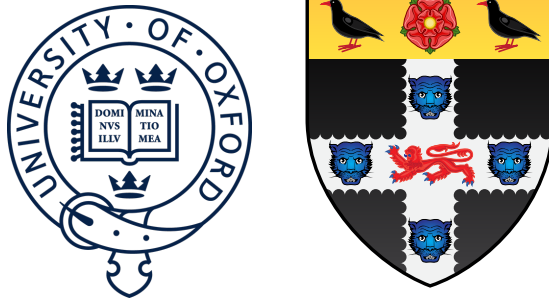


First Measurement of the Solar Neutrino Oscillation Parameters via Boron-8 Solar Neutrinos in SNO+



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A thesis submitted in fulfilment of the requirements for the degree of
Doctor of Philosophy
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To my parents

Acknowledgements

And I would like to acknowledge ...

Abstract

This is where you write your abstract ...

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Chapter 1

Getting started

1.1 What is loren ipsum? Title with math σ

Lorem Ipsum is simply dummy text of the printing and typesetting industry (see Section 1.3). Lorem Ipsum [3] has been the industry’s standard dummy text ever since the 1500s, when an unknown printer took a galley of type and scrambled it to make a type specimen book. It has survived not only five centuries, but also the leap into electronic typesetting, remaining essentially unchanged. It was popularised in the 1960s with the release of Letraset sheets containing Lorem Ipsum passages, and more recently with desktop publishing software like Aldus PageMaker including versions of Lorem Ipsum [1, 4, 5].

The most famous equation in the world: $E^2 = (m_0c^2)^2 + (pc)^2$, which is known as the **energy-mass-momentum** relation as an in-line equation.

A *L^AT_EX* class file is a file, which holds style information for a particular L^AT_EX.

$$CIF : \quad F_0^j(a) = \frac{1}{2\pi i} \oint_{\gamma} \frac{F_0^j(z)}{z - a} dz \quad (1.1)$$

1.2 Why do we use loren ipsum?

It is a long established fact that a reader will be distracted by the readable content of a page when looking at its layout. The point of using Lorem Ipsum is that it has a more-or-less normal distribution of letters, as opposed to using ‘Content here, content here’, making it look like readable English. Many desktop publishing packages and web page editors now use Lorem Ipsum as their default model text, and a search for

1 ‘lorem ipsum’ will uncover many web sites still in their infancy. Various versions have
2 evolved over the years, sometimes by accident, sometimes on purpose (injected humour
3 and the like).

4 1.3 Where does it come from?

5 Contrary to popular belief, Lorem Ipsum is not simply random text. It has roots in a
6 piece of classical Latin literature from 45 BC, making it over 2000 years old. Richard
7 McClintock, a Latin professor at Hampden-Sydney College in Virginia, looked up one
8 of the more obscure Latin words, consectetur, from a Lorem Ipsum passage, and going
9 through the cites of the word in classical literature, discovered the undoubtable source.
10 Lorem Ipsum comes from sections 1.10.32 and 1.10.33 of "de Finibus Bonorum et
11 Malorum" (The Extremes of Good and Evil) by Cicero, written in 45 BC. This book is
12 a treatise on the theory of ethics, very popular during the Renaissance. The first line
13 of Lorem Ipsum, "Lorem ipsum dolor sit amet..", comes from a line in section 1.10.32.

14 The standard chunk of Lorem Ipsum used since the 1500s is reproduced below for
15 those interested. Sections 1.10.32 and 1.10.33 from "de Finibus Bonorum et Malorum"
16 by Cicero are also reproduced in their exact original form, accompanied by English
17 versions from the 1914 translation by H. Rackham

18 "Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor
19 incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud
20 exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure
21 dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur.
22 Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt
23 mollit anim id est laborum."

24 Section 1.10.32 of "de Finibus Bonorum et Malorum", written by Cicero in 45
25 BC: "Sed ut perspiciatis unde omnis iste natus error sit voluptatem accusantium
26 doloremque laudantium, totam rem aperiam, eaque ipsa quae ab illo inventore veritatis
27 et quasi architecto beatae vitae dicta sunt explicabo. Nemo enim ipsam voluptatem
28 quia voluptas sit aspernatur aut odit aut fugit, sed quia consequuntur magni dolores
29 eos qui ratione voluptatem sequi nesciunt. Neque porro quisquam est, qui dolorem
30 ipsum quia dolor sit amet, consectetur, adipisci velit, sed quia non numquam eius modi
31 tempora incidunt ut labore et dolore magnam aliquam quaerat voluptatem. Ut enim
32 ad minima veniam, quis nostrum exercitationem ullam corporis suscipit laboriosam,
33 nisi ut aliquid ex ea commodi consequatur? Quis autem vel eum iure reprehenderit qui

in ea voluptate velit esse quam nihil molestiae consequatur, vel illum qui dolorem eum fugiat quo voluptas nulla pariatur?"

1914 translation by H. Rackham: "But I must explain to you how all this mistaken idea of denouncing pleasure and praising pain was born and I will give you a complete account of the system, and expound the actual teachings of the great explorer of the truth, the master-builder of human happiness. No one rejects, dislikes, or avoids pleasure itself, because it is pleasure, but because those who do not know how to pursue pleasure rationally encounter consequences that are extremely painful. Nor again is there anyone who loves or pursues or desires to obtain pain of itself, because it is pain, but because occasionally circumstances occur in which toil and pain can procure him some great pleasure. To take a trivial example, which of us ever undertakes laborious physical exercise, except to obtain some advantage from it? But who has any right to find fault with a man who chooses to enjoy a pleasure that has no annoying consequences, or one who avoids a pain that produces no resultant pleasure?"

Section 1.10.33 of "de Finibus Bonorum et Malorum", written by Cicero in 45 BC: "At vero eos et accusamus et iusto odio dignissimos ducimus qui blanditiis praesentium voluptatum deleniti atque corrupti quos dolores et quas molestias excepturi sint occaecati cupiditate non provident, similique sunt in culpa qui officia deserunt mollitia animi, id est laborum et dolorum fuga. Et harum quidem rerum facilis est et expedita distinctio. Nam libero tempore, cum soluta nobis est eligendi optio cumque nihil impedit quo minus id quod maxime placeat facere possimus, omnis voluptas assumenda est, omnis dolor repellendus. Temporibus autem quibusdam et aut officiis debitis aut rerum necessitatibus saepe eveniet ut et voluptates repudiandae sint et molestiae non recusandae. Itaque earum rerum hic tenetur a sapiente delectus, ut aut reiciendis voluptatibus maiores alias consequatur aut perferendis doloribus asperiores repellat."

1914 translation by H. Rackham: "On the other hand, we denounce with righteous indignation and dislike men who are so beguiled and demoralized by the charms of pleasure of the moment, so blinded by desire, that they cannot foresee the pain and trouble that are bound to ensue; and equal blame belongs to those who fail in their duty through weakness of will, which is the same as saying through shrinking from toil and pain. These cases are perfectly simple and easy to distinguish. In a free hour, when our power of choice is untrammelled and when nothing prevents our being able to do what we like best, every pleasure is to be welcomed and every pain avoided. But in certain circumstances and owing to the claims of duty or the obligations of business it will frequently occur that pleasures have to be repudiated and annoyances accepted. The wise man therefore always holds in these matters to this principle of selection: he

- ¹ rejects pleasures to secure other greater pleasures, or else he endures pains to avoid
- ² worse pains."

Chapter 2

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My second chapter

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2.1 Reasonably long section title

3

I'm going to randomly include a picture Figure 2.1.

4

If you have trouble viewing this document contact Krishna at: kks32@cam.ac.uk or raise an issue at <https://github.com/kks32/phd-thesis-template/>

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Enumeration

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Lorem ipsum dolor sit amet, consectetur adipiscing elit. Sed vitae laoreet lectus. Donec lacus quam, malesuada ut erat vel, consectetur eleifend tellus. Aliquam non feugiat lacus. Interdum et malesuada fames ac ante ipsum primis in faucibus. Quisque a dolor sit amet dui malesuada malesuada id ac metus. Phasellus posuere egestas mauris, sed porta arcu vulputate ut. Donec arcu erat, ultrices et nisl ut, ultricies facilisis urna. Quisque iaculis, lorem non maximus pretium, dui eros auctor quam, sed sodales libero felis vel orci. Aliquam neque nunc, elementum id accumsan eu, varius eu enim. Aliquam blandit ante et ligula tempor pharetra. Donec molestie porttitor commodo. Integer rutrum turpis ac erat tristique cursus. Sed venenatis urna vel tempus venenatis. Nam eu rhoncus eros, et condimentum elit. Quisque risus turpis, aliquam eget euismod id, gravida in odio. Nunc elementum nibh risus, ut faucibus mauris molestie eu. Vivamus quis nunc nec nisl vulputate fringilla. Duis tempus libero ac justo laoreet tincidunt. Fusce sagittis gravida magna, pharetra venenatis mauris semper at. Nullam eleifend felis a elementum sagittis. In vel turpis eu metus euismod tempus eget sit amet tortor. Donec eu rhoncus libero, quis iaculis lectus. Aliquam erat volutpat. Proin id ullamcorper tortor. Fusce vestibulum a enim non volutpat.

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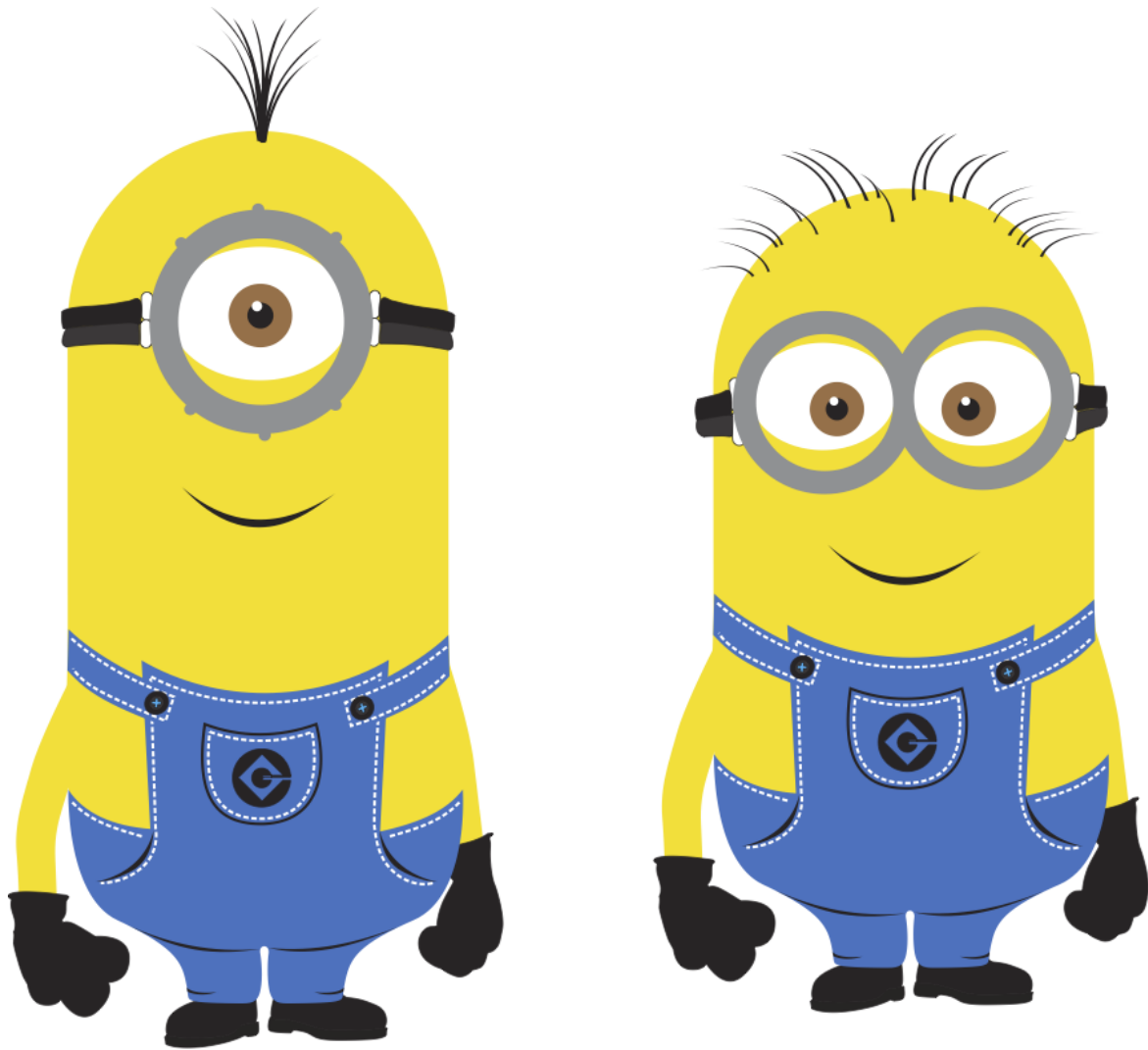


Fig. 2.1 This is just a long figure caption for the minion in Despicable Me from Pixar

Nam ut interdum nulla. Proin lacinia felis malesuada arcu aliquet fringilla. Aliquam condimentum, tellus eget maximus porttitor, quam sem luctus massa, eu fermentum arcu diam ac massa. Praesent ut quam id leo molestie rhoncus. Praesent nec odio eget turpis bibendum eleifend non sit amet mi. Curabitur placerat finibus velit, eu ultricies risus imperdiet ut. Suspendisse lorem orci, luctus porta eros a, commodo maximus nisi.

Nunc et dolor diam. Phasellus eu justo vitae diam vehicula tristique. Vestibulum vulputate cursus turpis nec commodo. Etiam elementum sit amet erat et pellentesque. In eu augue sed tortor mollis tincidunt. Mauris eros dui, sagittis vestibulum vestibulum vitae, molestie a velit. Donec non felis ut velit aliquam convallis sit amet sit amet velit. Aliquam vulputate, elit in lacinia lacinia, odio lacus consectetur quam, sit amet facilisis mi justo id magna. Curabitur aliquet pulvinar eros. Cras metus enim, tristique ut magna a, interdum egestas nibh. Aenean lorem odio, varius a sollicitudin non, cursus a odio. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae;

1. The first topic is dull

2. The second topic is duller

(a) The first subtopic is silly

(b) The second subtopic is stupid

3. The third topic is the dullest

Morbi bibendum est aliquam, hendrerit dolor ac, pretium sem. Nunc molestie, dui in euismod finibus, nunc enim viverra enim, eu mattis mi metus id libero. Cras sed accumsan justo, ut volutpat ipsum. Nam faucibus auctor molestie. Morbi sit amet eros a justo pretium aliquet. Maecenas tempor risus sit amet tincidunt tincidunt. Curabitur dapibus gravida gravida. Vivamus porta ullamcorper nisi eu molestie. Ut pretium nisl eu facilisis tempor. Nulla rutrum tincidunt justo, id placerat lacus laoreet et. Sed cursus lobortis vehicula. Donec sed tortor et est cursus pellentesque sit amet sed velit. Proin efficitur posuere felis, porta auctor nunc. Etiam non porta risus. Pellentesque lacinia eros at ante iaculis, sed aliquet ipsum volutpat. Suspendisse potenti.

Ut ultrices lectus sed sagittis varius. Nulla facilisi. Nullam tortor sem, placerat nec condimentum eu, tristique eget ex. Nullam pretium tellus ut nibh accumsan elementum. Aliquam posuere gravida tellus, id imperdiet nulla rutrum imperdiet. Nulla pretium ullamcorper quam, non iaculis orci consectetur eget. Curabitur non

1 laoreet nisl. Maecenas lacinia, lorem vel tincidunt cursus, odio lorem aliquet est,
2 gravida auctor arcu urna id enim. Morbi accumsan bibendum ipsum, ut maximus dui
3 placerat vitae. Nullam pretium ac tortor nec venenatis. Nunc non aliquet neque.

4 Itemize

- 5 • The first topic is dull
- 6 • The second topic is duller
 - 7 – The first subtopic is silly
 - 8 – The second subtopic is stupid
- 9 • The third topic is the dullest

10 Description

11 **The first topic** is dull

12 **The second topic** is duller

13 **The first subtopic** is silly

14 **The second subtopic** is stupid

15 **The third topic** is the dullest

2.2 Hidden section

Lorem ipsum dolor sit amet, *consectetur adipiscing elit*. In magna nisi, aliquam id blandit id, congue ac est. Fusce porta consequat leo. Proin feugiat at felis vel consectetur. Ut tempus ipsum sit amet congue posuere. Nulla varius rutrum quam. Donec sed purus luctus, faucibus velit id, ultrices sapien. Cras diam purus, tincidunt eget tristique ut, egestas quis nulla. Curabitur vel iaculis lectus. Nunc nulla urna, ultrices et eleifend in, accumsan ut erat. In ut ante leo. Aenean a lacinia nisl, sit amet ullamcorper dolor. Maecenas blandit, tortor ut scelerisque congue, velit diam volutpat metus, sed vestibulum eros justo ut nulla. Etiam nec ipsum non enim luctus porta in in massa. Cras arcu urna, malesuada ut tellus ut, pellentesque mollis risus. Morbi vel tortor imperdiet arcu auctor mattis sit amet eu nisi. Nulla gravida urna vel nisl egestas varius. Aliquam posuere ante quis malesuada dignissim. Mauris ultrices tristique eros, a dignissim nisl iaculis nec. Praesent dapibus tincidunt mauris nec tempor. Curabitur et consequat nisi. Quisque viverra egestas risus, ut sodales enim blandit at. Mauris quis odio nulla. Cras euismod turpis magna, in facilisis diam congue non. Mauris faucibus nisl a orci dictum, et tempus mi cursus.

Etiam elementum tristique lacus, sit amet eleifend nibh eleifend sed ¹. Maecenas dapibu augue ut urna malesuada, non tempor nibh mollis. Donec sed sem sollicitudin, convallis velit aliquam, tincidunt diam. In eu venenatis lorem. Aliquam non augue porttitor tellus faucibus porta et nec ante. Proin sodales, libero vitae commodo sodales, dolor nisi cursus magna, non tincidunt ipsum nibh eget purus. Nam rutrum tincidunt arcu, tincidunt vulputate mi sagittis id. Proin et nisi nec orci tincidunt auctor et porta elit. Praesent eu dolor ac magna cursus euismod. Integer non dictum nunc.

¹My footnote goes blah blah blah! ...



Fig. 2.2 Best Animations

Subplots

I can cite Wall-E (see Fig. 2.2b) and Minions in despicable me (Fig. 2.2c) or I can cite the whole figure as Fig. 2.2

Chapter 3

1

My third chapter

2

3.1 First section of the third chapter

3

And now I begin my third chapter here ...

4

And now to cite some more people Read [6], Ancy et al. [2]

5

3.1.1 First subsection in the first section

6

...and some more

7

3.1.2 Second subsection in the first section

8

...and some more ...

9

First subsub section in the second subsection

10

...and some more in the first subsub section otherwise it all looks the same doesn't it?

11

well we can add some text to it ...

12

3.1.3 Third subsection in the first section

13

...and some more ...

14

First subsub section in the third subsection

15

...and some more in the first subsub section otherwise it all looks the same doesn't it?

16

well we can add some text to it and some more and some more and some more and

17

some more and some more and some more and some more ...

18

1 Second subsub section in the third subsection

2 ...and some more in the first subsub section otherwise it all looks the same doesn't it?
3 well we can add some text to it ...

4 3.2 Second section of the third chapter

5 and here I write more ...

6 3.3 The layout of formal tables

7 This section has been modified from “Publication quality tables in L^AT_EX^{*}” by Simon
8 Fear.

9 The layout of a table has been established over centuries of experience and should
10 only be altered in extraordinary circumstances.

11 When formatting a table, remember two simple guidelines at all times:

12 1. Never, ever use vertical rules (lines).

13 2. Never use double rules.

14 These guidelines may seem extreme but I have never found a good argument in
15 favour of breaking them. For example, if you feel that the information in the left half
16 of a table is so different from that on the right that it needs to be separated by a
17 vertical line, then you should use two tables instead. Not everyone follows the second
18 guideline:

19 There are three further guidelines worth mentioning here as they are generally not
20 known outside the circle of professional typesetters and subeditors:

21 3. Put the units in the column heading (not in the body of the table).

22 4. Always precede a decimal point by a digit; thus 0.1 *not* just .1.

23 5. Do not use ‘ditto’ signs or any other such convention to repeat a previous value.

24 In many circumstances a blank will serve just as well. If it won't, then repeat
25 the value.

26 A frequently seen mistake is to use ‘\begin{center}’ ... ‘\end{center}’ inside a
27 figure or table environment. This center environment can cause additional vertical
28 space. If you want to avoid that just use ‘\centering’

Table 3.1 A badly formatted table

	Species I		Species II	
Dental measurement	mean	SD	mean	SD
I1MD	6.23	0.91	5.2	0.7
I1LL	7.48	0.56	8.7	0.71
I2MD	3.99	0.63	4.22	0.54
I2LL	6.81	0.02	6.66	0.01
CMD	13.47	0.09	10.55	0.05
CBL	11.88	0.05	13.11	0.04

Table 3.2 A nice looking table

Dental measurement	Species I		Species II	
	mean	SD	mean	SD
I1MD	6.23	0.91	5.2	0.7
I1LL	7.48	0.56	8.7	0.71
I2MD	3.99	0.63	4.22	0.54
I2LL	6.81	0.02	6.66	0.01
CMD	13.47	0.09	10.55	0.05
CBL	11.88	0.05	13.11	0.04

Table 3.3 Even better looking table using booktabs

Dental measurement	Species I		Species II	
	mean	SD	mean	SD
I1MD	6.23	0.91	5.2	0.7
I1LL	7.48	0.56	8.7	0.71
I2MD	3.99	0.63	4.22	0.54
I2LL	6.81	0.02	6.66	0.01
CMD	13.47	0.09	10.55	0.05
CBL	11.88	0.05	13.11	0.04

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