Project #3: Measuring Stellar Elemental Abundance

***Project description:***

You will learn how to measure elemental abundance using the curve of growth method. For more information, you can check the Jupyter notebook: Project\_03\_Measuring\_abundance.ipynb

The notebook includes a few examples and many useful links for you to understand different aspects of the project.

You will need to:

1, Measure the equivalent width of one of the solar sodium (Na) doublet lines.

2, Find the number density of Na atoms in the ground state based on the following curve of growth plot.

2, Estimate the ratio of sodium atoms in the ground state to sodium atoms in excited states using the Boltzmann equation.

3, Estimate the ratio of neutral sodium atoms to ionized sodium atoms using the Saha equation.

4, Compute the total column density of sodium atoms in the sun's photosphere bases on the above two ratios and the measured Na number density in the ground state.

5, The column density of hydrogen atoms is about 6.6×1023; what is the abundance of sodium relative to hydrogen, in both physicists’ and astronomers’ terminology.

The questions are:

1, What is the number density of Na atoms in the ground state?

2, What is the number density of neutral Na atoms?

3, What is the number density of ironized Na atmos?

4, What is the total number density of Na atoms in all states?

5, What is the relative abundance for Na to H, in NNa/NH and [Na/H]?

6, Bonus, can you apply the method to a different line, e.g., Fe, Mg, Si?

***Goals:***

1, Understand the curve of growth method.

2, Understand how stellar abundance is measured in real world.

3, Understand the Boltzmann and Saha equation and the application.

4, Be able to report the results of abundance measurement in ways that physicists and astronomers can understand.

***Deliverables:***

1, A 10-min oral presentation led by one of the team members. We will rotate the leading presenter as the semester goes on.

A, The 10-min presentation needs to spare ~2 min for questions.

B, The presentation should cover motivation, methods, results, and conclusions.

C, The presentation should address all questions in the project

D, The presenter should acknowledge the contribution of each team member when appropriate.

2, A written report led by one of the team members. We will rotate the leading writer as the semester goes on.

A, The report should be less than 5-page and cover motivation, methods, results, and conclusions.

B, The report should clearly lay out all the assumptions and calculations.

C, The report should address all questions in the project.

D, The report should acknowledge the contribution of each team member when appropriate, e.g., specifying leader and contributors for each section of the report.

***Evaluation and rubric:***

Your oral presentation and written report will be evaluated by other teams based the following rubric. Your score will be the average of scores from other teams.

1, 5 pts for the oral presentation.

A, Is the presentation clear? (1 pt)

B, Is the presentation engaging? (1 pt)

C, Is the presentation complete, i.e., covering motivation, methods, results, and conclusions (2 pt)

D, Does the presentation address all the questions from audience? (1 pt)

2, 5 pts for the written report.

A, Is the report complete, i.e., covering motivation, methods, results, and conclusions (2 pt)

B, Does the repot clearly lay out all the assumptions and calculations? (1 pt)

C, Does the report address all questions in the project? (1 pt)

D, Are the results sensible? (1 pt)

The 10 pt peer evaluation will be converted to 5 pt that goes into the peer review score. In addition, your projects, your questions to presenters and your evaluation of other teams, and self-evaluation will be evaluated by instructors (5 pt). Points are given at a 0.5 pt increment.

***Tips for collaborative research***:

1, It is a teamwork, so think carefully how you would use the expertise in your team to accomplish the goals. Here is how I would break up the project (feel free to disagree):

A, Understanding the quantum nature of the Na doublet line

B, Understanding the Boltzmann equation

C, Understanding the Saha equation

D, Coding for equivalent width measurement

E, Oral presentation

F, PowerPoint, or other presenting tools

G, Academic writing

H, Miscellaneous

2, Break the project into small parts and tackle each part based on the expertise that the part requires.

3, Risk management. Suggestion #1: dividing the team into two to work independently and then cross validate the results; #2: dividing the into two so that one team working on the required Na line and the other team going for the bonus line.

4, Identifying expertise and specific role is important because it helps to appropriately

5, Acknowledge the contribution in the written report.

6, Set explicit deadlines and expectations for each other.

7, Meet regularly at predetermined time.

6, Yell for help.