A Thought Experiment
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We have a large set of uniformly-observed stellar spectra
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We know labels (parameters and abundances) for a small subset of those spectra
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*We have* a large set of uniformly-observed stellar spectra

*We know* labels (parameters and abundances) for a small subset of those spectra

*We want* labels for all the spectra
A Thought Experiment

We have a large set of uniformly-observed stellar spectra

We know labels (parameters and abundances) for a small subset of those spectra

The problem is that doing this *ab initio* requires high S/N and elaborate machinery

We want labels for all the spectra
The Cannon:

Data-driven labels* from spectra

M. Ness, D.W. Hogg, H.-W. Rix, Anna Ho, G. Zasowski
Ness et al. 2015

*(Parameters and abundances)
The Cannon: 

Data-driven labels* from spectra

ASSUMPTIONS:
• spectra of stars with identical labels look identical
• spectra vary smoothly with label changes

*(Parameters and abundances)
1. TRAINING STEP
\[ f_{n\lambda} = a_{\lambda} + b_{\lambda}(T_{\text{eff}})_n + c_{\lambda} (\log g)_n \\
+ d_{\lambda} ([Fe/H])_n + e_{\lambda} ([\alpha/Fe])_n \\
+ \text{scatter}_{\lambda} \]
$f_{n\lambda} = a_\lambda + b_\lambda (T_{\text{eff}})_n + c_\lambda (\log g)_n$
$+ d_\lambda ([Fe/H])_n + e_\lambda ([\alpha/Fe])_n$
$+ \text{scatter}_\lambda$
$f_{n\lambda} = a_\lambda + b_\lambda (T_{\text{eff}})_n + c_\lambda (\log g)_n$
$+ d_\lambda ([Fe/H])_n + e_\lambda ([\alpha/Fe])_n$
$+ \text{scatter}_\lambda$

1. TRAINING STEP

2. TEST STEP
The Cannon: A tool for cross-calibration
(A. Ho, M. Ness, C. Liu in prep)

Survey A

Survey B

Training Set:
• Spectra from A
• Labels from B

Test Set:
• Spectra from A

Result:
• Transfer labels from B to A
The Cannon: A tool for cross-calibration
(A. Ho, M. Ness, C. Liu in prep)

Training Set (10%):
• Spectra from LAMOST
• Labels from APOGEE

Test Set (Remainder):
• Spectra from LAMOST

Result:
• Labels for LAMOST on the APOGEE scale
• First alpha enh. from LAMOST spectra

11,056 overlap objects
The Cannon:
A tool for cross-calibration
...between fundamentally different datasets
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A tool for cross-calibration
...between fundamentally different datasets

Typical High-S/N APOGEE Spectrum

\[ R \sim 22,500 \]
\[ 15200-16900 \text{ Å} \]

Typical High-S/N LAMOST Spectrum

\[ R \sim 1,800 \]
\[ 3700-9000 \text{ Å} \]
APOGEE-scale labels for 10,111 LAMOST spectra
First alpha-enhancement values from LAMOST spectra

\( \frac{[Fe/H]}{[\alpha/Fe]} \) Distribution for Test Objects

(Derived from 10,111 LAMOST spectra after training on APOGEE labels)
The Cannon:
Ages from spectra?
(Martig et al *in prep*, Ness et al *in prep*)

Survey A
Survey B

Training Set:
• Spectra from A
• Labels from B

Test Set:
• Spectra from A

Result:
• Labels for A
The Cannon: 
Ages from spectra? 
(Martig et al in prep, Ness et al in prep)

Training Set:
- Spectra from APOGEE
- Labels from Kepler

Test Set:
- Spectra from APOGEE

Result:
- Spectroscopic age estimates throughout the disk?

APOGEE  
Kepler

1600 overlap objects
Spectroscopic age estimates throughout the disk? (Martig et al in prep, Ness et al in prep)
Abundance/age distribution throughout the disk?
(Martig et al *in prep*, Ness et al *in prep*)
The Cannon: 

*Data-driven labels from spectra*

Label Transfer:

• Put surveys onto the same physical scale
• Infer stellar ages from spectra

https://github.com/annayqho/TheCannon
https://annayqho.github.io/TheCannon/
First-Order Fit Coefficients and Scatter from the Spectral Model

Wavelength $\lambda(\text{Å})$
First-Order Fit Coefficients and Scatter from the Spectral Model

Mg

Wavelength \( \lambda(\text{\AA}) \)
First-Order Fit Coefficients and Scatter from the Spectral Model

\[ \text{Wavelength } \lambda(\text{Å}) \]
Backup Slide: APOGEE FeH-alpha plane

$[Fe/H] - [\alpha/Fe]$ Distribution for Test Objects