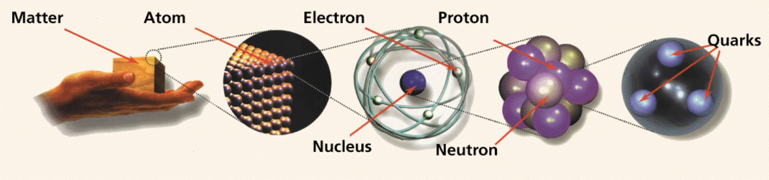
What holds atoms together?



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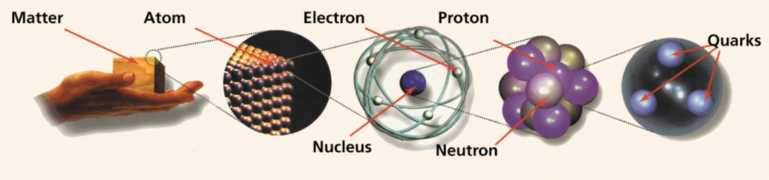
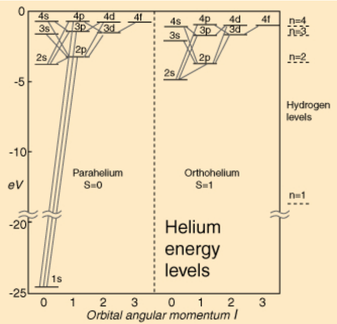


How do we know?

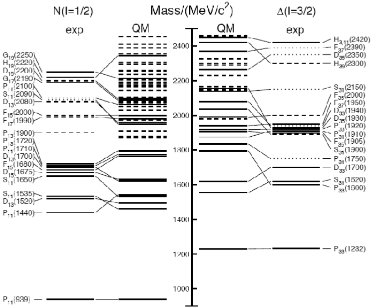
Spectroscopy

The pattern of states of a quantum system is a direct consequence of the force binding the system.



Energy levels of the helium atom.

$$V = k_e \frac{q_1 q_2}{r}$$

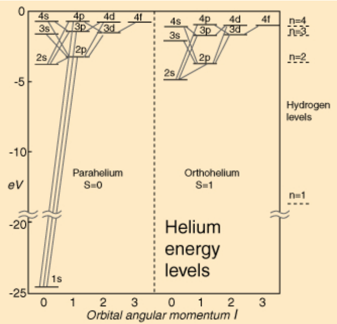


Energy levels of the nucleon.

$$V = -\frac{4}{3}\frac{\alpha_s \hbar c}{r} + kr$$

Spectroscopy

The pattern of states of a quantum system is a direct consequence of the force binding the system.



Energy levels of the helium atom.

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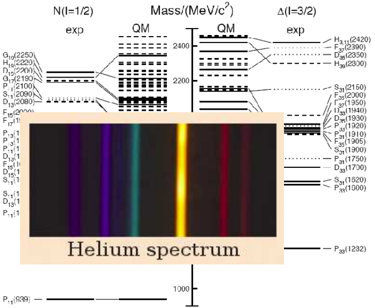

Energy levels of the nucleon.

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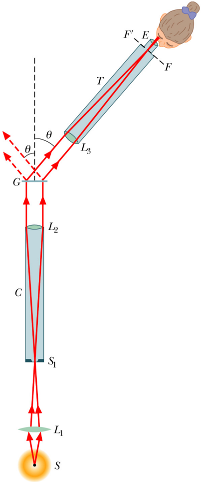
How Do We Measure the Energy States?



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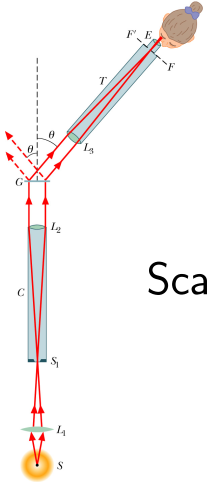

Scattering of light in a spectrometer.

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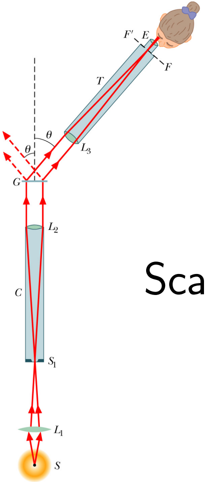
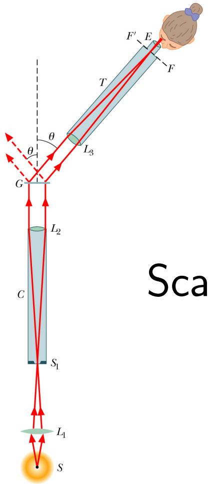


Scattering of light in a spectrometer.

What is light?

How Do We Measure the Energy States?

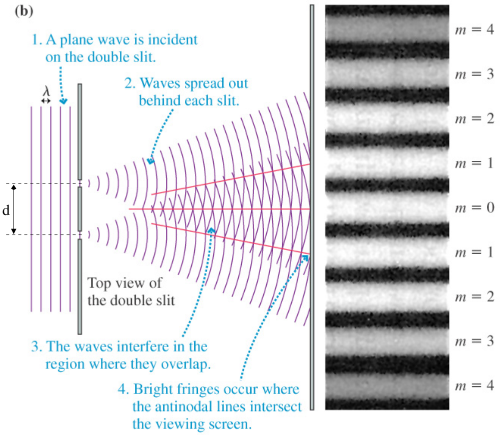


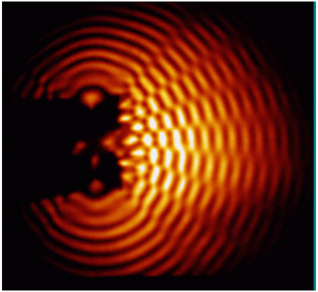
Scattering of light in a spectrometer.

What is light?

electromagnetic waves

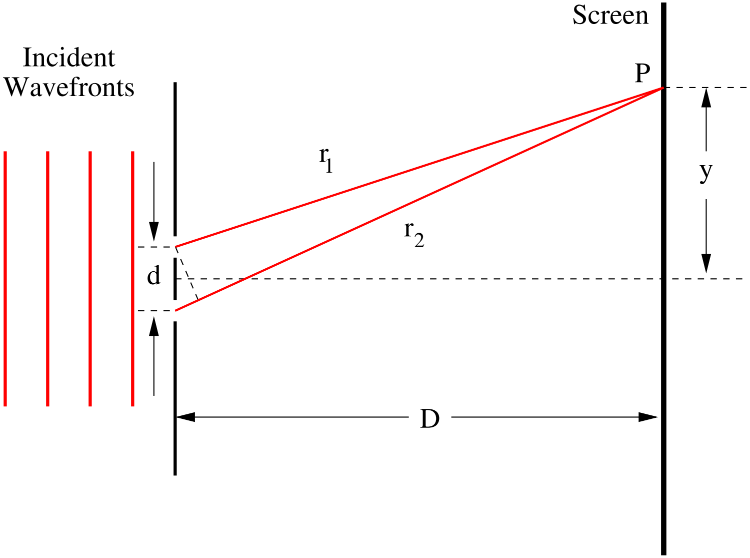
Double-Slit Interference





Interfering waves

Double Slit Interference



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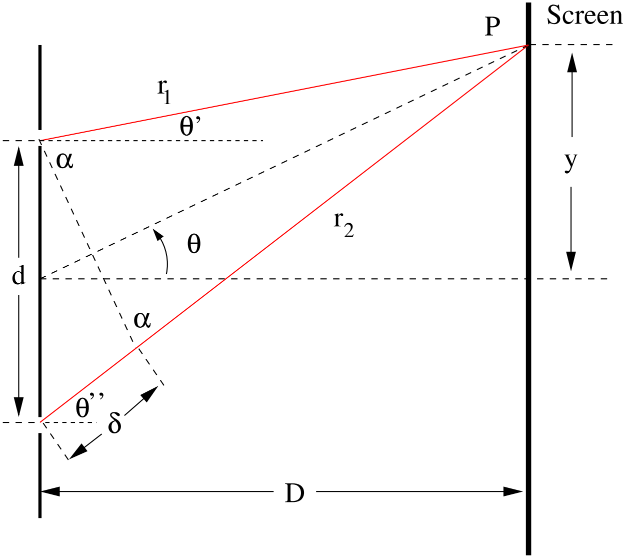

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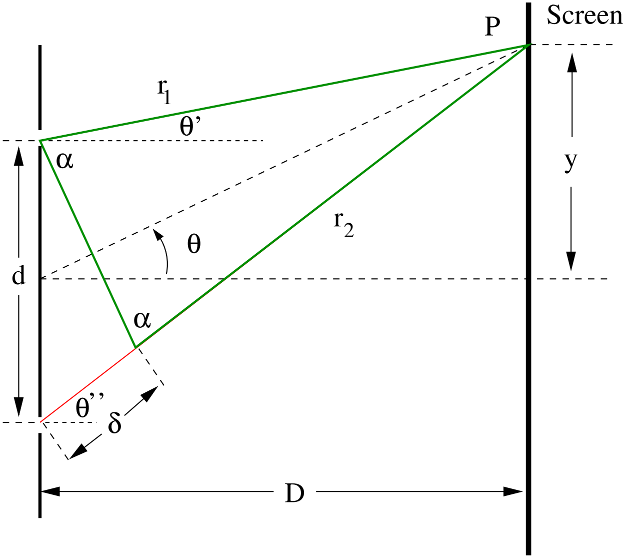

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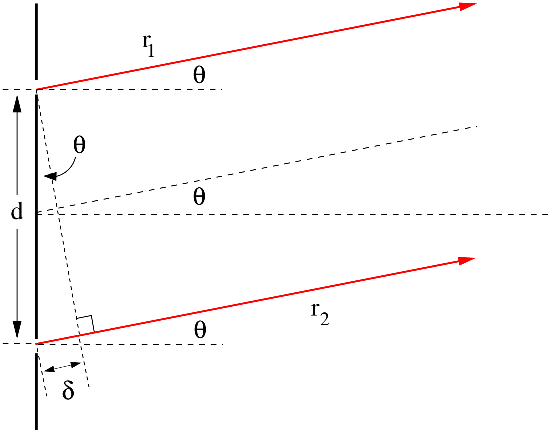
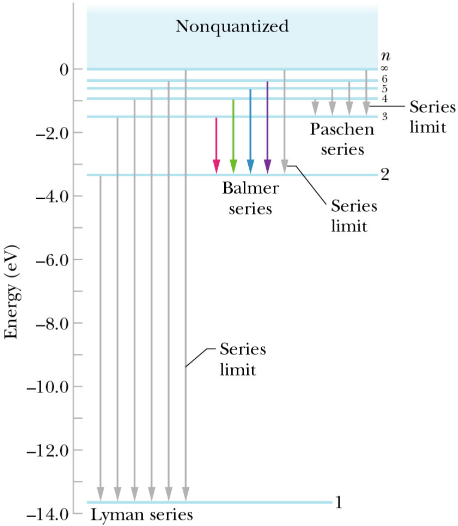


The Hydrogen Lines



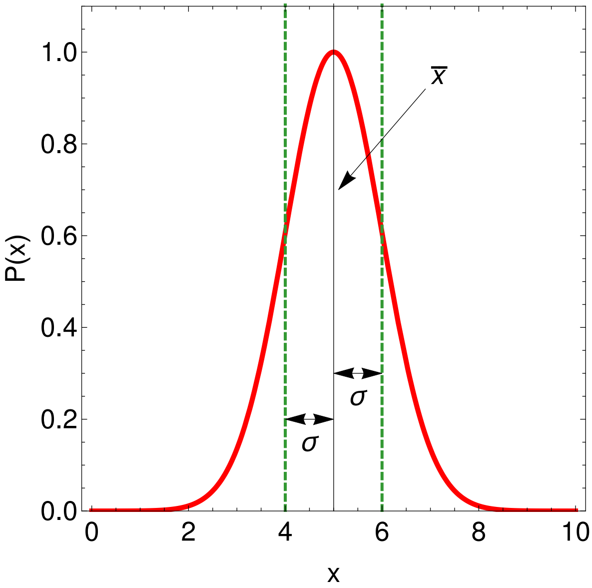
$$\lambda = d \sin\theta$$

$$E = h\nu = \frac{hc}{\lambda}$$

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

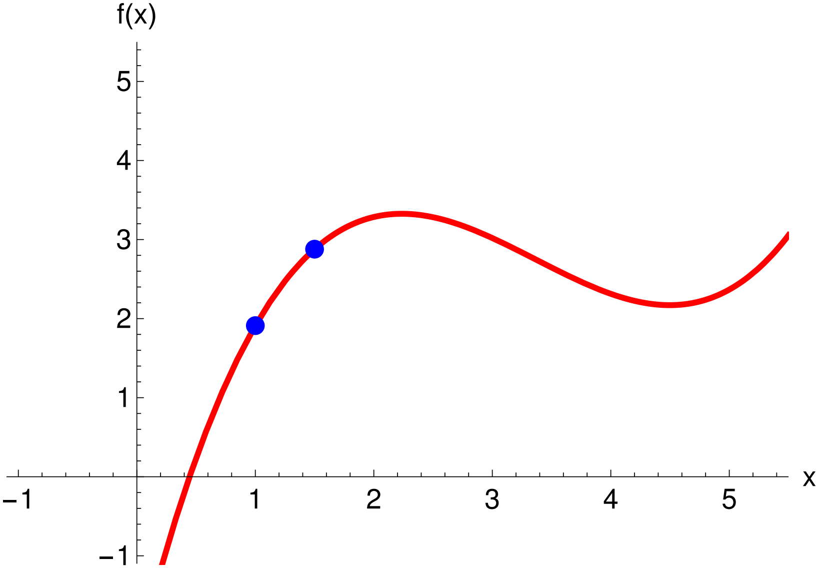
R_H - Rydberg constant

The Gaussian Distribution

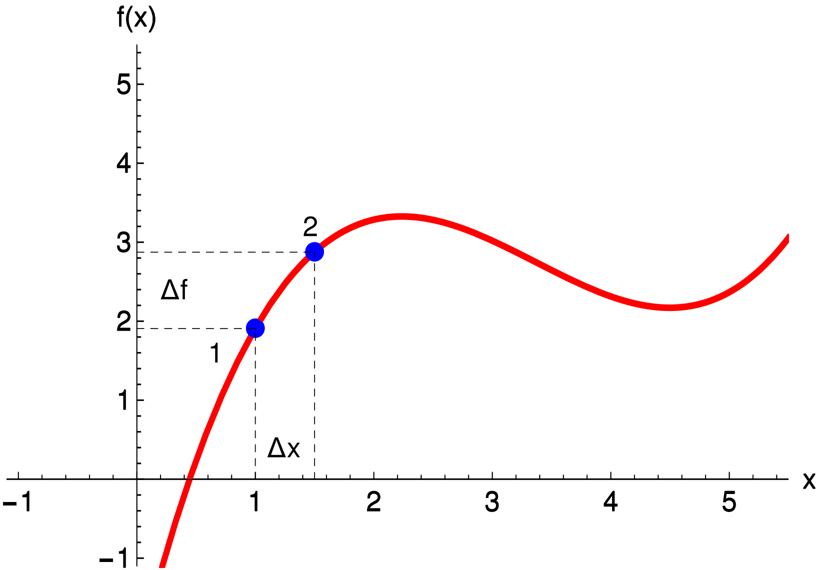


$$y = P(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\overline{x})^2}{2\sigma^2}}$$

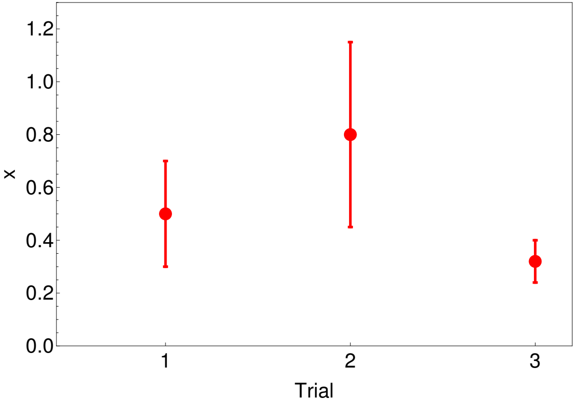
The Differential



The Differential



Which Point is Best?



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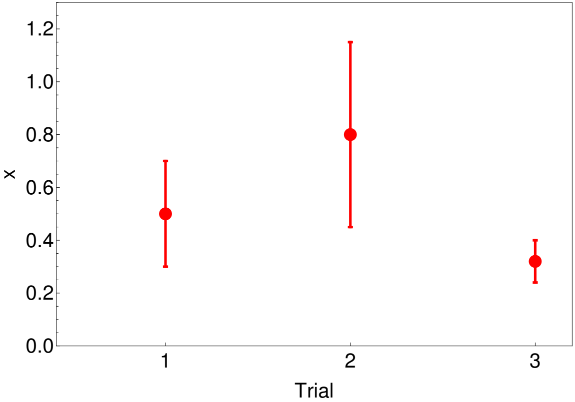
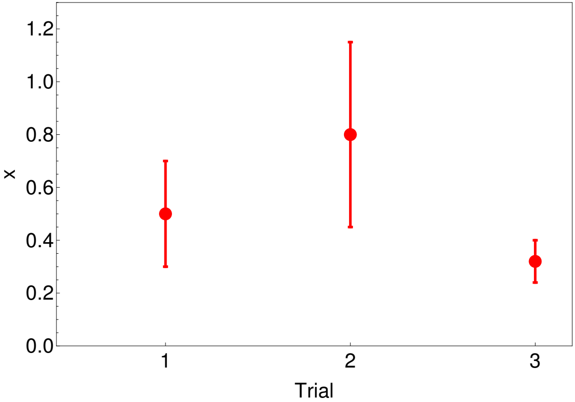


$$\bar{x} = \frac{\sum_i \frac{x_i}{\sigma_1^2}}{\sum_i \frac{1}{\sigma_i^2}}$$

Which Point is Best?

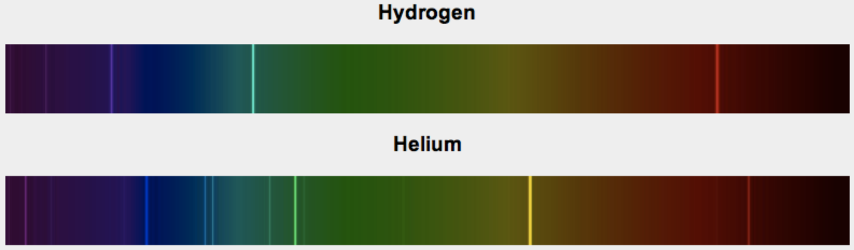


$$\overline{x} = \frac{\sum_i \frac{x_i}{\sigma_1^2}}{\sum_i \frac{1}{\sigma_i^2}}$$

You will need this to get the final value for R_H.

Identifying Your Unknown - 1

1. Pattern recognition - `http://astro.u-strasbg.fr/~koppen/discharge/`.



2. Listing of hydrogen data from website (wavelength (Å) and relative intensity).

3970.07	8
4101.74	15
4340.47	30
4861.33	80
6562.72	120
6562.85	180

Identifying Your Unknown - 2

3. Quantitative comparison for hydrogen in units of σ.

Line	My Results (Å)	NIST Results (Å)	Normalized Difference
α	$6.64 \pm 0.09 \times 10^3$	6.56280×10^3	0.86
β	$4.85 \pm 0.15 \times 10^3$	4.86133×10^3	0.08
γ	$4.39 \pm 0.06 \times 10^3$	4.34047×10^3	0.83

Physics 221 Guidelines for Laboratory Reports

1. The standard outline of any scientific lab report is the following.
    1. Motivation and objectives.
    2. Apparatus and procedure.
    3. Results and analysis.
    4. Conclusions.
2. Don't contradict yourself! Your conclusions should be based on what you actually observe; NOT what you expect to see or what some manual tells you.
3. Keep the written portion of the report to single page. Use the following pages for figures, captions, derivations, sample calculations, tables, drawings, *etc*. The goal here is to focus on the things that are most important instead of generating a lot of text. For example, if the apparatus is described in a manual available on the web, then summarize in a few words the apparatus and the procedure and then refer the reader to that reference 'for more details.'
4. Whenever you write, keep you audience in mind. In this course, write so that another physics student who is not in the class can understand what you are doing.
5. Use appendices for derivations and sample calculations.
6. Don't contradict yourself!
7. Significant figures should be accurate throughout anything you write.
8. Build your report around your procedure, data, and figures.
9. If you don't discuss it in the text, don't include it in the report.
10. Number the pages, figures, tables, and appendices and use those numbers when you refer to those items in the report.
11. Use proper scientific notation and symbols throughout the report. All reasonable word processors now have equation editors.
12. Use proper units.

Guidelines are also available at
`https://facultystaff.richmond.edu/~ggilfoyl/intermediate/ReportGuidelines/ReportGuidelines.html`