# Dark Matter in Compact Objects (TBD)

Michael Virgato
0000-0002-8396-0896

Submitted in total fulfilment
of the requirements of the degree of

Doctor of Philosophy

School of Physics
The University of Melbourne

XXX XXX

Produced on archival quality paper.

# Abstract

DM in COs Heat up Maybe See

# Publications

Refs. [2, 3, 5, 4, 1] below are the journal publications, and preprints authored or co-authored during my PhD candidature. The authors are listed alphabetically in all of the titles.

## Journal papers and preprints

[1] Papers

# Declaration

This is to certify that

1. the thesis comprises only my original work towards the PhD except where indicated in the preface;

2. due acknowledgement has been made in the text to all other material used;

3. the thesis is less than 100,000 words in length, exclusive of tables, maps, bibliographies and appendices.

---

Michael Virgato, XXX XXX

# Preface

We don't know what DM is. Can NSs constrain it?

# Acknowledgements

Why did I do this?

# Contents

# List of Figures

# List of Tables

# 1 Introduction

*Background on DM and its current status*

This is the intro. About DM and its current status

# 2

# Compact Objects for Particle Physics

*Introduce COs, formation, structure etc...*

# 3

# Dark Matter Capture in Celestion Bodies

*Review capture in the Sun, move to what's needed for COs in general, then specify to WDs (ions + electrons) and NS (interacting baryons)*

## 3.1 Capture in the Sun

## 3.2 Capture in Compact Objects

## 3.3 White Dwarfs

## 3.4 Neutron Stars

# 4

# Thermalisation in Compact Objects

*Go Over the full thermalisation process for WDs and Neutron Stars*

# 5
# Dark Matter Induced Heating

*DM kinetic and annihilation heating applied to NSs and WDs*

# 6 Conclusion

*Concluding remarks*

# A
# Kinematics

*Derivation of $E_f^{'}$ as needed for capture and other kinematics*

# Definition of Symbols and Abbreviations

$\boldsymbol{C}_{\text{geo}}$ Geometric Capture Rate

**DM** Dark Matter
$\boldsymbol{K}_{\chi}$ Dark Matter Kinetic Energy
$\boldsymbol{\rho}_{\chi}$ DM halo density
$\boldsymbol{m}_{\chi}$ Dark Matter Mass

**EFT** Effective Field Theory
**EoS** Equation of State

$\boldsymbol{f}_{\text{FD}}$ Fermi-Dirac Distribution
$\boldsymbol{\varepsilon}_{F,i}$ Fermi kinetic energy of target species

$\boldsymbol{|\overline{\mathcal{M}}|^2}$ Spin-averaged squared matrix element
$\boldsymbol{\mu}$ DM-Target mass ratio, $m_{\chi}/m_i$

**NS** Neutron Star

**PB** Pauli Blocking

**QMC** Quark-Meson-Coupling EoS

$\boldsymbol{\sigma_{\text{th}}}$ Threshold Cross Section

$\boldsymbol{T}_{\text{eq}}$ Equilibrium Temperature
$\boldsymbol{t}_{\text{eq}}$ Capture-Annihilation equilibrium time
$\boldsymbol{T}_{\star}$ Temperature of the star
$\boldsymbol{t}_{\text{therm}}$ Thermalisation time

$\boldsymbol{v}_d$ DM halo dispersion velocity
$\boldsymbol{v}_{\star}$ Star velocity

# Bibliography


[1] Filippo Anzuini et al. "Improved Treatment of Dark Matter Capture in Neutron Stars III: Nucleon and Exotic Targets". In: *JCAP* 11.11 (Nov. 29, 2021), p. 056. DOI: 10.1088/1475-7516/2021/11/056. arXiv: 2108.02525 [hep-ph].

[2] Nicole F. Bell et al. "Improved Treatment of Dark Matter Capture in Neutron Stars". In: *JCAP* 09 (Sept. 15, 2020), p. 028. DOI: 10.1088/1475-7516/2020/09/028. arXiv: 2004.14888 [hep-ph].

[3] Nicole F. Bell et al. "Improved Treatment of Dark Matter Capture in Neutron Stars II: Leptonic Targets". In: *JCAP* 03 (Mar. 26, 2021), p. 086. DOI: 10.1088/1475-7516/2021/03/086. arXiv: 2010.13257 [hep-ph].

[4] Nicole F. Bell et al. "Improved Treatment of Dark Matter Capture in White Dwarfs". In: *JCAP* 10 (Oct. 29, 2021), p. 083. DOI: 10.1088/1475-7516/2021/10/083. arXiv: 2104.14367 [hep-ph].

[5] Nicole F. Bell et al. "Nucleon Structure and Strong Interactions in Dark Matter Capture in Neutron Stars". In: *Phys. Rev. Lett.* 127.11 (Sept. 10, 2021), p. 111803. DOI: 10.1103/PhysRevLett.127.111803. arXiv: 2012.08918 [hep-ph].