Stellar Age Estimates through use of Machine Learning

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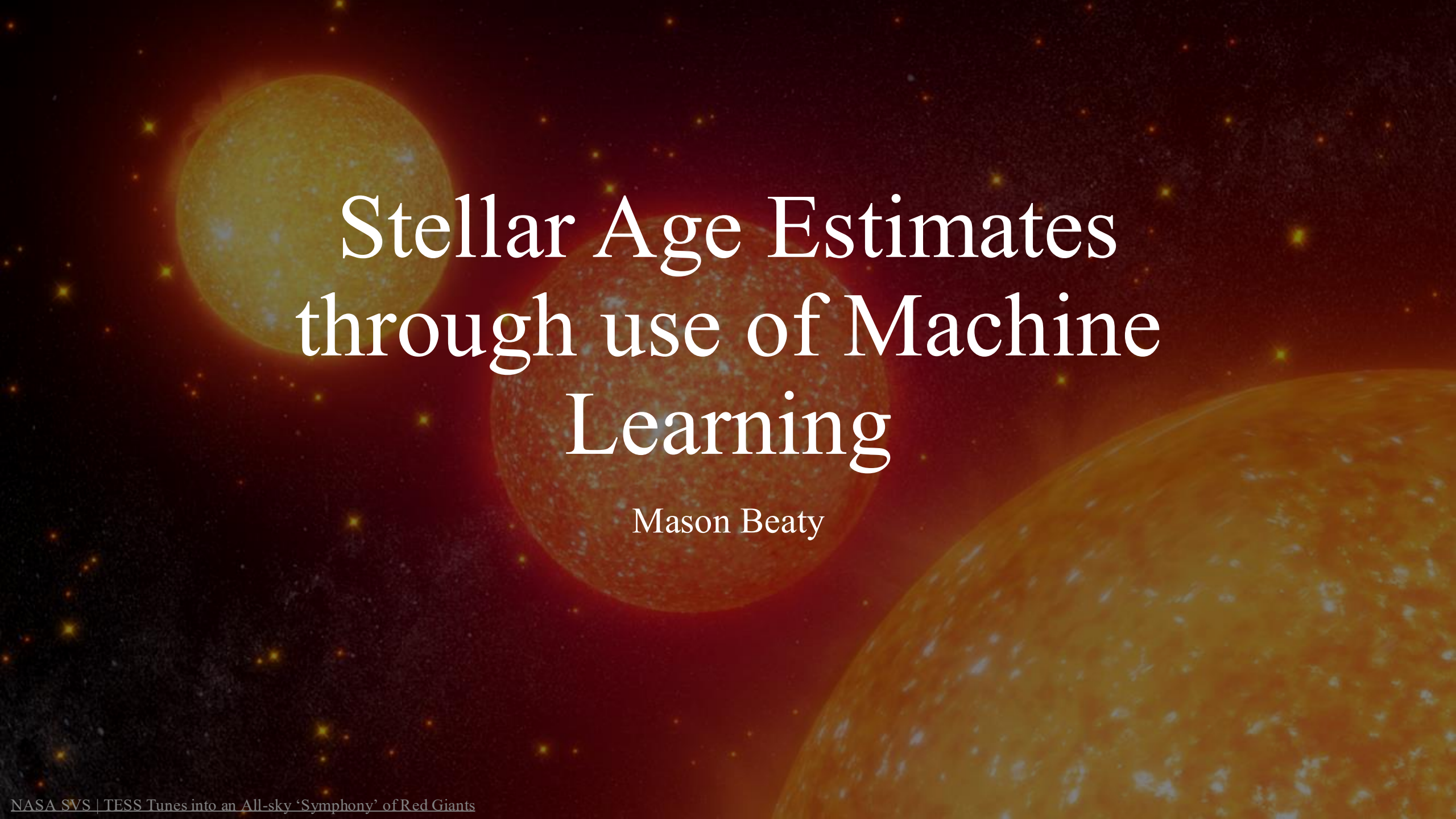


NASA SVS | TESS Tunes into an All-sky ‘Symphony’ of Red Giants

Data We Have

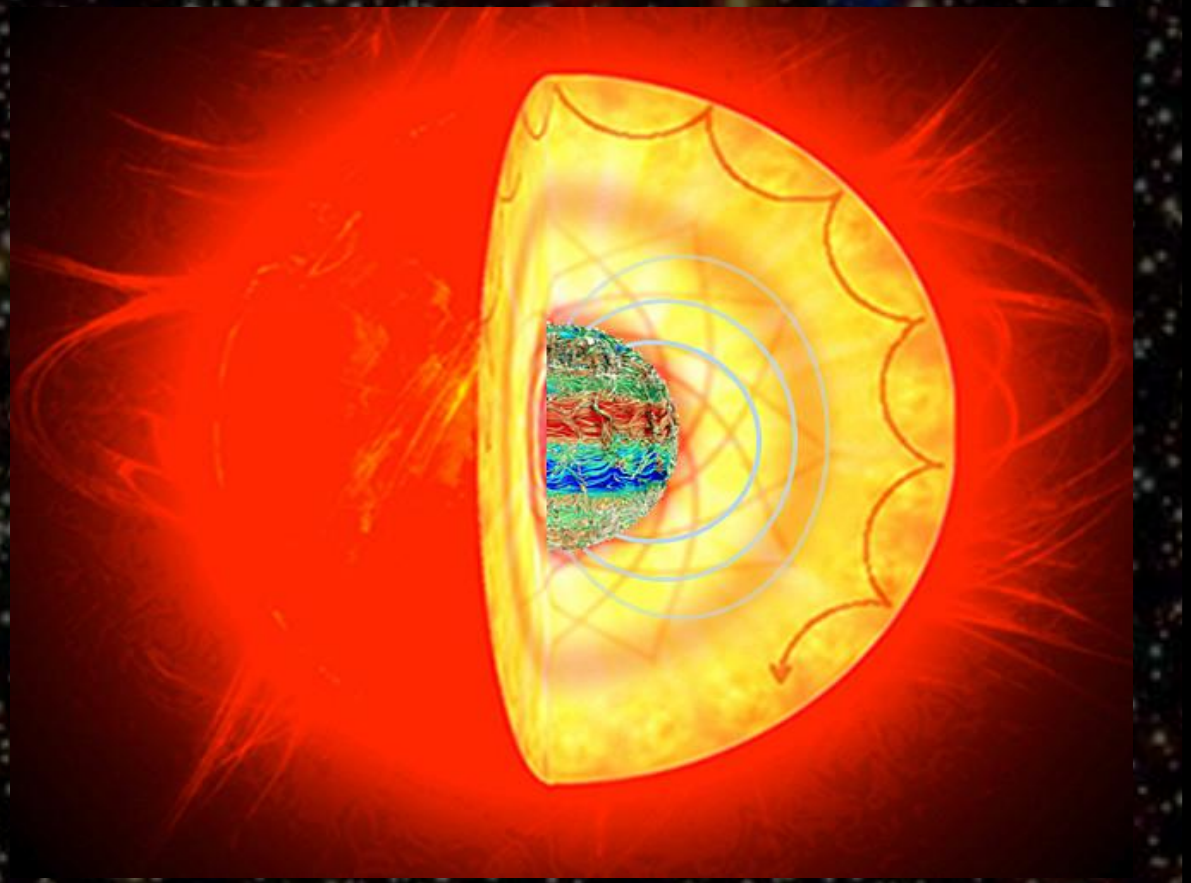


Image credit: Rafael A. García (SAp CEA), Kyle Augustson (HAO), Jim Fuller (Caltech) & Gabriel Pérez (SMM, IAC), Photograph from AIA/SDO.

- Millions of spectra exist for known stars. This does not give any information on the interior of the star
- Asteroseismology uses the frequency of stellar oscillations which creates small changes in the luminosity of a star, to probe the interior of the star
- Only a small portion of stars have been surveyed with asteroseismology due to expense and need for high-calibrated equipment

Star Clusters: Inside the Universe's Stellar Collections - NASA Science

Why We Need Mass

- One of the hardest characteristics to measure in stars is their age. Mass, however, is the biggest constraint on age
- Different masses of stars (along with their evolutionary phases) provides information on how fast they burn their fuel, giving an age estimate
- Using seismic scaling relations, stellar masses can be determined

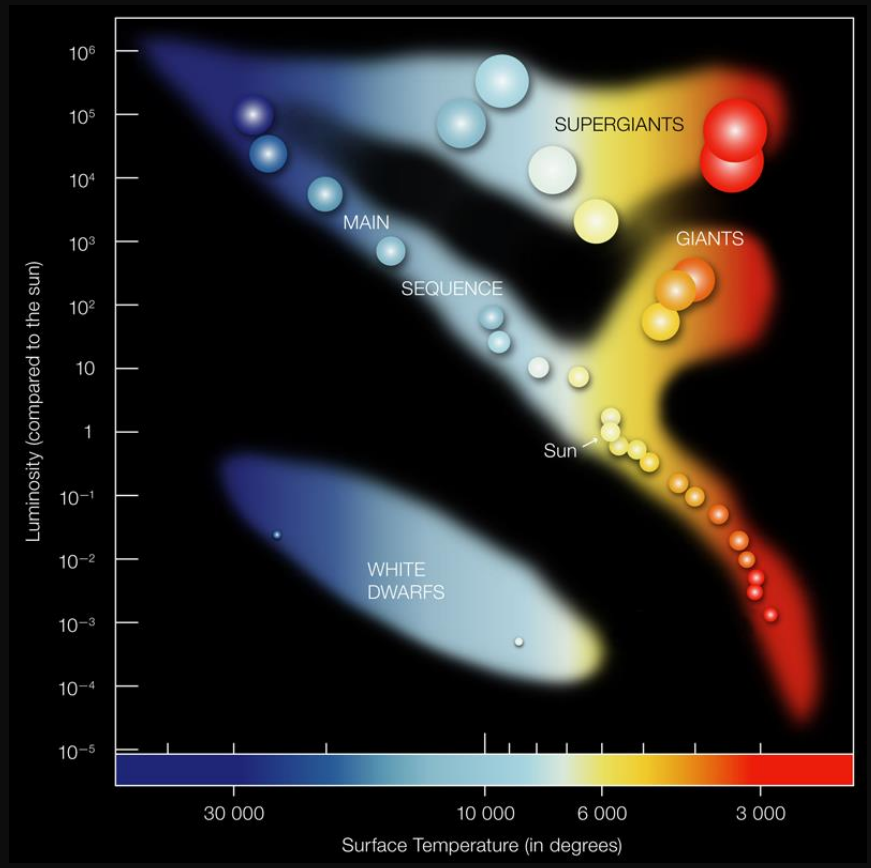


Image credit: Chandra :: Educational Materials :: Pulsating Variable Stars and the Hertzsprung-Russell Diagram

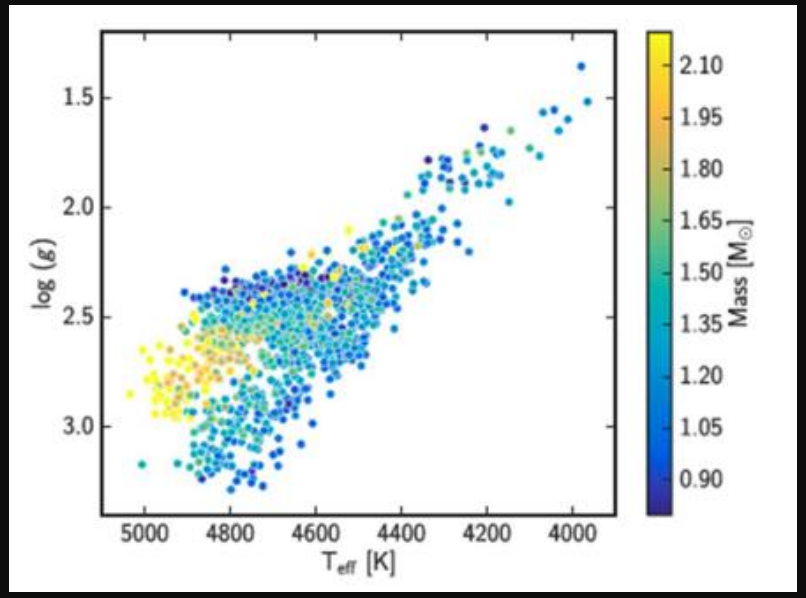
$$M = \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right)^{3} \left(\frac{\Delta\nu}{\Delta\nu_{\odot}}\right)^{-4} \left(\frac{T_{\rm eff}}{T_{\rm eff,\odot}}\right)^{1.5}.$$

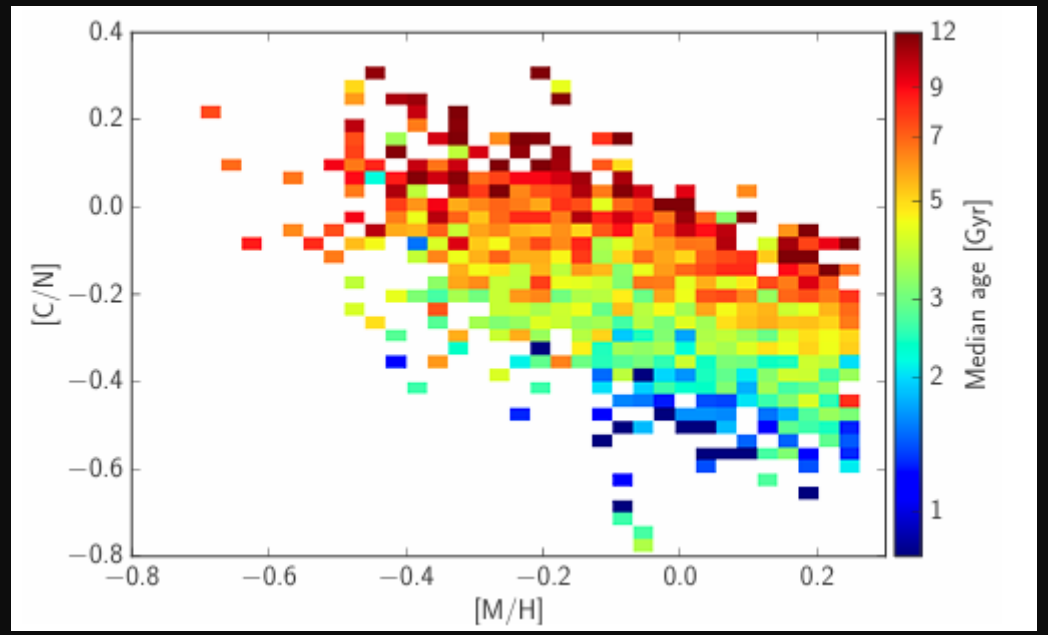
Ness, M., Hogg, D. W., Rix, H.-W., Martig, M., Pinsonneault, M. H., & Ho, A. Y. Q. (2016). Spectroscopic determination of masses (and implied ages) for red giants. The Astrophysical Journal, 823(2), 114.

TheCannon

- TheCannon is a machine learning tool that can learn the relationship between a star's spectra and its known physical properties, applying a training set to a test set

- Once seismic masses are found for a few stars, those stars can then train stars with no mass data



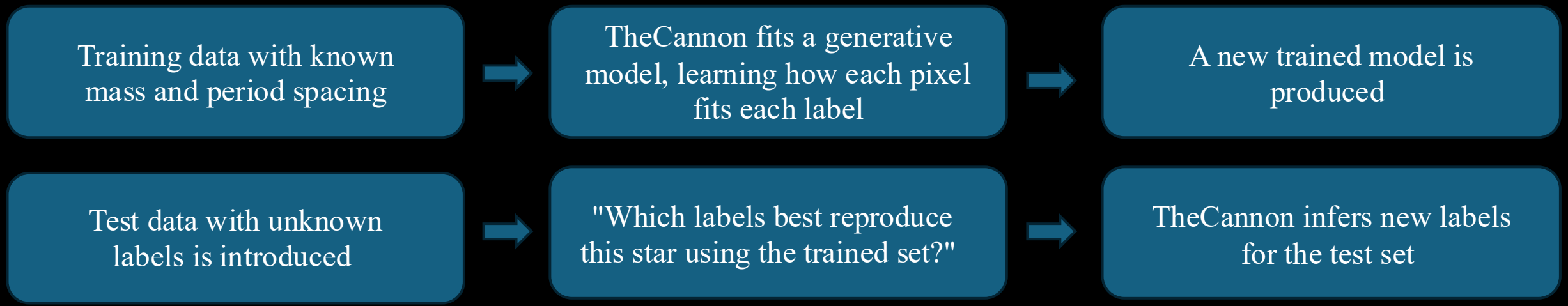


M. Martig et al. 2015 Red giant masses and ages derived from carbon and nitrogen abundances

Goal

- Spectra can therefore encode information regarding the mass, and therefore age of stars
- Need both the evolutionary phases via period spacing and predicted seismic masses to form a training set to test on new stars to imply their ages

Machine Learning Process



Implied ages can then be found using scaling relations!

Our Current Model

- We currently have a working model of TheCannon using APOGEE
- Assures what we have done so far works
- Having some trouble applying this to Kepler