Tau Neutrinos in IceCube

Dissertation
zur Erlangung des akademischen Grades
doctor rerum naturalium
(Dr. rer. nat.)

im Fach: Physik
Spezialisierung: Experimentalphysik

eingereicht an der
Mathematisch-Naturwissenschaftlichen Fakultät
der Humboldt-Universität zu Berlin

von
Neha Lad M. Sc.
geboren am 18. April 1995

Präsidentin der Humboldt-Universität zu Berlin
Prof. Dr. Julia von Blumenthal

Dekanin der Mathematisch-Naturwissenschaftlichen Fakultät
Prof. Dr. Caren Tischendorf

Colophon
This document was typeset with the help of KOMA-Script and LaTeX using the open-source kaobook template class.

The source code of this thesis is available at:
https://github.com/LeanderFischer/phd_thesis

Abstract

In icecube, we have many neutrinos, select some very high energy ones, spend 1 year with them to group them in three flavour categories. I guess we will learn something about where they came from by doing this. Pretty normal stuff, not at all racist.

Zusammenfassung

Im IceCube haben wir viele Neutrinos, von denen wir einige mit sehr hoher Energie auswählen, verbringen 1 Jahr mit ihnen, um sie in drei Geschmackskategorien einzuteilen. Ich vermute, dass wir auf diese Weise etwas darüber erfahren, woher sie kommen. Ziemlich normales Zeug, ganz und gar nicht rassistisch.

Contents

Phenomenology of TeV Neutrinos | 1

The concept of the neutrino, initially called the "neutron," was first proposed by Pauli in 1930 [1] to explain the observed continuous energy spectrum in the beta decay process. Even 60 years after the first direct detection of neutrinos from nuclear reactors by Cowan and Reines [2], neutrinos are still the subject of intense experimental investigation, and many of their fundamental properties remain to be measured. This chapter details fundamental properties of Neutrinos in standard model, their interactions and other properties. Last section shall highlight properties and interactions assuming theories *Beyond Standard Model*.

[1]: Pauli (1978), *Dear radioactive ladies and gentlemen*

[2]: Reines et al. (1960), *Detection of the Free Antineutrino*

1.1 Neutrinos in Standard Model

1.1.1 Mass and Oscillations

1.1.2 Interactions

Interaction Cross-Sections

Neutrino-Nucleon Deep Inelastic Scattering

Glashow Resonance

Interaction Channels

Inelasticty

1.2 Beyond Standard Model Neutrinos

Appendix

List of Figures

List of Tables

Bibliography

Here are the references in citation order.

[1] W. Pauli. “Dear radioactive ladies and gentlemen”. In: *Phys. Today* 31N9 (1978), p. 27 (cited on page 1).

[2] F. Reines et al. “Detection of the Free Antineutrino”. In: *Phys. Rev.* 117 (1 Jan. 1960), pp. 159–173. DOI: 10.1103/PhysRev.117.159 (cited on page 1).