

# PHOTOMETRY OF BRIGHT B STARS USING CONTAMINATED *KEPLER*/K2 PIXELS

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## KEPLER AND THE K2 MISSION

- Sent up in 2009, to scan a particular field.
- ...until it malfunctioned in 2013 (*oops!*).
- Repurposed to do **awesome** science on new fields.
- One of the greatest telescopes in history.



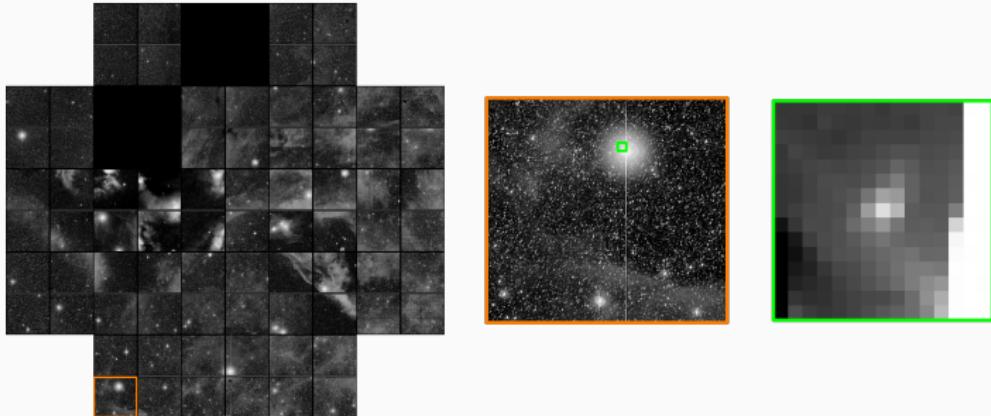
# ASTEROSEISMOLOGY AND PHOTOMETRY

- Stars aren't static — they show variability.
- **Asteroseismology:** study of variability to probe inside stars.
- **Photometry:** counting photons to do *asteroseismology*.
- Traditionally believed photometry requires all flux from target.

# WHY BRIGHT STARS?

- We like bright stars!
- Nearby and well studied.
  1. Improve existing models.
  2. No good data for these targets (for quite a while yet).
  3. Follow-up research from the ground.
- But, bright star photometry is hard.

## BANDWIDTH ISSUES



- Limited bandwidth as *Kepler* is very far away and covers a large field of view.
- Provide “postage stamps” ( $\approx 30000$ ) – small cutouts around chosen targets taken every 30 minutes.
- Bright stars require bigger cutouts and thus more bandwidth.
- $\therefore$  No postage stamps of bright stars.

WHAT IF ...

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- ...postage stamps we **do** have could be used to do photometry on bright stars **without** postage stamps?

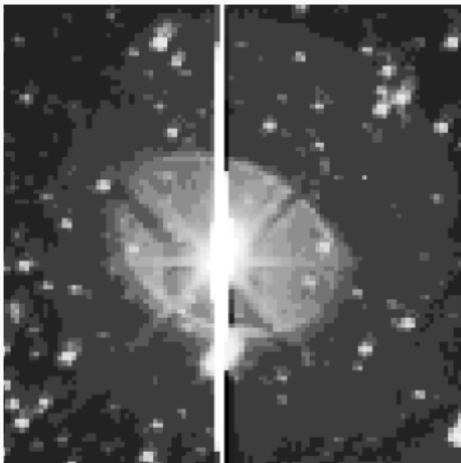
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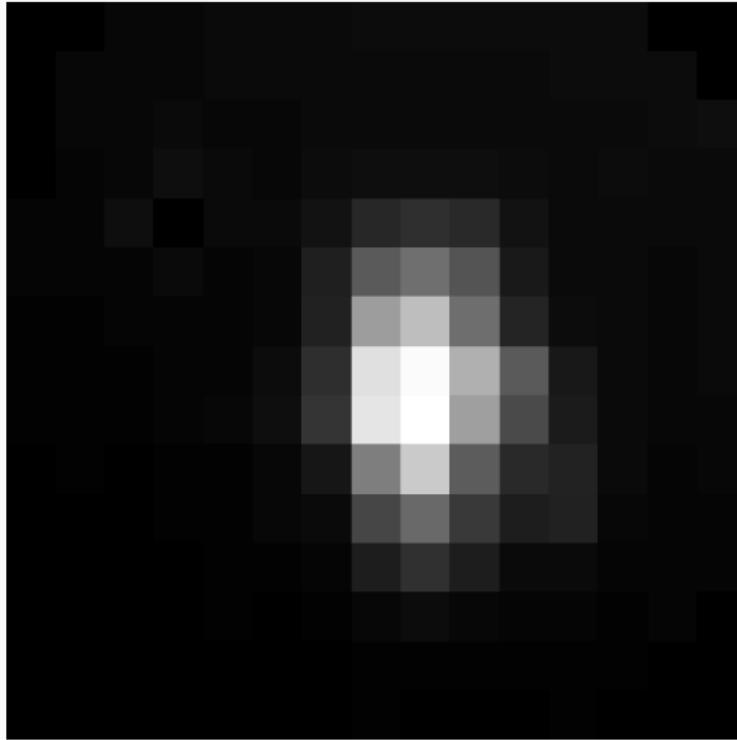
- ...postage stamps we **do** have could be used to do photometry on bright stars **without** postage stamps?
- ...there are targets close enough to bright stars such that the flux *contaminates* the postage stamp?
- ...we could do photometry on **ALL THE THINGS?**

## CONTAMINATION



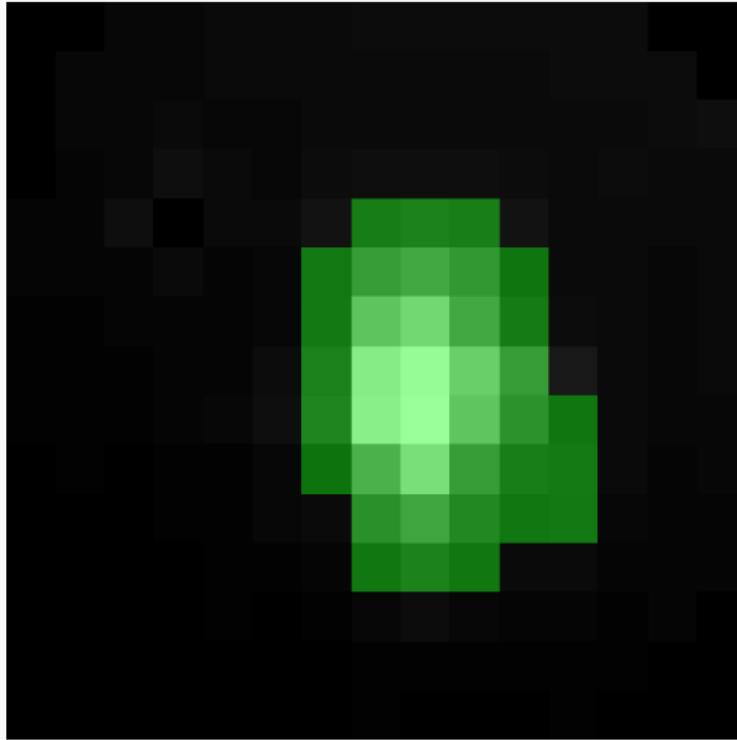
- CCD sensors work by counting electrons ejected by photons in each pixel.
- Photons are scattered, internally reflected and defracted, causing a halo.
- Subset of halo pixels have a proportional photon count.
- ∴ Photometry can be done using subset of halo pixels.

## NORMAL



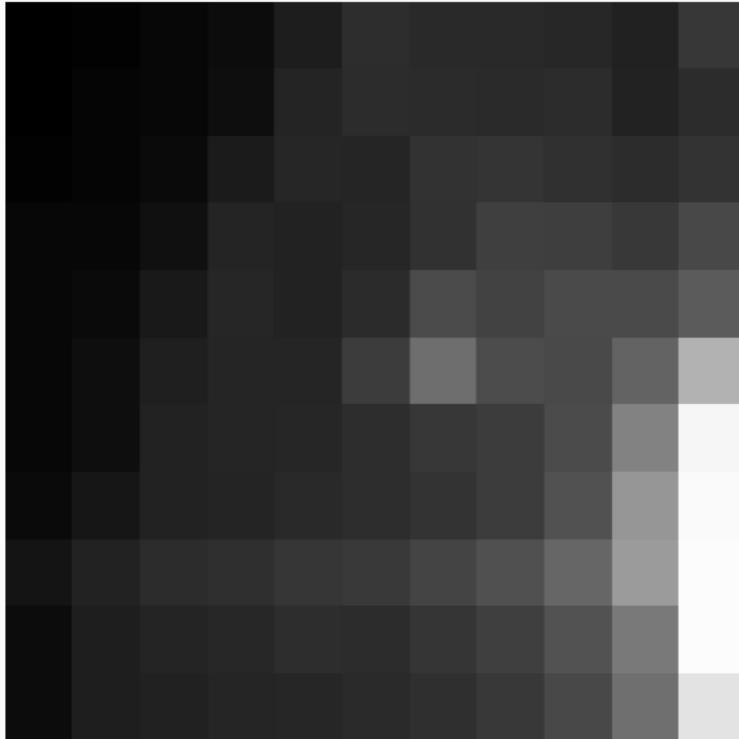
*Kepler/K2:* Normal (*aka boring*) postage stamp.

## NORMAL



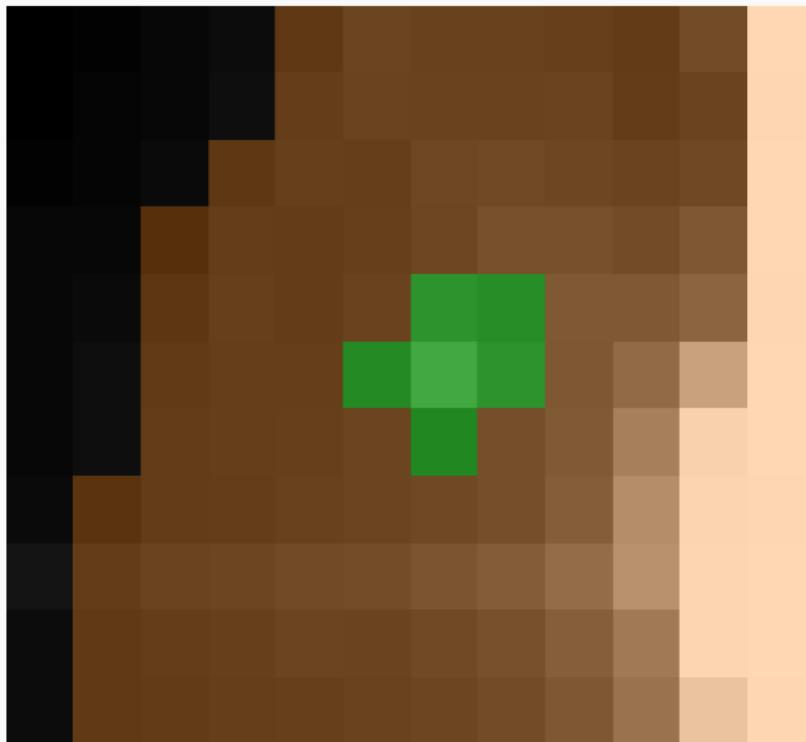
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# CONTAMINATED



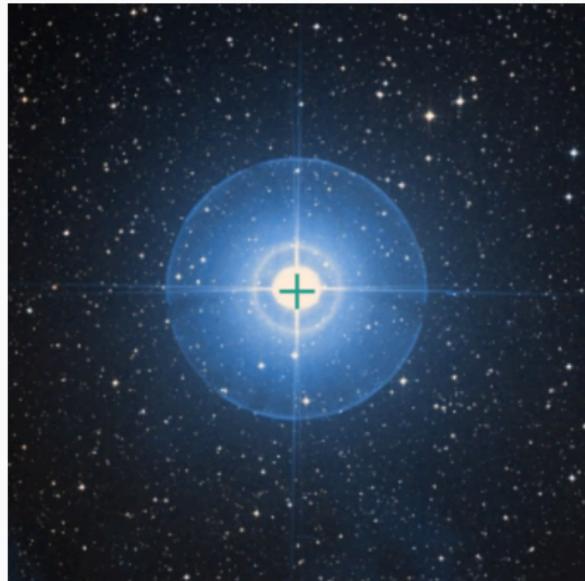
*Kepler/K2:* Contaminated postage stamp.

# CONTAMINATED



*Kepler/K2:* Contaminated postage stamp.

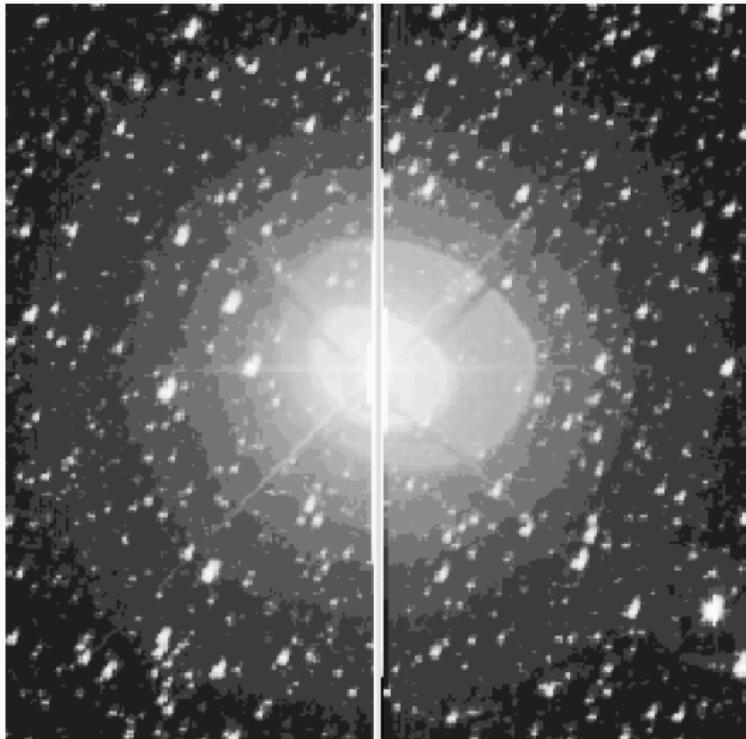
## BACKGROUND



*Ground-based:*  $\pi$  Sco.

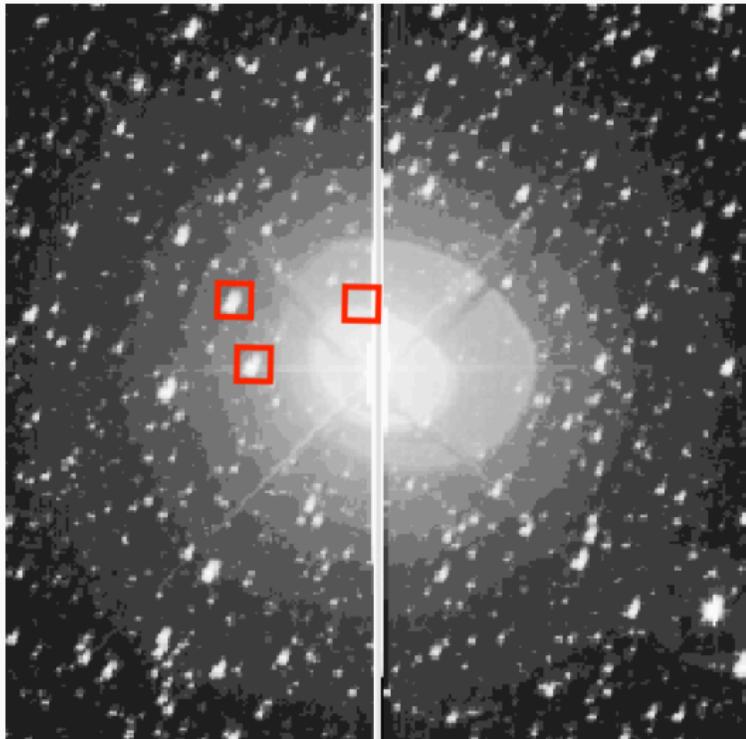
- Scorpio constellation.
- 2.7 magnitude (**very** bright – can even be seen from Sydney!).
- Ellipsoidal binary,  $T = 1.57d$ .
- In the *Kepler*/K2 field in C02.

## FULL FRAME IMAGE (K2)



*Kepler/K2:  $\pi$  Sco.*

## FULL FRAME IMAGE (K2)



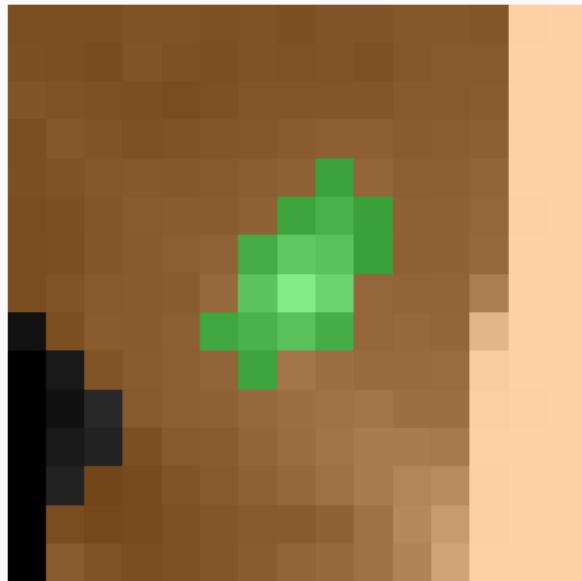
*Kepler/K2:  $\pi$  Sco.*

# EPIC 203442993

1. Follow motion.
2. Mask contaminated pixels.
3. Sum flux in mask for each frame.

*Kepler/K2:* EPIC 203442993.

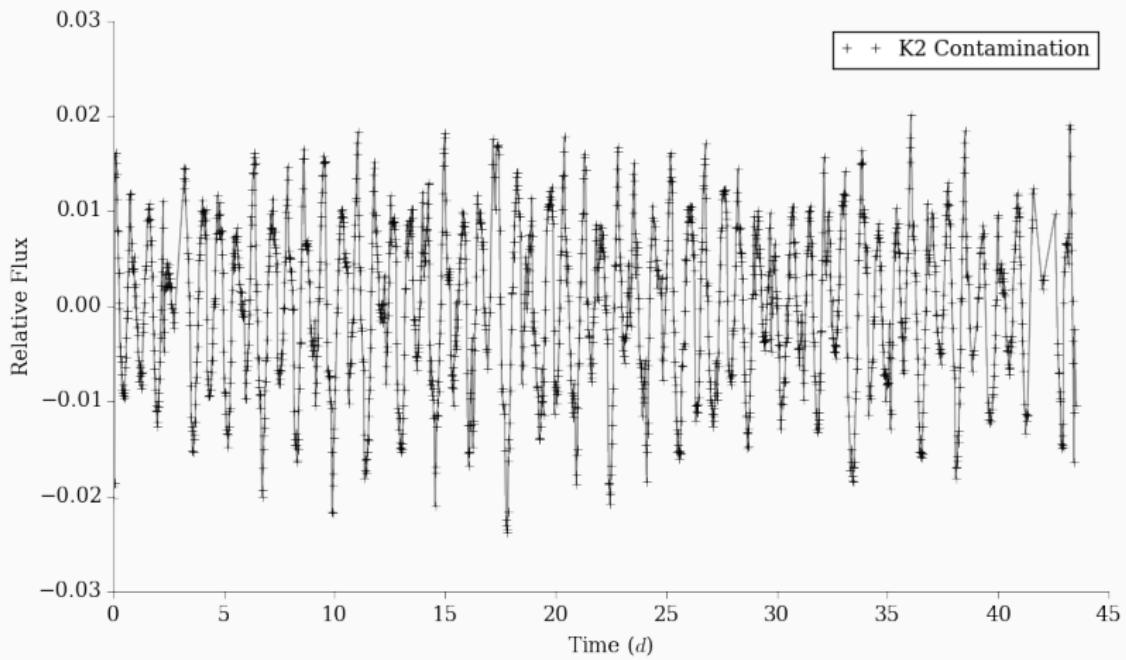
# EPIC 203442993



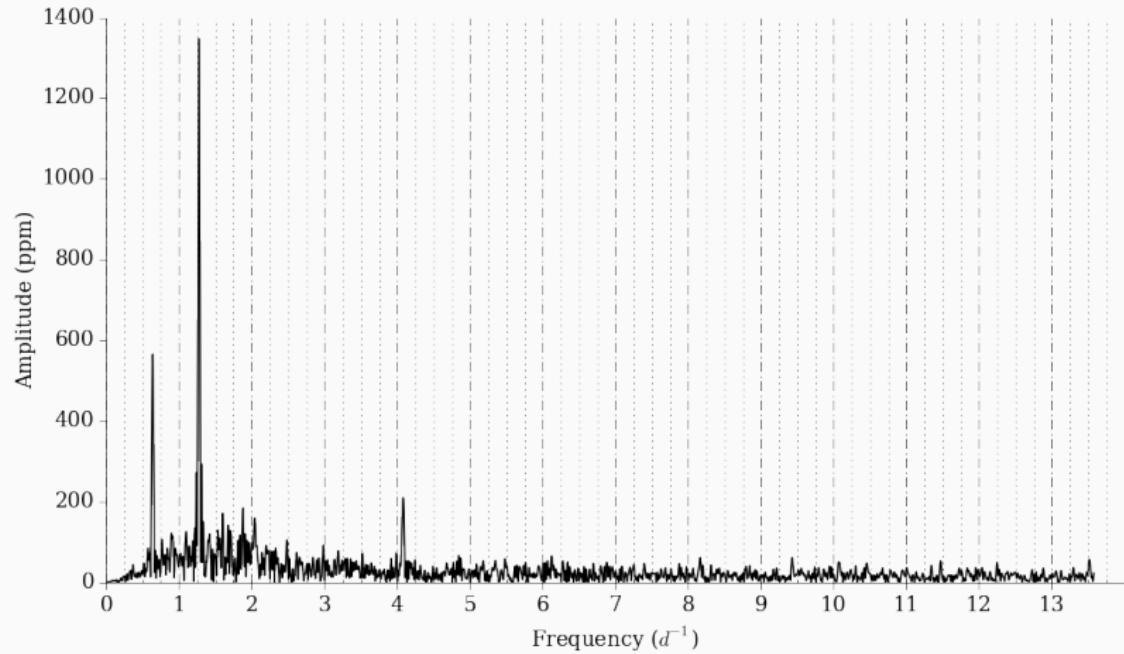
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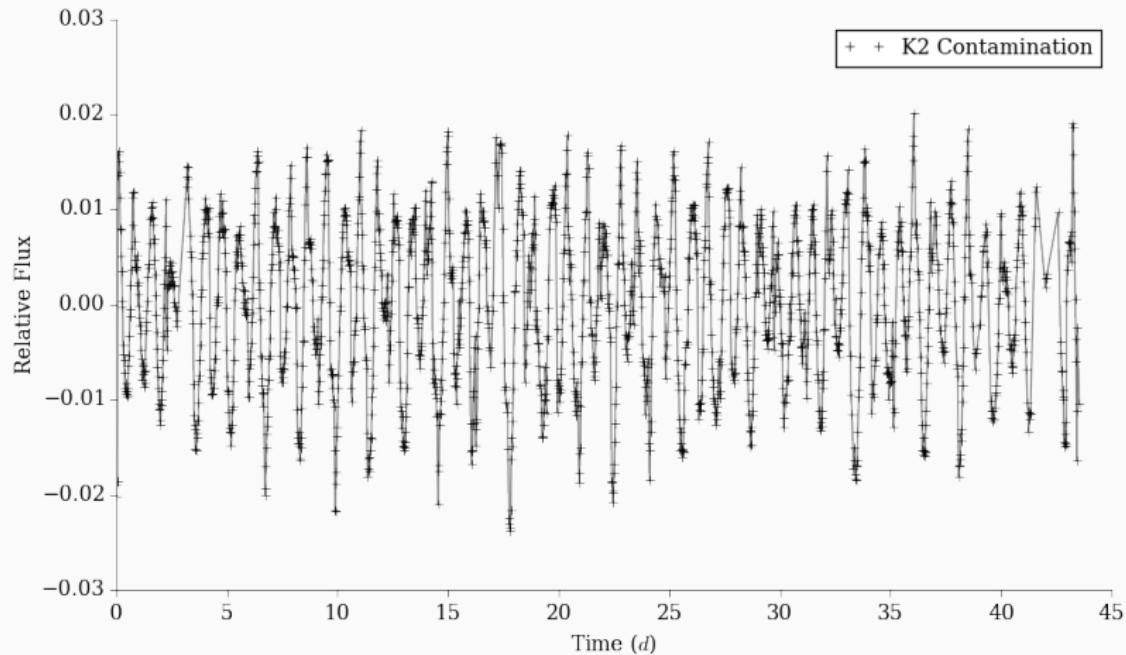
# OUR ANALYSIS



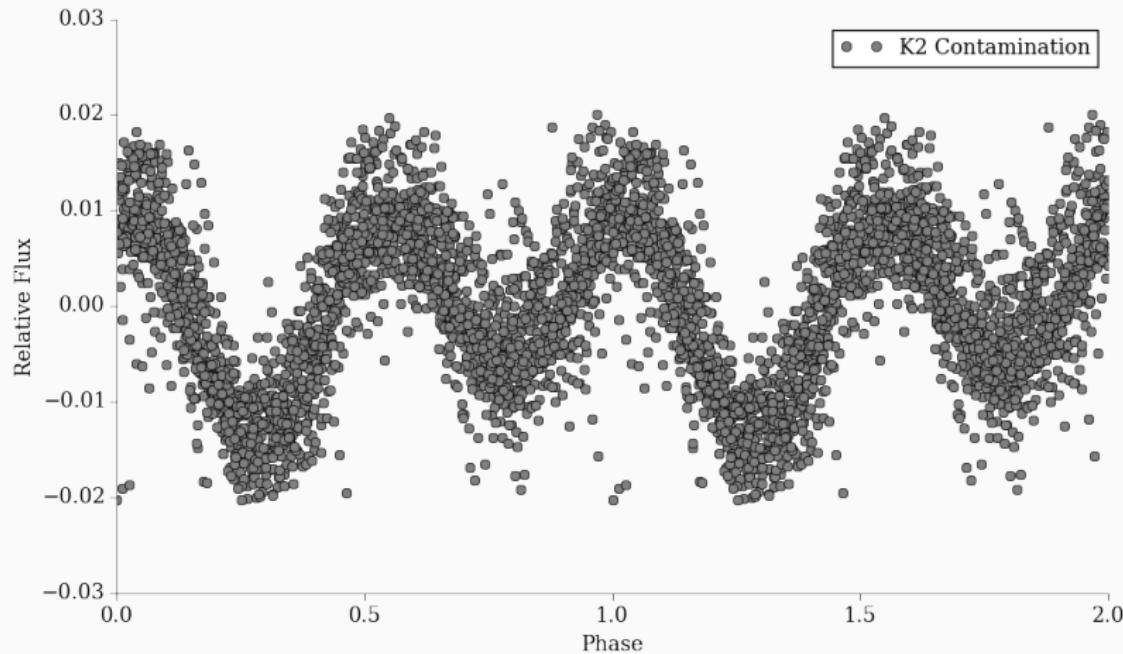
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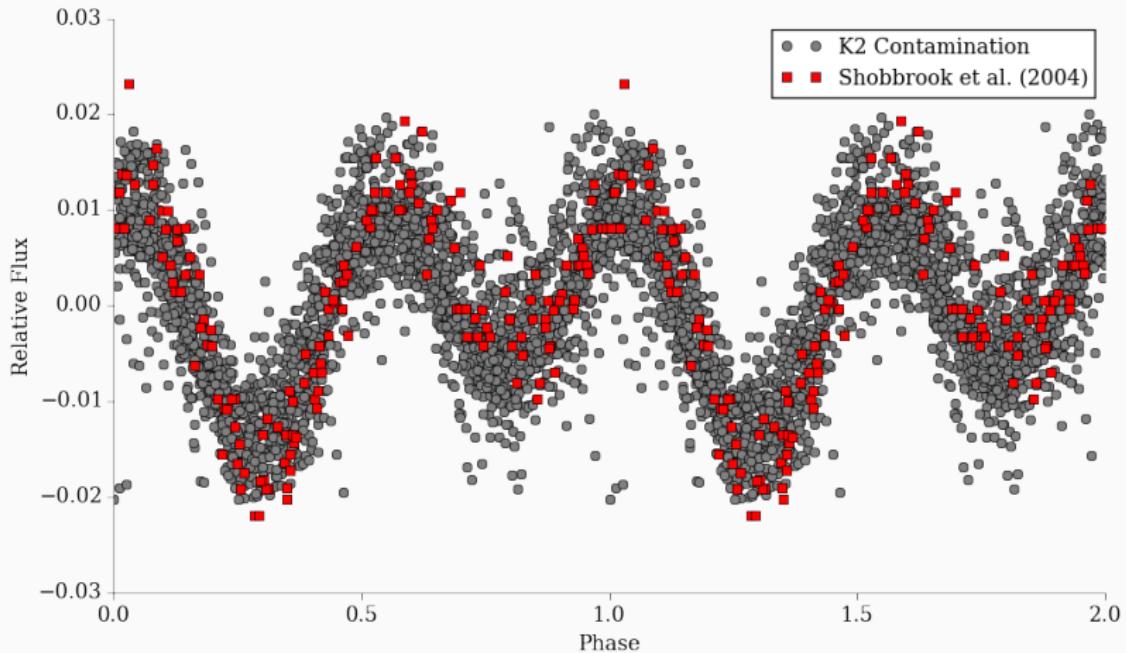
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## PREVIOUS SURVEYS



- Shobbrook (ANU 2004) photometric analysis of  $\pi$  Sco, from ground with **10 year** baseline.

## FUTURE RESEARCH

- Wrapping up:
  1. Reproduced ground-based data.
  2. Shown contamination photometry is viable.
  3. Did in 45 days what took Shobbrook 10 years (with more data).
- More postage stamps, from more campaigns.
- Do new science with data otherwise neglected.
- Investigate improvements to technique.

## ACKNOWLEDGEMENTS

- Thanks to my supervisors:
  - Tim Bedding
  - Daniel Huber
  - Simon Murphy
- ...and to some other researchers, whose help was also invaluable:
  - Benjamin Pope
  - Tim White
- ...and the Talented Student Program organiser Helen Johnston.

QUESTIONS?

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