FIRST OBSERVATION OF A BIGGS PARTICLE

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Abstract

In the abstract we put the barest information about what we did and what were the results. No explanations or theory or descriptions of apparatus etc are necessary or relevant. If the reader wishes to know about these he/she knows that they will be found in the paper. The abstract is used to allow the reader to decide whether the paper is interesting to him. There are journals such as 'Physics Abstracts' which publish titles and abstracts from a wide range of journals, which can be searched on CD-ROM in the Science Division of the Main library.

Having read the abstract, the reader will frequently then jump to the 'Summary' or 'Conclusions' section, and only then decide whether or not to read the paper. When you have finished composing your report, look at the abstract and conclusions sections to see if they provide the required information to encourage the reader to go further.

1 Introduction

The introduction should give a brief description of the place of the work to be described in the general context of physics. You should refer to previous work where the papers may assist the reader to evaluate your claims as to the possible significance of the work you are going to describe.

This means talking in terms familiar to an educated physicist who may not be familiar with work in this particular area. The context will include a discussion of theory and of experimental method and apparatus but not at the level of detail to be found in the sections devoted to those topics later in the report. This discussion will place the present work in context with respect to existing theory and experiment, (with references like this [1]) and will state what improvements and advances are anticipated and have been achieved as a result of the present work.

Of course in a student laboratory this context will often be different from that in a research laboratory but you should nevertheless make the attempt to deal with the contextual question. The introduction should contain as its last section a description of the layout of the report - what the subsequent sections contain: this is a further guide to the reader as to whether he/she should continue reading and where the details the reader may be seeking are to be found.

2 Theory

Here you review in detail the salient points of the theory. You don't do a step by step reproduction of the standard theory to be found in texts or published documents, but you do

- Write down the beginning fundamental theoretical equations
- Set down any essential steps leading from the fundamentals to
- the set of equations essential to your work.

It is fairly common in experimental papers to place the theory in other sections rather than in a section of its own. For instance, some background theory might appear in the introduction and theory associated with how you manipulate the data might occur in the section on Method or one on Data Analysis and Discussion.

2.1 Mathematical expressions

In this and other sections you will find the LaTeX equation writing tools very useful. As an example:

<u>Relativistic Notation</u>
The normal space co-ordinates are written as

$$x_1,\ x_2,\ x_3.$$

Einstein's interpretation of the Michelson-Morley experiment was that the speed of light is the same to all observers. This concept can be expressed mathematically by introducing time as a fourth dimension, ie.

$$x_4 \;=\; ict.$$

An invariant distance dS can be defined such that

$$\begin{aligned}
dS^2 &= -(dx_\lambda)^2 \\
&= c^2dt^2 \;-\; dx_1^2 - dx_2^2 - dx_3^2. \\
&= c^2dt^2\{1 \;-\; \tfrac{dx_1^2+dx_2^2+dx_3^2}{c^2dt^2}\} \\
&= (1 - \tfrac{v^2}{c^2})c^2dt^2 \\
&= (1-\beta^2)c^2dt^2 \\
&= \tfrac{c^2}{\gamma^2}dt^2
\end{aligned}$$

where

$$\beta^2 \;=\; \tfrac{dx_1^2+dx_2^2+dx_3^2}{c^2dt^2} \;=\; \tfrac{v^2}{c^2}$$

and

$$\gamma \;=\; \tfrac{1}{\sqrt{1-\beta^2}}$$

As dS is a Lorentz invariant we can introduce a dimensionless velocity

$$u_\lambda = \frac{dx_\lambda}{dS} = \frac{\gamma}{c}\frac{dx_\lambda}{dt}$$

such that

$$u_\lambda^2 \;=\; -1$$

Using this definition of the four velocity we can define the four momentum

$$p_\lambda \;=\; mcu_\lambda$$

such that

$$\mathbf{p}_i \;=\; mc\tfrac{\gamma}{c}\tfrac{\mathbf{dx}_i}{dt} = m\gamma\mathbf{v_i} \quad i=1,2,3$$

and

$$p_4 \;=\; mc\tfrac{\gamma}{c}\tfrac{dx_4}{dt} = \tfrac{i}{c}\gamma mc^2 \;=\; \tfrac{i}{c}E$$

as

$$\begin{aligned}
u_\lambda^2 &= -1 \\
-p_\lambda^2 &= m^2c^2 \;=\; \tfrac{E^2}{c^2} - \mathbf{p}_i^2
\end{aligned}$$

or

$$E^2 - \mathbf{p}^2c^2 \;=\; m^2c^4$$

where the convention is that a four vector is written in normal type and a three component vector is written in boldface..

This is the end of the math typesetting example.

2.2 newcommands

At the beginning of the document you will have noticed a section containing numerous 'newcommands' These enable you to define shorthand sequences for frequently used structures; whether you bother with such things depends on the length of the dopcument and the number of times you will use the newcommands

As an example: the chisquared

$$\chi^2$$

expression used in statistics has been prepared as a newcommand above.

3 Method

Here you describe how the measurements were made. This will frequently involve you in discussing which experimental factors affect the precision of the final results and how you dealt with them. At this point one distinguishes between:

- random or statistical errors, and how you minimised them and how you determined their values,
- systematic errors (of calibration etc) which cannot be determined by repeated measurements.

At this point you also discuss all effects which although not directly part of the physics you are studying, may possibly have a significant role to play in the results. experiment. The rule is- if you can identify a possible factor, you must specifically find the magnitude of the effect it may have, and then classify it as either ignorably small, or include it in the subsequent analysis. Much ingenious effort goes into planning improvements on experiments in which various factors which could contribute to the error of the measurements are diminished or eliminated.

It frequently happens that several different classes of measurement are made in one experiment. These are best dealt with using subsections:

3.1 Class One

Include description of class 1 method. The subsectioning would then continue on into other sections of the report.

3.2 Class Two

You will note that the latex compiler automatically numbers sections and subsections (and subsubsections etc)

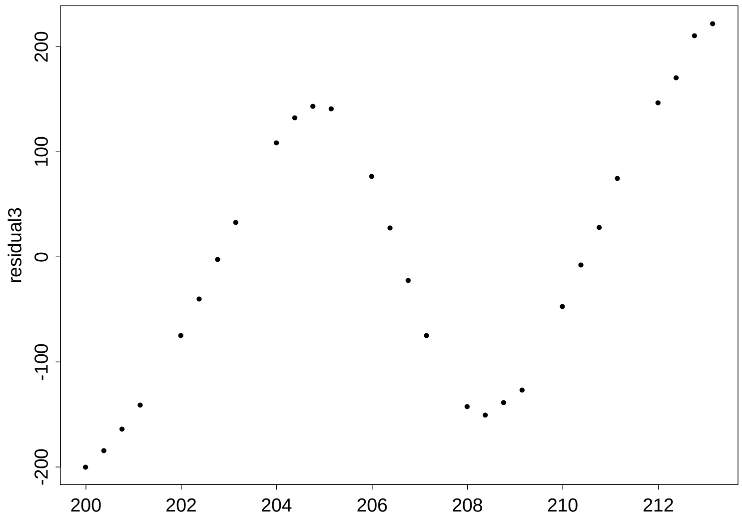
4 Apparatus

A diagram of essentials of mechanical details, block diagrams of instruments and interrelated equipment, and detailed circuit diagrams of important parts of the electronics where such things are important. The Apparatus section can often be simply included as part of the Methods section.

To draw diagrams which may be incorporated into the report as in the example below you can use any drawing or drafting program which produces output files for PostScript. (they will have an extension .ps)

5 Measurements

The results of your raw measurements as collected in your lab notebook are collected, and summarised here. Often the raw results will be shown in graphical or tabular form. (see below)



5.1 Arrays

Arrays organise data neatly but don't provide boxes and lines to guide the eye.

$$\begin{array}{clcr} a+b+c & uv & x-y & 27 \\ a+b & u+v & z & 134 \\ a & 3u+vw & xyz & 2,978 \end{array}$$

5.2 Tables

These are often the best way to show numerical data. If the data is available in a machine readable form you can use your editor to incorporate it into the document and format it for LaTeX printing.

integer	square	cube	sqrt
1	1	1	1.0000
2	4	8	1.4142
3	9	27	1.7321
4	16	64	2.0000
5	25	125	2.2361
6	36	216	2.4495
7	49	343	2.6458
8	64	512	2.8284
9	81	729	3.0000
10	100	1000	3.1623

6 Data Analysis and Discussion

The raw data is converted into a form suitable for comparison with theory; eg for the LRC experiment, the data is fitted placed into a form where it can be fitted with curves whose shapes can be characterised by resonant freqencies, bandwidths etc. Here you confront your results (as extracted from the raw data) with theory, and state to what extent your work supports the theory, or perhaps supports one theory more strongly than others. The comparison of theory and experiment is done precisely, with emphasis on the difference between theory and experiment (the residuals) and how large these residuals are compared with carefully established errors for both theory and experiment.

7 Conclusions

Important section where you concisely summarise your work and what it means and to what extent it has achieved the aims set out in the introduction. If further work and improvements are suggested by the present work, you may mention this.

8 Acknowledgements

Where you thank those who have helped and or provided support, but whose contribution does not qualify for co-authorship.
Thanks to Mr. William Walker for ... and to the Government and citizens of BC for ... etc. Usual in research papers, not obligatory for student reports.

References

[1] S. Ahmad, C. Amsler, R. Armenteros, E. Auld, D. Axen, G. Beer, J.C. Bizot, M. Caria, M. Comyn, W. Dahme, B. Delcourt, K. Erdman, P. Eschtruth, U. Gastaldi, M. Heel, R. Howard, J. Jeanjean, H. Kalinowsky, F. Kayser, E. Klempt, R. Landua, H. Nguyen, L. Robertson, C. Sabev, R. Schneider, O. Schreiber, U. Straumann, P. Truol, B. White and W.R. Wodrich. "PROTONIUM SPECTROSCOPY AND IDENTIFICATION OF P-WAVE AND S-WAVE INITIAL STATES OF $\overline{p}p$ ANNIHILATIONS AT REST WITH THE ASTERIX EXPERIMENT AT LEAR." "Physics at LEAR with Low-Energy Cooled Antiprotons" Eds. Ugo Gastaldi and Robert Klapisch (Plenum Publishing Corporation, 1984) p109-141.