Fliper: A Powerful Tool to Detect and Characterise Solar-like Pulsators.

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Fliper Class
Towards the classification of all Kepler DR25 stars

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Context: What is hidden inside the DR25 catalog?

≈67% (≈120,000) of all Kepler targets are main-sequence stars, ≈21% (≈37,000) are subgiants, and ≈12% (≈21,000) are red giants.

- [Kolenberg+ 2010]
  - KIC: logg, [Fe/H], R, etc.
  - 7 Mars 2009

- [Tkatchenko+ 2012]
  - RRLyrae
  - 26 gDor
  - May 2013

- [Debosscher+ 2011]
  - ~150,000 light curves analysed, ~12,000 classified

- [Prsa+ 2011]
  - ~1,800 Eclipsing binaries

- [Uytterhoeven+ 2011]
  - 750 candidate A-F type stars

- [Berger+, 2018]
  - Hon+ accepted
  - 600 newly identified oscillating red giants

- [Yu+ 2018]
  - May 2013
  - ~1,800 Eclipsing binaries

- [Kolenberg+ 2010]
  - 26 gDor
  - May 2013

- [Tkatchenko+ 2012]
  - RRLyrae
  - 26 gDor
  - May 2013

- [Kurtz+ 2015]
  - SPB, gDor

- [Mathur+ 2016, 2017]
  - May 2013
  - 30,000 RG
  - RRLyrae/Cepheids

- [Balona 2018]
  - 30,000 RG
  - RRLyrae/Cepheids

- [García+ in prep]
  - 600 newly identified oscillating red giants
What is hidden inside the DR25 catalog?

Classification of all ~197,000 Kepler main mission targets

Classification of all K2 targets [Bugnet+ in prep]

Classification of all TESS targets

T'DA (TESS Data for Asteroseismology) collaboration

[Tkachenko et al., in prep]
The granule size/number depends on the evolutionary state, varying inversely with logg

The rms of brightness variations should scale at the square root of the number of granules

F8: Measure of the rms of the light curve on time scales shorter than 8 hours.

“At some point, around log g ~ 2.7, the dominant granulation timescale begins to cross 8 hr into longer timescales excluded from the F8 metric, such that the contribution of granulation to the F8 signal decreases. The timescales and amplitudes of the solar-like oscillations, on the other hand, remain comparatively small but increase to levels detectable with flicker, presumably becoming the dominant driver of flicker by log g ~ 2.”
FliPer *(Flicker in Power)*

\[ F_p = \overline{PSD} - P_n \]

![Graph showing power spectrum with \( f_{\text{min}} \) and mean PSD between \( f_{\text{min}} \) and LC Nyquist frequency.](image)

- **\( f_{\text{min}} \)**: Mean value of the power density between \( f_{\text{min}} \) and LC Nyquist frequency.

- **\( P_n \)**: Photon noise [Jenkins+, 2010]

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[Bugnet+ 2018]
FliPer (Flicker in Power)

\[ F_p = \overline{\text{PSD}} - P_n \]

Main-sequence stars (MS)

Red giants (RGB, RC)

High luminosity stars (AGB, RGB)

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[Bugnet+ 2018]
Characteristic patterns in the PSD
Characteristic patterns in the PSD

Solar-like

δScuti

Binaries
Characteristic patterns in the PSD

Solar-like  δScuti  Binaries  RRLyrae
$$F_p = \overline{PSD} - P_n$$
Fliper

TESS simulated Data (T'DA)

[Bugnet+, Accepted]
Fliper

Decision tree

Set of parameters \( X_i \): \( F_{07}, F_7, F_{20}, F_{50}, T_{\text{eff}}, L \)

\( Y_i \): Class predicted

Supervised machine learning: need a known set of data

A decision tree algorithm constructs a binary tree during the training, with each node representing a split point on a single input variable \( (X_i) \). The leaf nodes of the tree contain the output possible predictions \( (Y_{\text{predicted}}) \)
Random Forest Algorithm

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Random Forest Algorithm

[Breiman, 2001]

Mean prediction of the individual trees
**FLiPerClass**

- Solar-like
- Classical Pulsators (=non Solar-like)
- Binaries/ Transits/ pollution

**Set of 1,942 stars**

- **Train set:** contains 80% of all classes
- **Test set:** contains the remaining 20%

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**PRELIMINARY**

- Solar-like
- Classical Pulsators
- Binaries

**FLiPerClass**

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FliperClass

Preliminary

Solar-like
Classical Pulsators (=non Solar-like)
Binaries/ Transits/ pollution

Classification by FliperClass 135,876 stars

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**FliperClass**

Solar-like

- 2157600
- 2157725
- 2157964

Binaries

- 5460709
- 5467102
- 5470960

Classical pulsators

- 684861
- 6951642
- 7268500

[Bugnet+, in prep]
logg for Solar-type stars using FliPer

Classification of TESS simulated data with FliPerClass: 98 %. [Bugnet+, accepted]

Classification of Kepler DR25 catalog with FliPerClass. [Bugnet+ in prep]

Classification of K2. [Bugnet+ in prep]

T’DA classifier for TESS data. [Tkachenko+ in prep]

Misclassified RG for legacy RG catalog see talk by Rafael García. [García+ in prep]

Improvements: Gaia colors, etc.

Call for inputs & collaborations!

GitHub repositories in development

github.com/lbugnet/FLIPER_CLASS

github.com/lbugnet/FLIPER

Thank you for your attention!