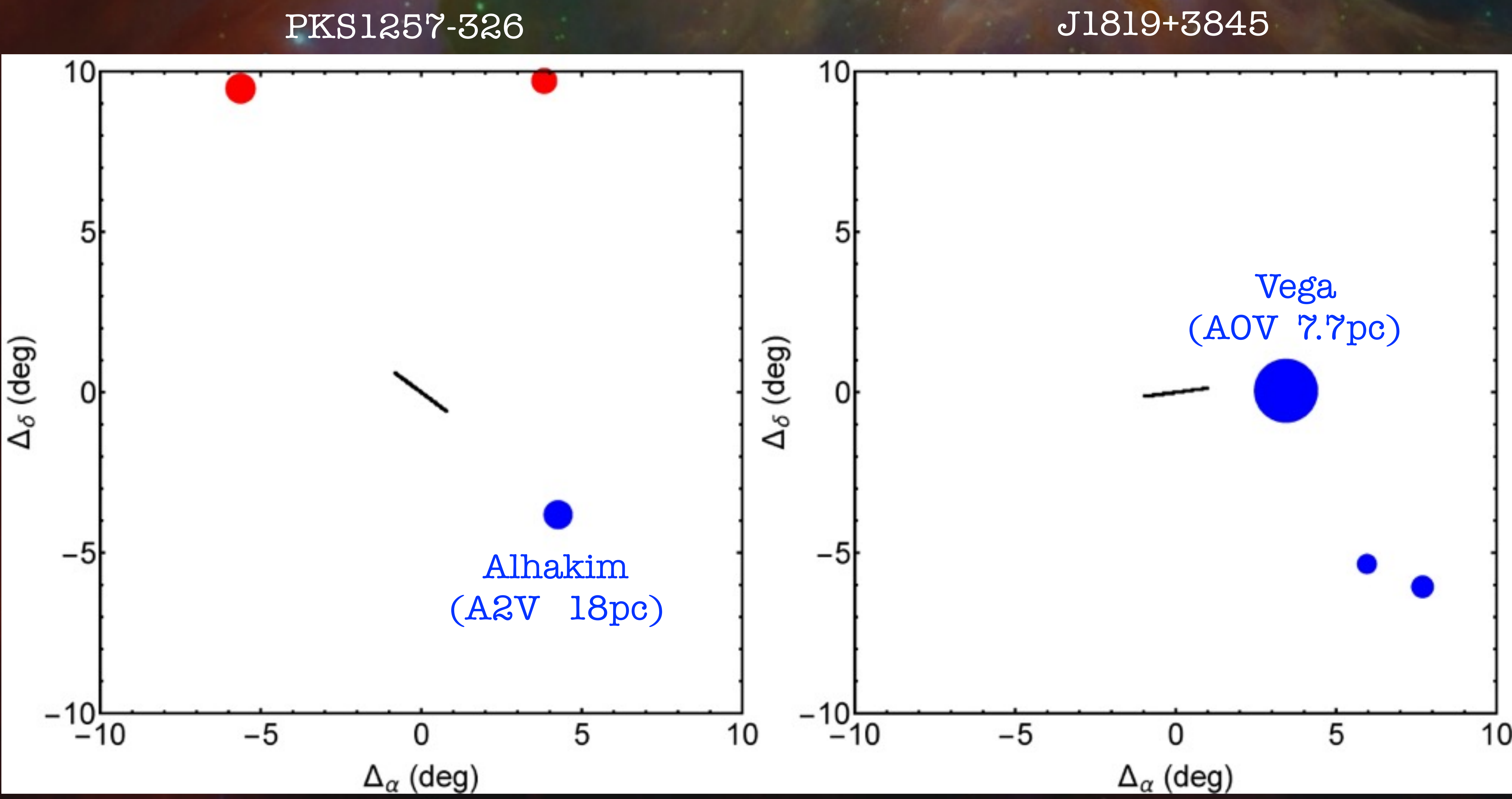
J1819+3845 (Jane's source)



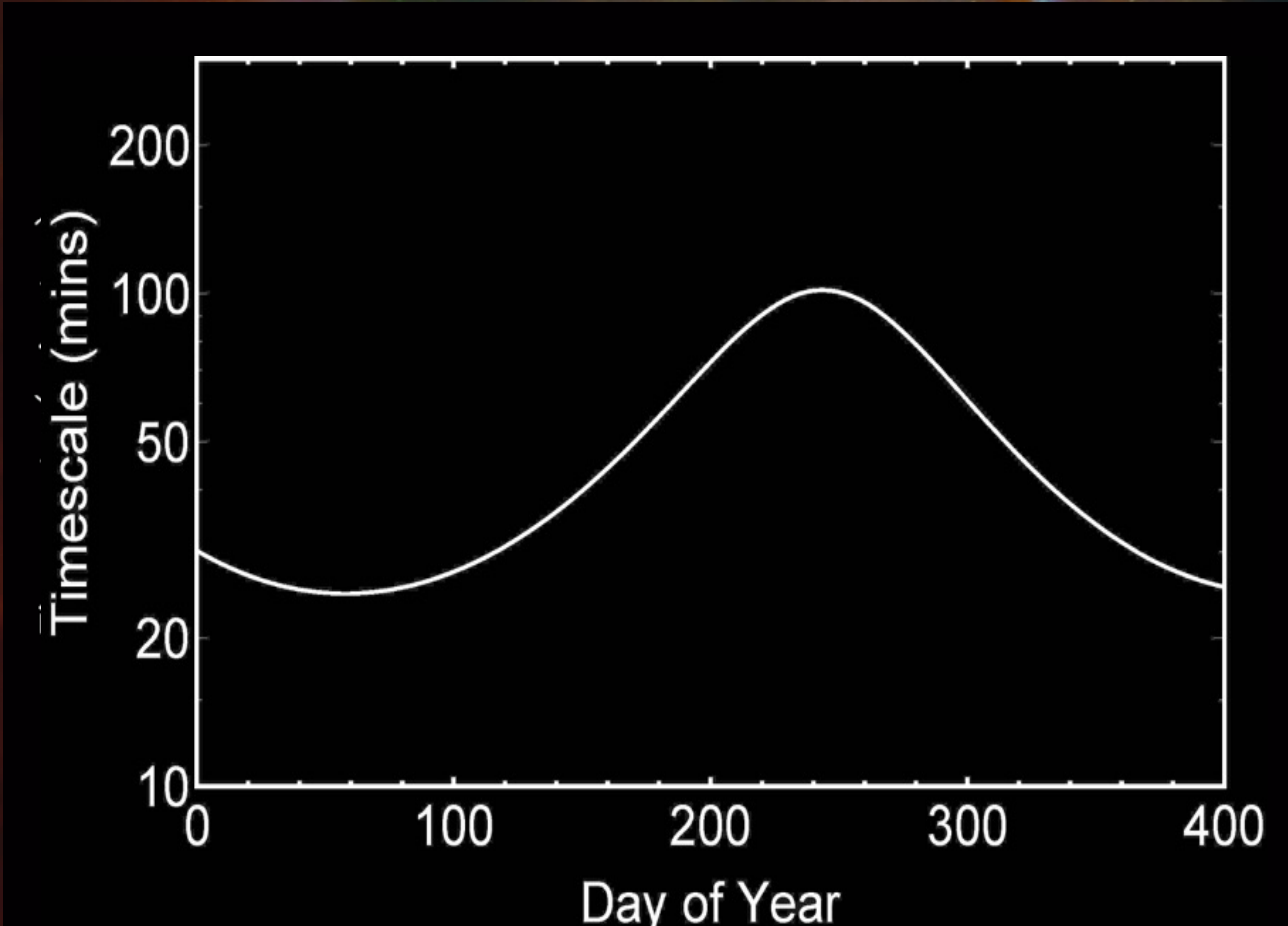
J1819+3845 (Jane's source)



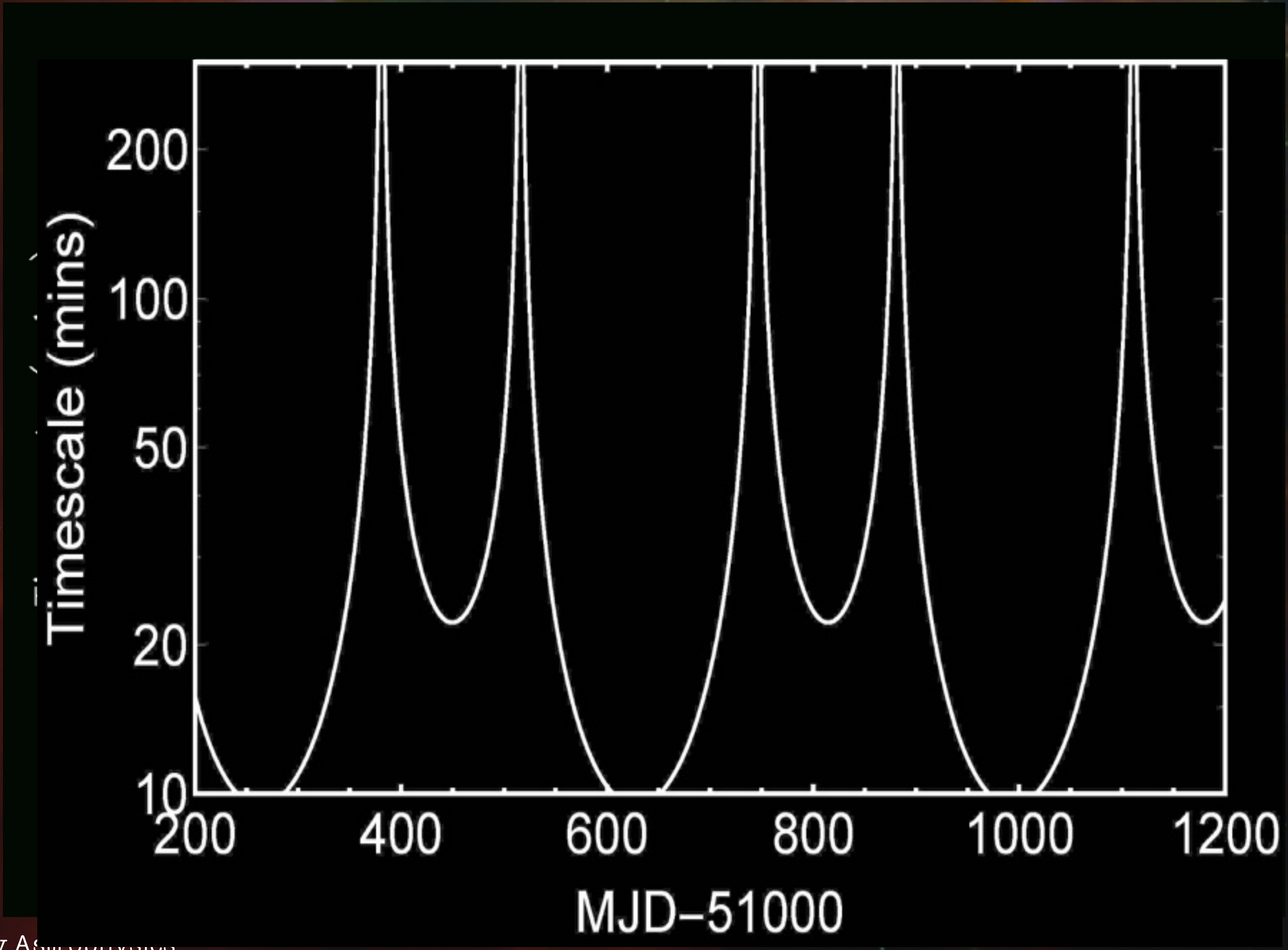
Bright stars in the foreground



PKS1257-326 (Hayley's source)



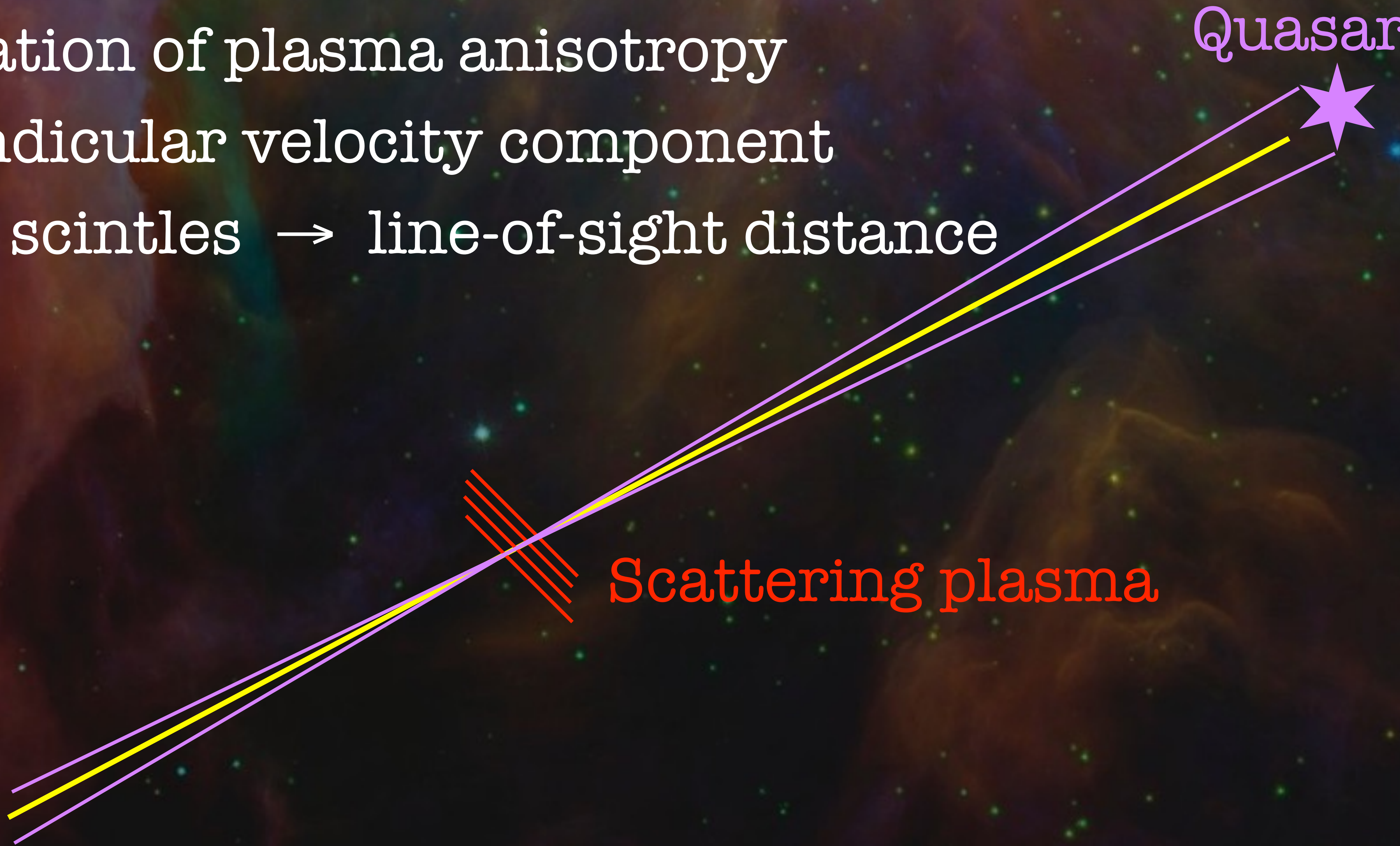
J1819+3845 (Jane's source)



Lucky coincidences?

Fitting to annual cycle gives:

1. Orientation of plasma anisotropy
2. Perpendicular velocity component
3. Size of scintles $\rightarrow$ line-of-sight distance



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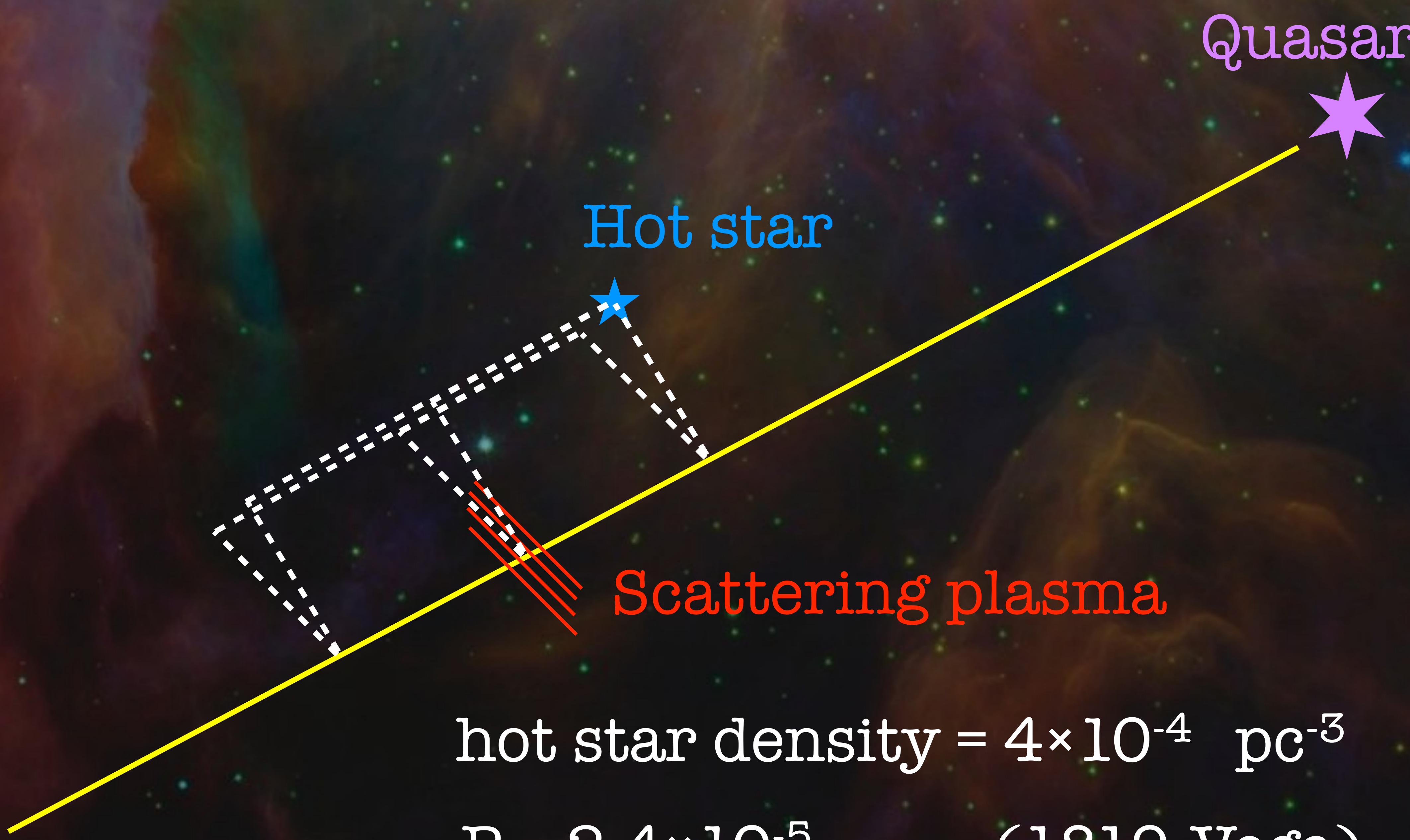
Lucky coincidences?



hot star density $= 4\times10^{-4}$ pc^{-3}

$P = 2.4\times10^{-5}$ (1819-Vega)

$P = 1.7\times10^{-4}$ (1257-Alhakim)

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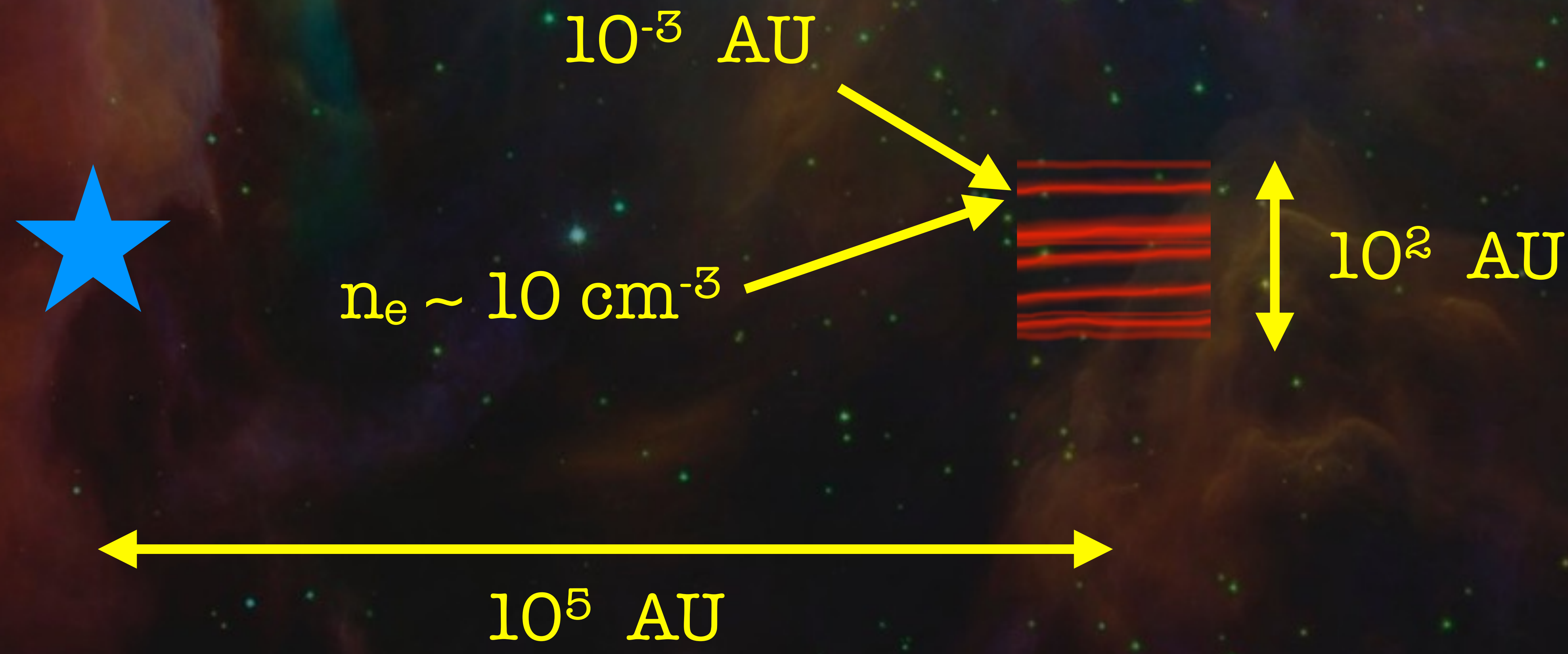
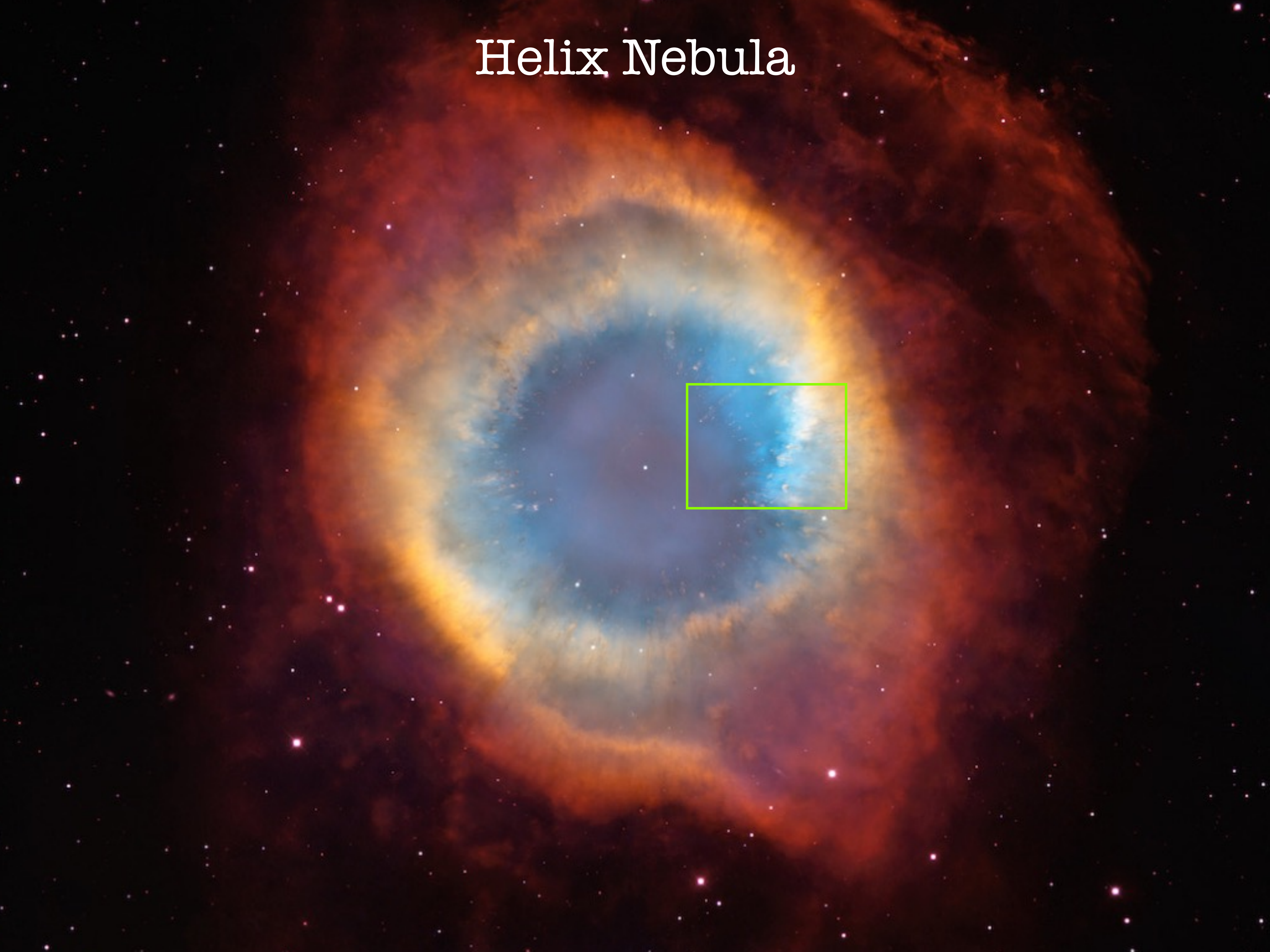
The environments of hot stars



The environments of hot stars


Helix Nebula


Matsuura++ 2009
H_2 2.1 µm
Total molecular mass ~ $M_\odot$
Same for all stars ?

Conclusions

- IDV caused by plasma around hot, local stars
  - Not attributable to stellar winds
- Plasma concentrations appear similar to those in Helix
  - In Helix, plasma forms a skin around H_2 globules
  - $\therefore$ swarms of H_2 globules around local, hot stars
- Qualifiers “local” and “hot” due to IDV selection bias
  - $\therefore$ swarms of H_2 globules around all stars
- Total mass in globules is comparable to stellar mass