# MA4447 The Standard Model

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## Contents

Preface . . . . . 1

**1 Introduction** **1**
1.1 SM . . . . . 1

**2** **3**

# 1 Introduction

The Standard Model (SM) of elementary particle physics. Assignment during reading week worth 1/10th. There are things on the webpage www.maths.tcd.ie/ sint etc. look there for book list. SM is unchanged since 1978 so books from 89s are still ok to read:

- Griffiths
- Aitchinson and Hey
- Halzon and Martin
- D.H. Perkins, but this has emphasis on experimental techniques
- Peskin and Schroder QFT
- Bjorken and Drell, relativistic QM (vol1), QFT (vol2)
- Itzykson and Zuher, QFT

## 1.1 SM

- is the essence of 100 years of experiments and theoretical developments

- describes all experiments carried out to date with good to extremely high precision [1]
- Gravity is excluded in the SM

Phenomological argument for excluding gravity in microscopic physics.

$$F_G = G_N \frac{m_e}{r^2}$$

$$F_{Coulomb} = \frac{/abse^2}{r^2}$$

$$\frac{F_G}{F_{Coulomb}} = O^{-10}$$

SM can be specified by an action or a Lagrangian density

$$S_{SM} = \int d^4x L_{SM}(x)$$

$$\mathcal{L}_{SM}(x) = \mathcal{L}_{quarks}(x) + \mathcal{L}_{gauge}(x) + \mathcal{L}_{Higgs}(x) + \mathcal{L}_{Yukama}(x)$$

$$\mathcal{L}_{quarks}(x) = \sum_{i=1}^{3} \bar{\Psi}_{q_1}(x) \bar{D} \Psi_{q_1}(x)$$

$$\Psi_q = \begin{pmatrix} u \\ d \end{pmatrix}, \begin{pmatrix} c \\ s \end{pmatrix}, \begin{pmatrix} t \\ b \end{pmatrix} \bar{D} = \gamma_\mu D^{\mu 2} \in ofW^{\pm}, Z^0, \gamma$$

$$\mathcal{L}_{leptons}(x) = \sum_{i=1}^{3} \bar{\Psi}_{e_1} \bar{D} \Psi_{e_1}$$

$$\Psi_{e_1} = \begin{pmatrix} \nu_e \\ e^- \end{pmatrix}, \begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix}, \begin{pmatrix} \nu_\tau \\ e^- \end{pmatrix} \bar{D} \in ofasabovenogluons$$

$$\mathcal{L}_{gauge}(x) = -\frac{1}{4} \sum_{a=1}^{8} G^a_{\mu\nu} G^{a\mu\nu} - \frac{1}{4} \sum_{a=1}^{8} W^a_{\mu\nu} W^{a\mu\nu} - \frac{1}{4} B_{\mu\nu} B^{\mu\nu}$$

$$\mathcal{L}_{Higgs}(x) = D_\mu \Phi^+ D^\mu \Phi - V(\Phi) D_\mu elementofabove$$

$$\Phi = (verticalmatrix)(\Phi_1, \Phi_2), ofcomplexxcalrfields$$

$$\mathcal{L}_{Yukawa}(x) = \sum_{A,B=1}^{3} y^u_{AB} \bar{\Psi}_{q_A} P_L \Phi P_R (v, c, t)_B$$

[1] anamolous magnetic moment of muon good to $10^9$, though current experiments show neutrinos may have broken the temporal limit of the universe. A joke is: The barman says Sorry we dont serve neutrinos here, A neutrino walks into the bar, violition of causality

[2] covriant derivative

**2**

## List of Figures

## List of Tables