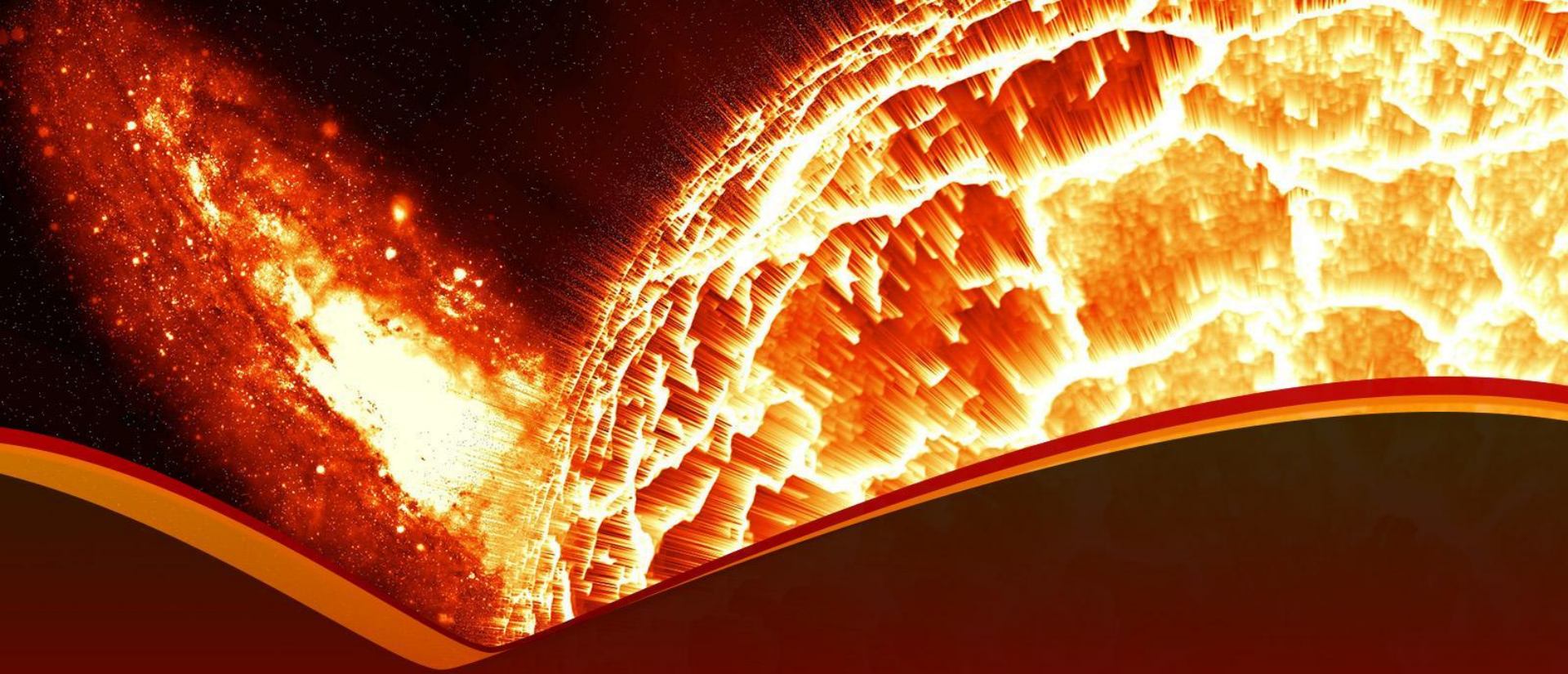

Project 3: Sodium Abundance in the Sun

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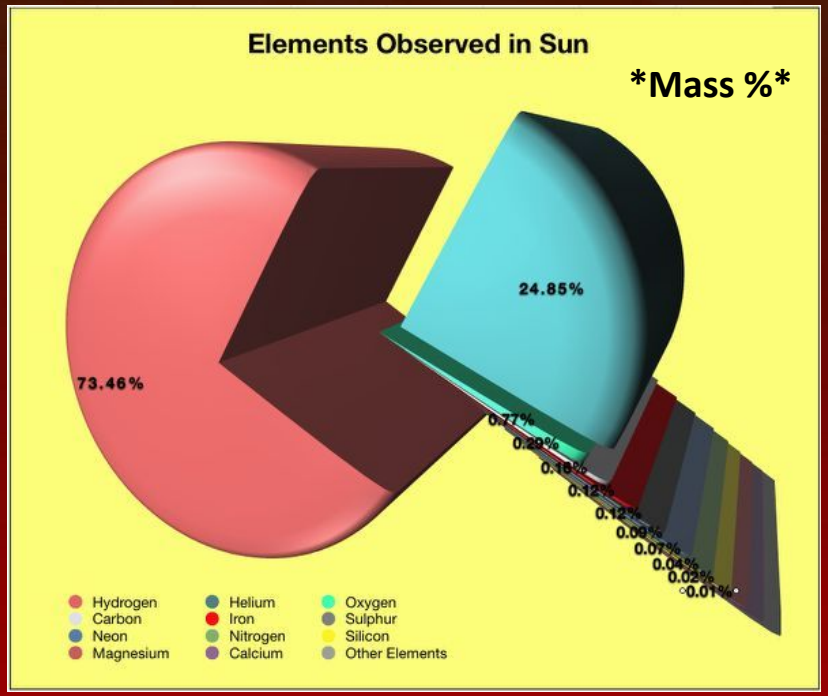
What is in our Sun?

Composed of roughly 91% of Hydrogen (# of atoms)

- Helium (8.9%) present from fusion and the Big Bang

Diverse composition of heavier elements due to conditions during formation (0.1%)



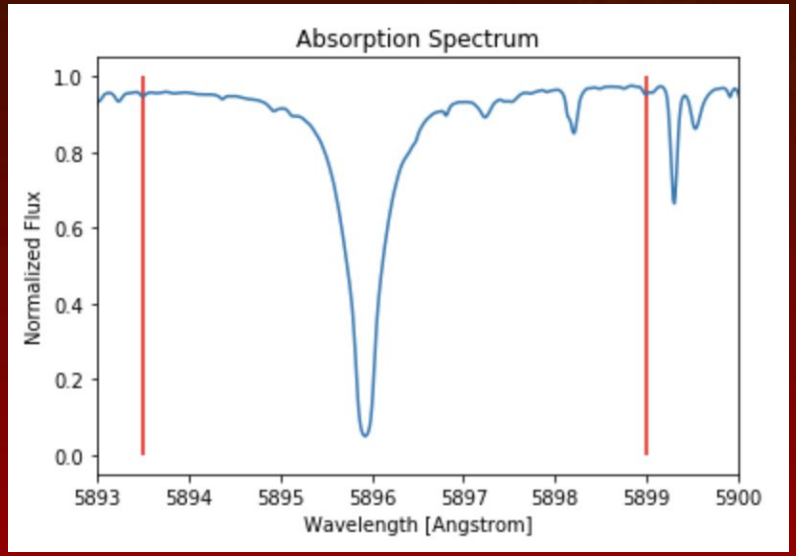
How do we know?

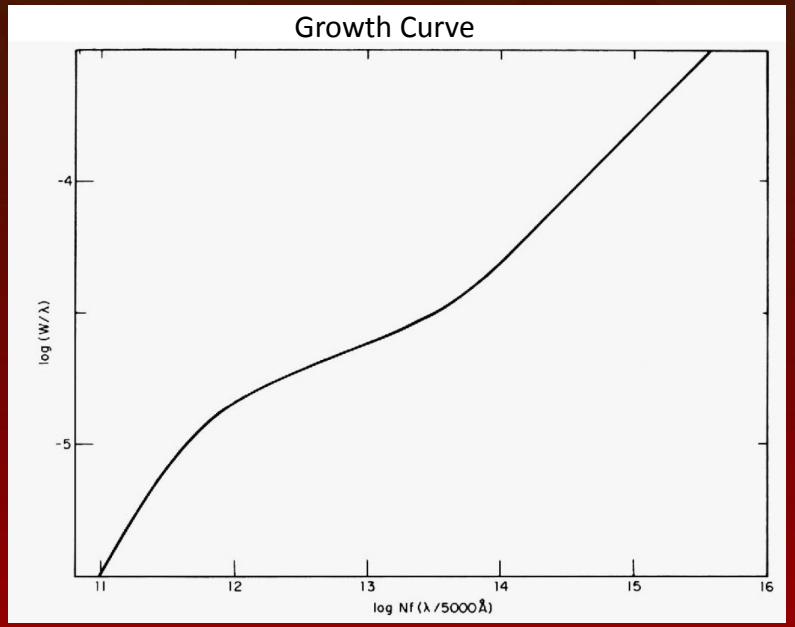
Spectroscopy

Observe absorption bands in light spectrum

QM permits specific electron transitions in elements

How much Sodium is in the Sun?





Equivalent width = 0.712Å

$N_{NaI} = 6.54 \times 10^{14}$ atoms/cm^2

Specifics of Sodium

Sodium can be relatively easily...

- Excited
  - Ground state $Na_0 = 1s^2 2s^2 2p^6 \boldsymbol{3s^1}$
- Ionized
  - $Na \rightarrow Na^+ + e^-$

Ratio of Excited Na Atoms

Excited state (2): $1s^2 2s^2 2p^6 \mathbf{3p^1}$

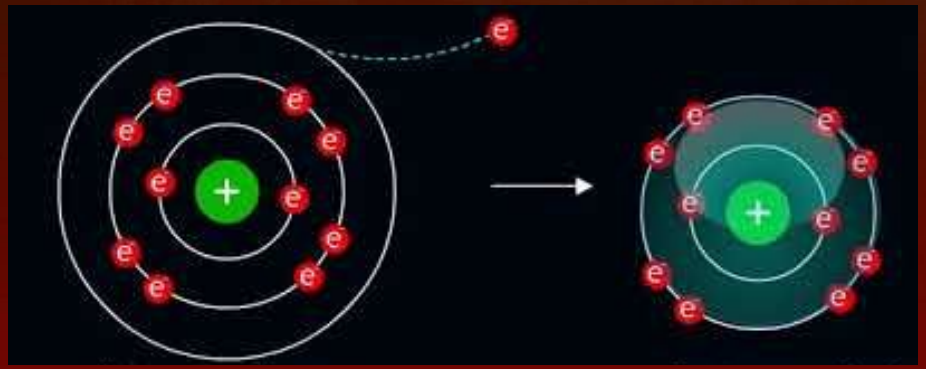
Ground State (1): $1s^2 2s^2 2p^6 \mathbf{3s^1}$

Boltzmann Equation:

$$\frac{N_2}{N_1} = \frac{g_2}{g_1} \exp\left(-\frac{E_2 - E_1}{kT}\right)$$

$N_{Excited}/N_{ground} = 0.0443$

Ratio of Ionized Na Atoms



Saha Equation:

$$\frac{Na_{II}}{Na_I} = \frac{2kT}{P_e}\frac{Z_{II}}{Z_I}\left(\frac{2\pi m_e kT}{h^2}\right)^{3/2}\exp\left(-\frac{\chi}{kT}\right)$$

$N^+/N = 2521.792$

Column Density of the Photosphere

Column Density (CD): $$N_1 \times (1 + \frac{N_2}{N_1}) \times (1 + \frac{Na_{II}}{Na_I})$$

$$CD_{Na} = 1.723 \times 10^{18} \text{ atoms/cm}^2$$

Ratio of Abundance

Compared to Hydrogen, Sodium is not very abundant

Abundance Number Ratio (physics):

- $CD_H/CD_{Na} = 2.610 \times 10^{-6}$

Mass Abundance Ratio (astronomy):

- $\text{Log(Na)} = 12 + \log(CD_{Na}/CD_H)$
- Log(Na) = 6.517 (6.30 from Lodders et al.)

Magnesium

Same procedure followed for for Magnesium

Noteworthy changes:

- Absorption band - location and equivalent width
- Ground and excited states
- Ionization energy
- Energy degeneracy
- ***Partition function***

Na and Mg Comparison

Magnesium is more abundant!

	Sodium	Magnesium
Equivalent Width (Å)	0.712	1.730
Neutral, Ground State Number Density	6.539×10^{14}	1.868×10^{15}
Ratio of Excited Atoms	0.044	0.025
Ratio of Ionized Atoms	2521.792	15.0756*
Column Density (atoms/cm$^{2)}$	1.723×10^{18}	3.077×10^{16}
Abundance (physics)	2.610×10^{-6}	4.662×10^{-8}
Abundance (astronomy)	6.517	6.055 (7.54)

Thank you!

Questions?