**Host-star and exoplanet compositions: a pilot study using a wide binary with a polluted white dwarf**

Bonsor et al. 2021

**Abstract:**

There is a theory that even though smaller bodies like planets and planetesimals tend to lose their volatile elements like H, C, O, and N as they evolve, they likely retain the same composition of refractory elements like metals/silicates as their host star. This has been tested before for chondritic meteorites and other rocky bodies in the solar system (like Alex mentioned in his talk last week), and they actually DO seem to have a refractory composition similar to that of the Sun.

Now, the authors of this paper are trying to see if this theory holds for exoplanetary systems by comparing the abundances of a K-dwarf star to those of its polluted white dwarf companion.

\*\*\*As I understand it, they’ll test the host-star-exoplanet abundance link by comparing the refractory abundances of the K-dwarf to the planetary material found in the polluted WD’s atmosphere.

**Introduction:**

Even though stars and planets form from the same stuff, there are many processes during planet formation/evolution that alter compositions.

Refractory content is not affected by high temperatures; and within the solar system, there are many bodies that match the Sun’s refractory composition.

\*\*There are many subtle variations in elemental and isotopic ratios which point to the nature of planet formation (Boyet & Carlson 2005; Burkhardt et al. 2011; Klaver et al. 2020)

Wide binary stars are more chemically homogeneous than random pairs of stars in the galactic disk. Cluster stars are more chemically homogeneous than field stars.

White dwarfs are supposed to have clean H/He atmospheres since metals sink to the WD interior on very short timescales (days to millions of years). Any WD’s that show metals in their atmospheres must have accreted them very recently and are called “polluted”. \*\*\*I guess we look at white dwarfs for this kind of experiment because otherwise you don’t know if either star in a binary has accreted planetary material.

Observations of polluted white dwarfs inform us about the range of compositions found in exoplanetary bodies. White dwarfs have accreted icy (volatile-rich) planetary bodies, rocky bodies, and bodies rich in highly refractory material.

**Observations and Abundance Determination:**

Data reduction is performed with standard IRAF echelle tasks. Two-dimensional spectral image frames are bias subtracted, flat-fielded, extracted, and finally wavelength calibrated with ThAr arclamp spectra. \*\*\*OMG you know how to do this!!!

The first step in their process was to find the set of suitable regions in the spectrum that they’d use to determine atmospheric parameters and then abundances. Specifically, these regions need to show dependency on temperature, surface gravity, metallicity as well as the elements measured in the white dwarf. \*\*\*They used 61 Cyg B and the Sun to help identify these lines/spectral regions

**Results:**

Results support the K-dwarf having the same refractory element composition as the planetary material accreted by its WD companion.

The Mg abundance for G200-40 (the K-dwarf) and the O abundance for 61 Cyg B do not align very well with the abundances calculated for the stars in Brewer & Fischer 2016.

\*\*\*These uncertainties are likely due to the blending of the Mg lines used in calculating the Mg abundance and having to use molecular features rather than the O triplet to determine the O abundance.

Additional complication: If accretion in WD started recently, the system is in build-up phase and the abundances will those of the accreted material. If accretion has reached steady-state between diffusion and accretion, abundances of the accreted material will have been adjusted as elemental species sink from the atmosphere of the WD into its interior.

\*\*\*Abundances are best explained if the WD is accreting in build-up phase

Pg 5: high Ca/Fe ratio causes and implications

**4.1 White Dwarfs as tracers of planetary composition:**

Assumption: Abundances are not altered during accretion.

The number of planetary bodies found in the WD atmosphere do not change the conclusion since the sum of those refractory abundances should still match that of the host star.

*Question:* Accretion in build-up phase (accreted abundances match those of known planetary bodies) vs. accretion in steady state? Differential sinking?

If the system is accreting in steady-state, we’d need to consider planetary processes that affect the Ca/Fe and Ni/Fe ratios specifically.

**4.2 A true match?**

Abundance comparisons between the wide binary partners can yield VERY precise differential abundances if the partners are very similar. The two objects studied here, however, are VERY DIFFERENT and the study is thus limited by large systematic uncertainties—especially from the WD because of the abundances’ dependance on stellar parameters and lines used.

**4.3 Implications for exoplanet composition**

Stellar abundances can be used to infer planetary composition, specifically core size.

**Conclusions:**

Analysis of polluted white dwarfs provides the bulk composition of the exoplanetary material they have accreted.

Elemental abundances (Ca, Ni, Fe, Mg, Si, C and O) of G200-40 are consistent with those of the exoplanetary bodies accreted by its white dwarf companion, WD 1425+540.

**ExoLab Intro:**

Hi everyone! I haven’t gotten much done with my own research if I’m being honest, but I AM in the process of reviewing the error propagation in my data analysis. I didn’t originally worry about uncertainties, so now I’m kinda backtracking to make sure I process them properly so I can use them in the final results.

In other news, last Friday the ExoExplorers got to meet with THE Victoria Meadows. She’s a professor of astronomy and director of the astrobiology program at the University of Washington. She’s also the principal investigator for the Virtual Planetary Laboratory which is this HUGE interdisciplinary collaboration of ~74 scientists that encompasses everything in the realm of biosignatures, exoplanet habitability, and detection of life. So like: looking at the Earth as an exoplanet, identifying biosignatures throughout the Earth’s history, identifying what things would make an exoplanet habitable, distinguishing between living/dead planet markers, and observing all of these things in exoplanets using telescopes. The group publishes 60-80 papers a year which is just INSANE. We also got to hear about her challenges in securing funding and establishing a support system as a woman in this field and what she did to overcome them which was pretty inspiring to hear as an underrepresented minority myself. She also told us about what it’s like to develop and manage such a big collaboration. She pretty much said it all comes down to finding the right people who aren’t jerks, are in it for the science, and are willing to train the next generation of scientists. It was a good talk.