Second Observation of a Biggs Particle

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Abstract

The abstract describes concisely what is contained in the report. It should outline what has been measured or investigated, how the measurement was done and the results. It is typically a single paragraph about five sentences long. For example it could begin with "Planck's constant has been determined from the the black body radiation emitted from a steel tube heated to a temperature in the range 800 to 1100 degrees C."

The abstract is really a separate document, as for scientific papers the abstract is published on its own, so it is ok to repeat things in the abstract elsewhere in the document.

1 Introduction

In this section you introduce the subject of the report and provide relevant background or historical information. Scientific motivation is a key element to a good introduction. For example why is this quantity (phonomenon) important (interesting) in physics, other areas of science and/or applications. Give a few specific examples.

You should summarize in your own words any background information in the lab manual and supplement it with additional facts you find in other references. Find at least 3 references on the subject from text books or journal articles. Items in the bibliography can be referenced as follows. [1], [2]. The letters inside the curly brackets are used to label the reference. Numbers appear automatically in the compiled text.

You should be able to write a good introduction in less than two typed pages. It should be concise, interesting and informative. Quality is more important than quantity. You should plan on rewriting the paper several times. A good opening sentence for might be:

"The surface of the earth is constantly being bombarded by a stream of subatomic particles known as cosmic ray muons...."

or "Thermal expansion is an important physical property of materials which arises microsopically from the anharmonic lattice vibrations. ..."

or "Fourier transforms are an important mathematical tool used to solve many problems in physics..."

An essential element of the introduction is the last paragraph which connects the more general subject matter presented in the first part of the introduction to the specific experiment being reported. The first part of the introduction gives you background information and leads up to the last paragraph which explains the experiment. Don't worry about repeating things already said in the abstract. The report should be self contained apart from the abstract. Of course don't simply repeat the abstract word for word. You can give a more detailed description here of what follows in the next sections.

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 Experimental Methods 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:

Relativistic Notation

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 Experimental Methods

In this section you should describe the apparatus used in the experiment. Use figures wherever possible to describe the setup, electronics etc. There are some simple rules to follow for figures:

1. Figures must be numbered.
2. Make them large and easy to read. **The text in a figure should be large enough so that if the figure were reduced to a single column the text would be the size of the regular text in the document.**
3. Figures must have a caption which explains what is in the figure. **There should be enough detail in the caption to understand the figure without reading the text**.
4. Every figure must be referred to in the text.

When describing equipment give model numbers and any relevant specifications that seem appropriate. e.g. wavelength of the laser or precision of the DVM etc.

Figures can be inserted from files (.ps or .eps files) as in the example below, but you can also just leave a blank space and paste them in.

4 Results

Present the data in tables and figures as much as possible. Tables should be numbered, have captions and referred to in the text. You can make a simple table as follows:

Figure 1: Schematic of the apparatus used to measure the angular dependence of the cosmic muon flux. Coincidences between the two plastic scintillation detectors indicate the passage of a cosmic ray muon. This figure is a blank dummy - image to be pasted in.

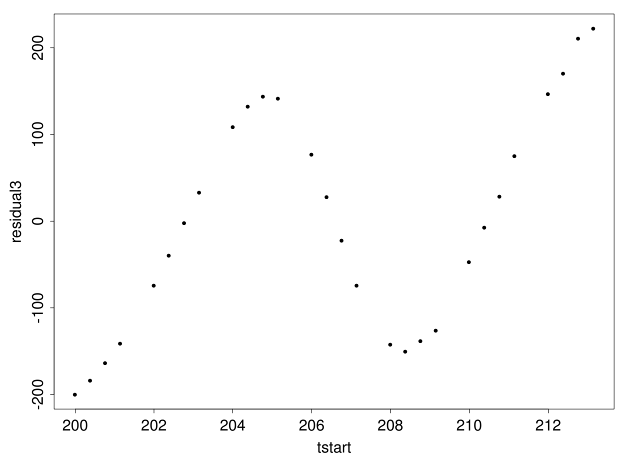

Figure 2: This is the figure caption that describes the data in the figure.

4.1 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.

Table 1: Cosmic Ray Muon Flux x as a Function of y and z

x1	y1	z1
x2	y2	z2
x3	y3	z3

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

All of your data should have errors of some type which you should discuss. The procedure for the analysis should be given in some detail.

5 Analysis and Discussion

What did you find out?

If parts of the experiment not work out can you say why?

If the data does not fit the theory or tabulated values (e.g. thermal expansion coefficent) can you give some reasons?

What were the main sources of error?

How would you redesign the experiment to make it faster or more accurate?

6 Conclusions

You should restate or summarize what has been measured or investigated, and give the main results. There is an old adage for writing good papers. “First you tell them what you are going to ‘tell them, then you tell them and then you tell them what you told them.”

What are the implications? e.g. Radiation dose from cosmic muons, background levels in radiation detectors.

The bibliography is generated as follows. Note the items refer to the reference names in the text e.g. garwin57 as sepcified in the text. Good luck!

7 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] R.L. Garwin, L.M. Lederman, M. Weinrich, Phys. Rev. 105, (1957) 1415.

[2] *Muon Science* edited by S.L. Lee, S.H. Kilcoyne, and R. Cywwinski, published by SUSSP publications and the Institute of Physics U.K. (1999).

[3] 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.