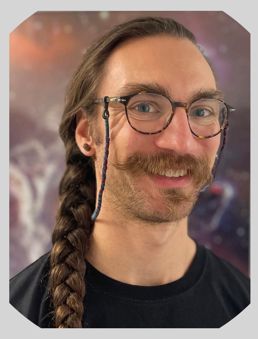
#123: S-Process Nucleosynthesis in and from AGB Stars

Modelling Binary Accretion from Abundances and Orbits



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1. High-resolution spectra: RVs and Abundances

- Echelle spectra of intrinsic (AGB) and extrinsic (ex. Ba, CEMP-s) stars from 5 telescopes covering the full optical spectrum for RVs and abundances

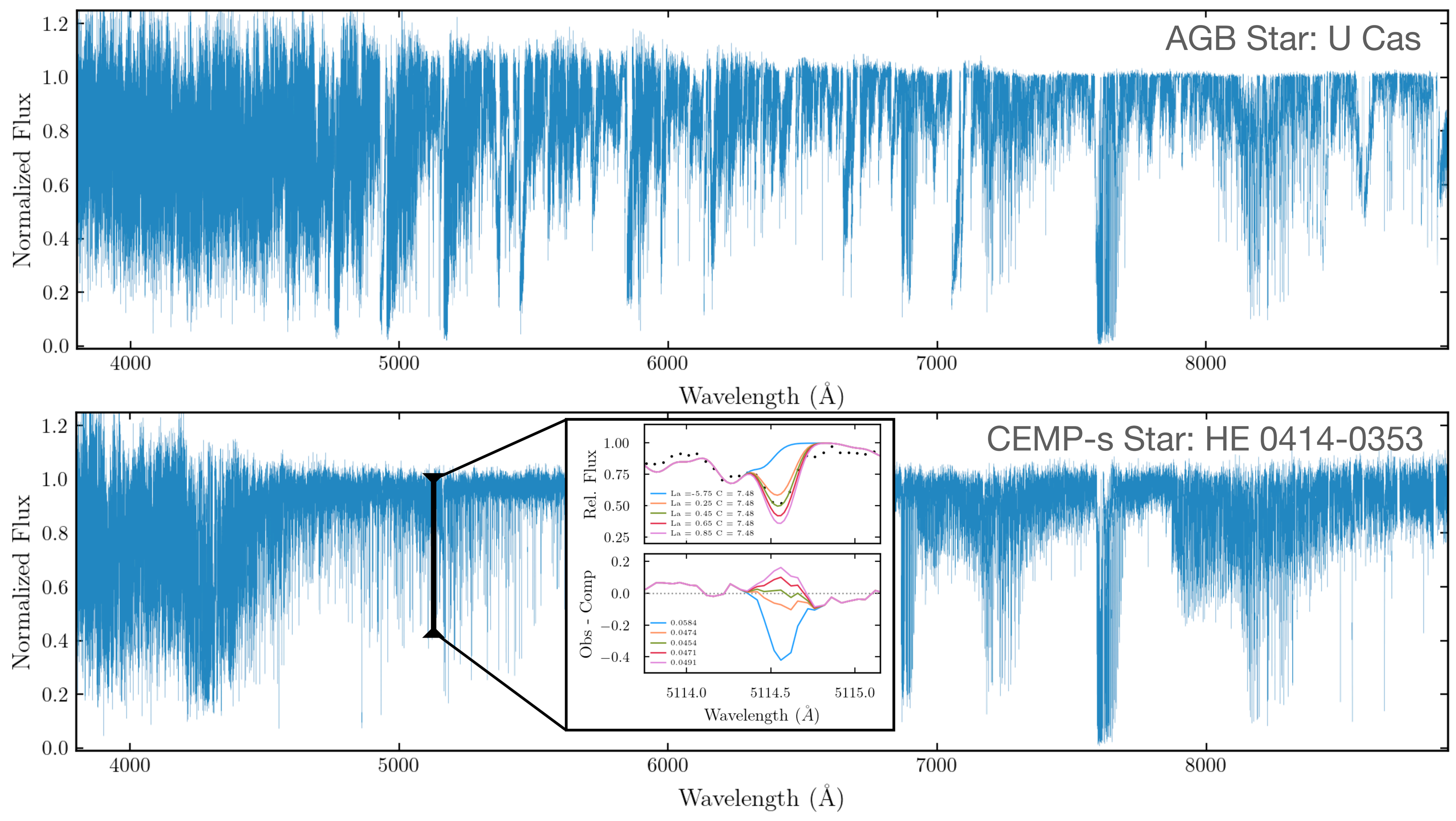

Figure 1: High-resolution FIES spectra of exemplary targets in our sample from the 2.65 Nordic Optical Telescope. TOP: An intrinsic AGB star, U Cas. Wide absorption features dominate the spectrum. BOTTOM: CEMP-s star HE 0414-0343. INSET: Synthesising La abundance in a blended carbon feature.

2. Model Binary Orbits for Stellar Masses

- Repeat observations for RV data points to identify and constrain binary orbits
- Compute orbits using the ELC program(1) with de-MCMC optimisation
- Bayesian posterior distributions provide orbital parameters and estimates of stellar masses

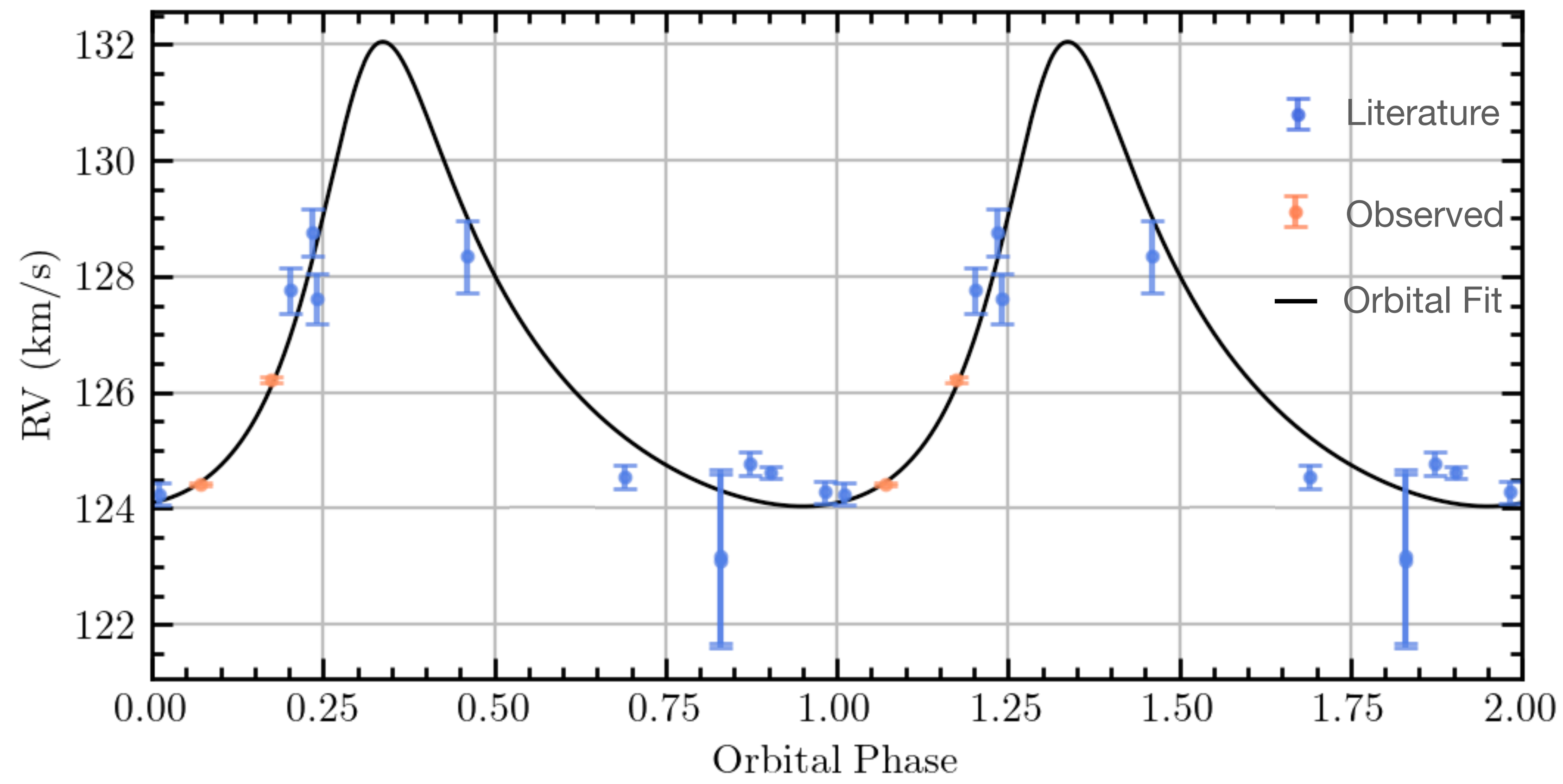

Figure 2: Computed radial velocity orbit of the CEMP-s star CD-62 1346, as modelled by the ELC program. This system has an orbital period of 358 days and an eccentricity of $e = 0.33$. Best fit component masses are 2.89 M⊙ and 0.50 M⊙.

3. Stellar Abundances Constrain AGB Donor Mass

- Compute 1D-LTE abundances using MOOG(2,3) program for spectral synthesis and equivalent widths: C, Mg, (Fe), Sr, Y, Zr, Mo, Ba, La, Ce, Nd, Eu, Pb
- Compare to dilution-modified FRUITY(4,5,6) AGB yields to estimate mass of donor AGB star based on elemental abundance pattern

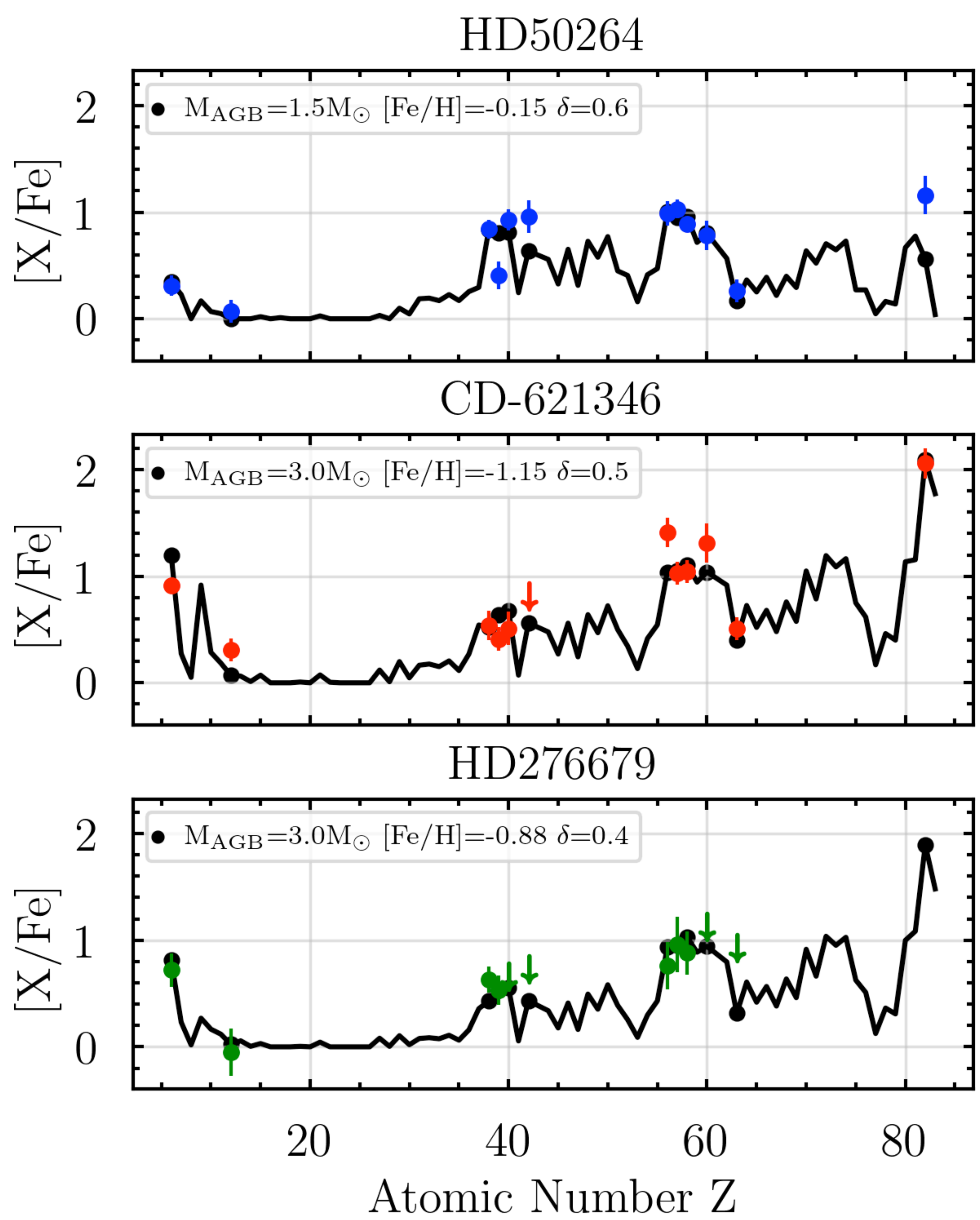

Figure 3: Abundance patterns for a sample of barium (blue), carbon-enhanced stars (red), and stars yet unclassified by their chemistry (green). Double (triple) peaked s-process signature around Sr (38), Ba (56), and Pb (82) visible in stars polluted by former AGB companions. Black data points and lines are best fit AGB abundance patterns from FRUITY.

4. Model Binary Mass Transfer to Investigate Accretion Mechanism and Efficiency

- Generate grid of accretion models using the Cambridge STARS (7,8,9) code
- Amount of accreted material (ΔM) combined with orbital parameters constrains mechanism and efficiency of mass transfer: RLOF, strong AGB wind

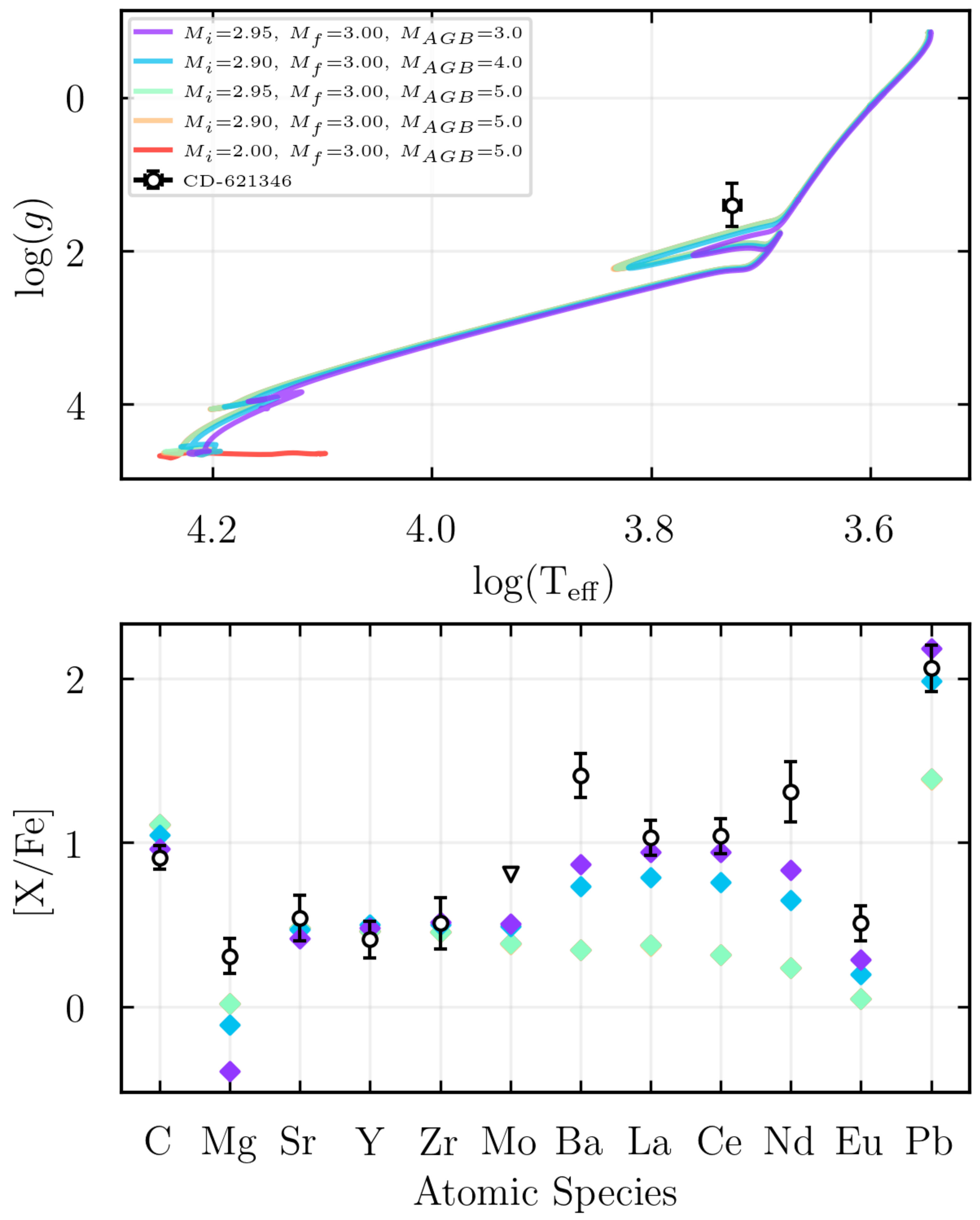

Figure 4: TOP: Comparing accretion model evolutionary tracks for the CEMP-s star CD-62 1346, for different accretion masses, final stellar masses, and AGB masses. The best fit model suggests 0.05 M⊙ of accreted material from a 3.00 M⊙ AGB star. BOTTOM: Example fit to accretion model surface abundances for the CEMP-s star CD-62 1346. Where the evolution tracks can be quite similar, the models separate themselves in abundance space.

Conclusions

- For a sample of 10 binary stars exhibiting chemical peculiarities consistent with AGB mass transfer, we estimate accretion efficiencies and mechanisms from abundance patterns and binary orbits.
- We find that *shorter* orbital periods correspond to *smaller* accretion masses and *lower* accretion efficiencies, hinting that close binary interactions may hinder or halt the mass transfer process!

References

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