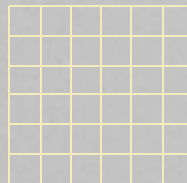
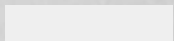


SOLAR SODIUM DOUBLET ANALYSIS

ABUNDANCE AND IONIZATION STATES

Ian Luckeydoo | Angelo O'Dorisio | Blake Sodikoff



GENERAL OUTLINE

A brief overview of the sections to be discussed in this presentation



Motivation

Importance of stellar elemental composition in determining planetary characteristics



Methodology

An analytical approach / equations employed in finding sodium abundances and ionization states from solar spectral data

Results

Interpretation of calculated sodium densities, ionization ratios, and elemental abundances

Conclusions / Future Directions

Implications of our findings for stellar / planetary science, and potential for extending analysis to exoplanetary systems



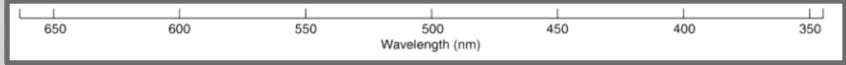
MOTIVATION

Why is this exploration into
stellar elemental composition
important?



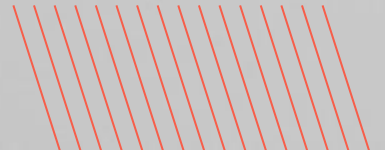
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MOTIVATION



- Understanding stellar composition is essential to planetary science.
- Sodium doublet spectral lines (5889/5895 Å) indicate stellar elemental abundances.

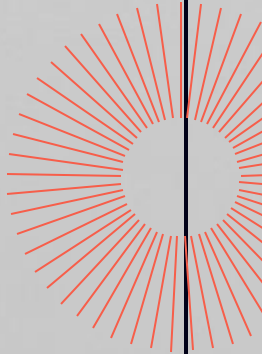
(UC Irvine Chemistry Department)



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METHODOLOGY

Analytical approach / equations
employed in finding sodium
abundances and ionization states



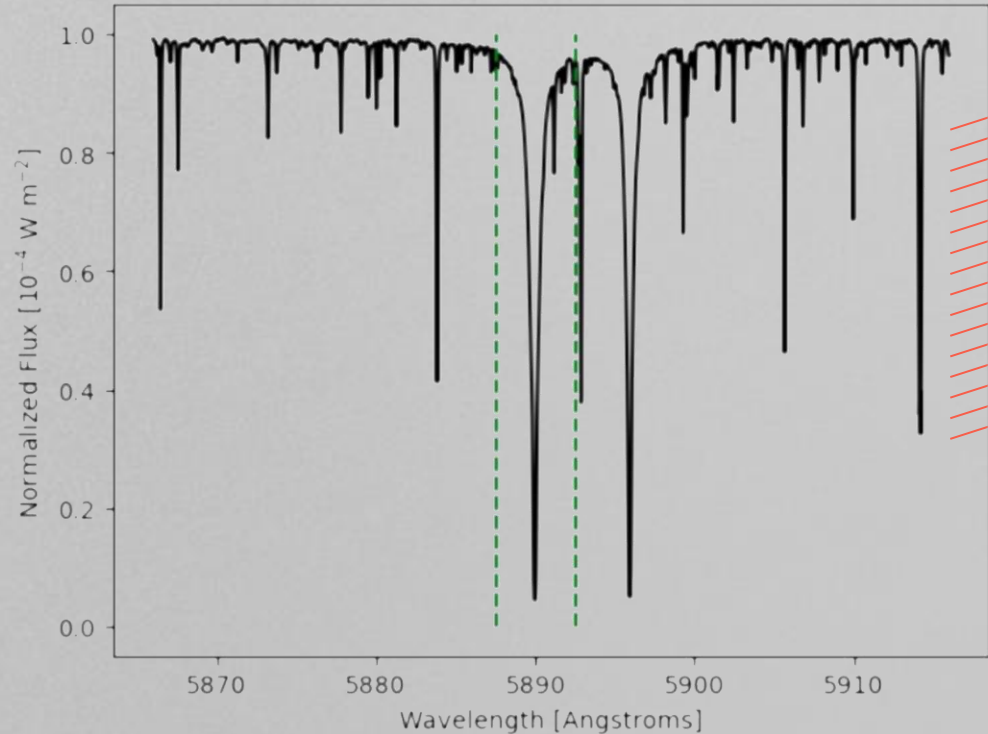
OBJECTIVES

- Find number density of sodium atoms (both ground and excited states)
- Determine sodium ionization ratios
 - Neutral vs. ionized
- Calculate sodium abundance relative to hydrogen



DATA OVERVIEW

- Analyzed solar spectral flux measurements
- Spectral region of sodium doublet lines, 5887.5-5892.5 Å
- Equivalent width gathered from spectral lines



ANALYTICAL EQUATIONS

Energy of atomic transitions: $E = \frac{hc}{\lambda}$

Boltzmann Ratio (excitation states): $\frac{n_2}{n_1} = \frac{g_2}{g_1} e^{-(E_1 - E_2)/k_B T}$

Saha Equation (ionization ratio): $\frac{N_{II}}{N_I} = \frac{2k_B}{P_e} \frac{Z_{II}}{Z_I} \left(\frac{2\pi m_e k_B T}{h^2} \right)^{3/2} e^{-\chi/k_B T}$



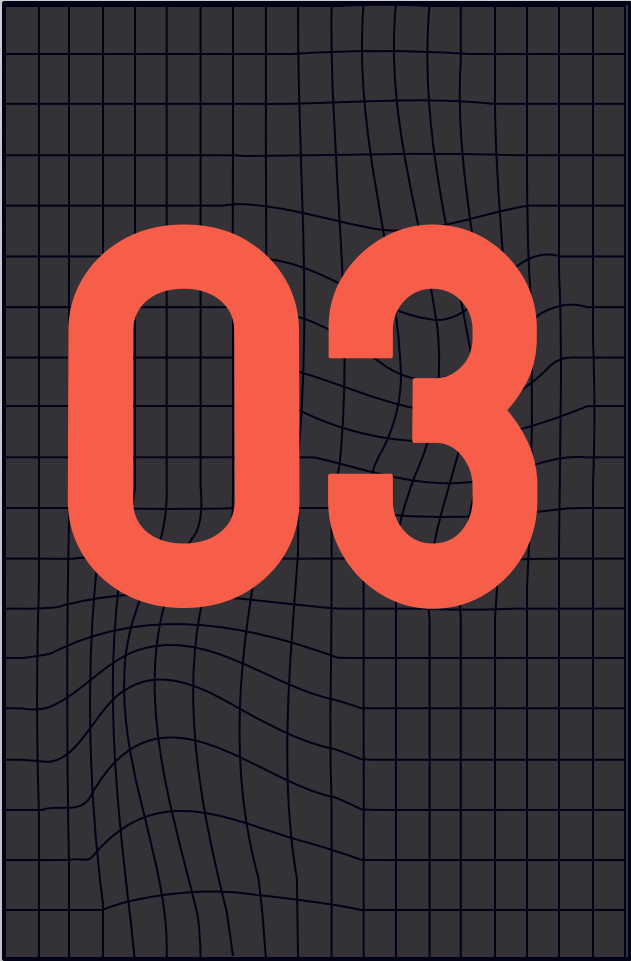
KEY ASSUMPTIONS

- Majority of Na atoms are neutral in photosphere
- High Na density due to gravitational conditions



RESULTS

Presentation and interpretation of
determined Na densities, ionization
ratios, elemental abundances



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IONIZATION RATIOS

Ionization Ratio	Calculated Value
Ionized / Ground State Sodium	0.044
Ionized / Neutral Sodium	2510



COLUMN DENSITY

Sodium Column Density:

$$2.16 \times 10^{18}$$

atoms/cm²



SODIUM ABUNDANCE

Expression Type	Sodium Abundance
Astronomer's (log scale)	0
Physicist's (numerical ratio)	3.096×10^{-9}



CONCLUSION

Implications of the findings for stellar and planetary science, and how this analysis could be extended to exoplanets



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CONCLUSION & FUTURE DIRECTIONS

- Characterized Na abundance and ionization in the Sun
- Applicable framework for analyzing stellar compositions relative to planet habitability
- Future Directions
 - Expand analysis
 - Compare stellar and planetary atmospheres
 - Identify solar analogs for habitability



FINAL QUESTIONS TO CONSIDER

- *How might Na abundance in other stars differ from in our Sun?*
- *What can Na ionization states tell us about star compositions elsewhere in the Universe?*
- *Could an exploration into other elemental spectral lines provide similar insight?*

