Measuring CO Isotopic Abundance Ratios in Solar Twin Stars

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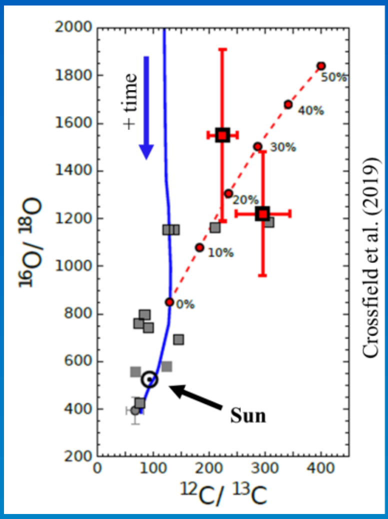
Introduction

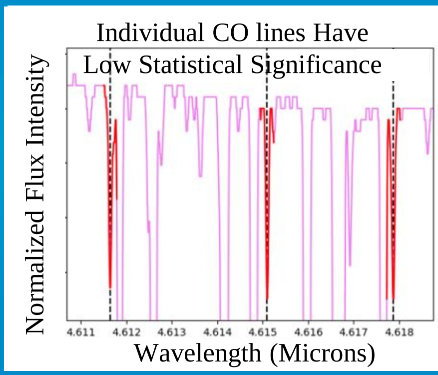
In the past, calculating precise stellar abundances has been rather difficult in cooler K and dwarfs, specifically, because of the overwhelming number of molecular features in their spectra. High-resolution spectroscopy, however, now makes determining elemental & isotopic abundances possible. Recent studies have demonstrated our current capabilities to observe rare isotopologues (like ^{13}CO and $C^{18}O$) in these cool stars. C & O isotopic abundances in cool dwarfs are a relatively unexplored area of galactic chemical evolution even though FGKM dwarf stars have make reliable tracers of chemical evolution because of their long, expected lifetimes on the main sequence. These isotopic abundances are also useful to exoplanet characterization for constraining planet formation, exoplanet atmospheres & interiors, and the search for biosignatures.

Refining Galactic Chemical Evolution (GCE) Models >>>

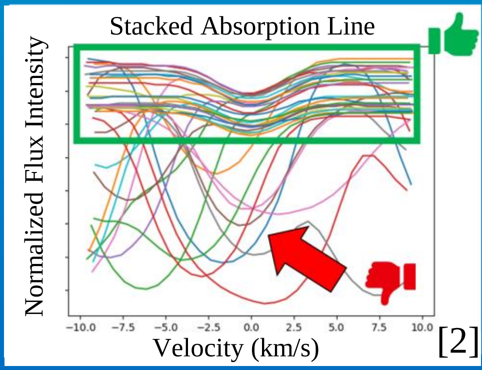
The GCE model at right (Kobayashi et al. 2011) shows the trajectory of C & O isotopic abundances over time. Recently analyzed M-dwarfs have abundance ratios that are inconsistent with current models. My project aims to uncover more of these discrepancies (and determine what caused them), especially those from the most pristine GCE tracers: cool GKM-type dwarf stars.



M-Dwarfs:
^^^Key
Young Stellar Objects:
Current GCE Model:
Proposed GCE Correction:



[1]



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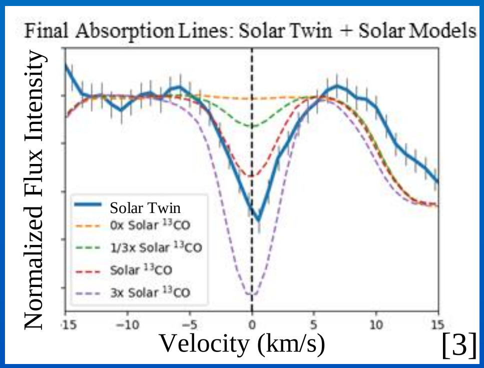

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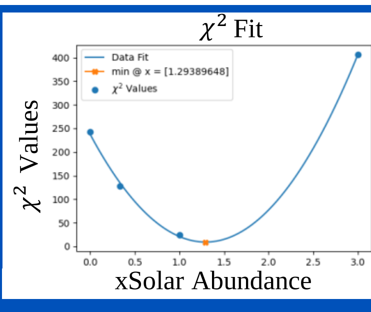
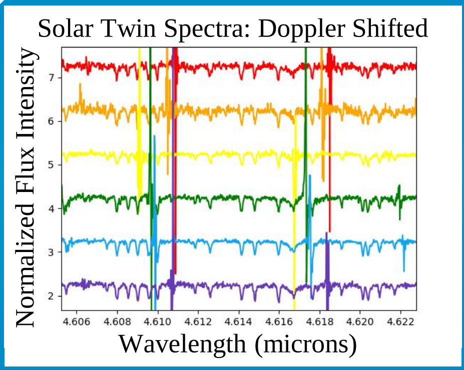


[4]

<<< Calculating Abundances is as easy as 1, 2, 3!!! (and 4)

Since most of the ideal CO lines have low statistical significance and are barely discerned by eye [1], it is important to create a single "stacked" line profile of each CO isotopologue. Stacked absorption lines allow us to turn a set of relatively low S/N lines into a single line profile with much higher S/N, especially after removing telluric-contaminated lines [2]. The single line profile is created by taking the weighted mean, after continuum-normalizing, of each desired line. We repeat the process for synthetic stellar models corresponding to various enrichments of the desired species and plot them side-by-side [3]. We can now estimate by eye whether the solar twin has sub- near- or super-solar abundances [3] but can also compare use a series of chi-squared fit tests in order to determine final abundances [4].



^^^Six Solar Twins

Sample contains spectral types: G8/K0 IV, G5V, G4V, G3V, G2V

*Note: the Sun is spectral type G2V

Next Steps

- Repeat abundance calculations (CO, ^{13}CO, & $C^{18}O$) for the all our solar twins, plus other stars in FGK (+M) binaries, stars in known moving group, and any exoplanet host stars that exhibit isotope signatures
- Test the feasibility of determining stellar ages from isotopic measurements
- Support JWST as it characterizes exoplanet atmospheres, interiors, and biosignatures
- Identify how unexplored stellar abundances correlate with galactic chemical evolution, formation, interior, age, metallicity, activity, and planetary properties for a wide range of host stars.

Bio: David Coria is a first-year graduate student at the University of Kansas and member of NASA's inaugural ExoExplorers Cohort. >>>Email: drcoria@ku.edu