Using Simultaneous Kepler Photometry to Mitigate Stellar Jitter

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Stellar jitter is the bottleneck for detecting Earth analogs.

- 1 Earth Mass in HZ around solar analog, 8 cm/s
- 1 Earth Mass in HZ around 0.5 solar mass M dwarf, 27 cm/s
- NASA's WIYN-NEID instrument precision, 30 cm/s
- Gravitational redshift, < 10 cm/s
- Magnetic cycle, 1-20 m/s
- Flare in active M dwarfs, < 1 m/s?
- Oscillations, a few m/s
- Granulation, a few m/s
- Active regions, a few m/s
- Time Scale
  - 1 year
  - Days
  - Days - Years
  - Years
  - Minutes - Hours
  - Minutes
  - Hours
  - Days

E.g., Lindegren & Dravins 2003
photometric variation

RV variation
photometric variation

RV variation

✅ timescale
✅ amplitude
Fields 9, 16, 17, and 19 are forward-facing campaigns.
tackle the problem of **stellar jitter** with **simultaneous** precise RV and space photometry
Stellar jitter is the bottleneck for detecting Earth analogs.

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- Active regions, a few m/s

Time Scale:
- days
- days
- days - years
- years
- hour
- min
- hours

E.g., Lindegren & Dravins 2003
Stellar oscillation:
averaging? modeling?
Stellar oscillation: averaging? modeling?
Stellar oscillation: averaging? modeling?

One of the advantages of 30-meter telescope: sampling the stellar oscillation of Sun-like stars.

e.g., GMT Science Book, Chapter 2.1, G-CLEF
Can we get rid of **stellar jitter** via **modeling** using photometry?
Stellar jitter from oscillation:

taking a stab via modeling

Same underlying model 1 free parameter
**Stellar jitter from oscillation:**

taking a stab via **modeling**

- Raw RMS = 3.29 m/s
- Residual RMS = 0.82 m/s
- Median Uncertainty = 0.78 m/s

Same underlying model

1 free parameter
Highlights with TESS and Magellan/PFS data:

Can we model stellar oscillation and granulation:

• on a variety of stars?
• longer than mode life time?
• with poor sampling?
Thank you

RVxK2 Data Hack
Wednesday 1:30pm
RVxK2.com

gratefully funded by
KEPLER & K2
GI Program
\( \text{Stellar jitter from oscillation:} \)

maybe even get rid of the free parameter?

\[
\left( \frac{\delta L}{L} \right)_\lambda \propto \frac{\nu_{osc}}{\lambda \cdot T_{\text{eff}}^2}
\]

photometric amplitude

RV amplitude

Kjeldsen & Bedding 1995
**C16: Dec 7, 2017 – Feb 25, 2018**

**K2 1-min Cadence**

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<thead>
<tr>
<th>Star</th>
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<th>Type</th>
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<td>HD 76445</td>
<td>7.6</td>
<td>G5 IV</td>
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<td>HIP 44072</td>
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<td>HD 76780</td>
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<td>HD 75784</td>
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<td>HD 73534</td>
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**K2 30-min Cadence**

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<tr>
<td>HIP 42783</td>
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Stellar jitter is an unsolved problem even for our Sun.