

# Contents

|          |   |           |
|----------|---|-----------|
| <b>1</b> | <b>Introduction</b>   | <b>1</b>  |
| 1.1      | Theoretical background . . . . .                                | 3         |
| 1.1.1    | Foundations of quantum mechanics . . . . .                      | 3         |
| 1.1.2    | Interpretations of quantum mechanics . . . . .                  | 5         |
| 1.1.3    | Emergent quantum mechanics . . . . .                            | 8         |
| 1.2      | Goals . . . . .   | 10        |
| 1.3      | Prior work . . . . .  | 11        |
| 1.4      | Structure of the thesis . . . . .                               | 11        |
| <b>2</b> | <b>Schroedinger vs. Navier-Stokes</b>                           | <b>13</b> |
| 2.1      | Introduction . . . . .  | 13        |
| 2.2      | The physics of Navier–Stokes from Schroedinger . . . . .        | 17        |
| 2.2.1    | Computation of the viscosity . . . . .                          | 17        |
| 2.2.2    | Viscous states <i>vs.</i> dissipation–free states . . . . .     | 19        |
| 2.2.3    | The ratio of viscosity to entropy density . . . . .             | 22        |
| 2.2.4    | Nonstationary states: emergent reversibility . . . . .          | 24        |
| 2.2.5    | Stationary states: emergent holography . . . . .                | 25        |
| 2.3      | Discussion . . . . .  | 26        |
| <b>3</b> | <b>The Holographic Quantum</b>                                  | <b>29</b> |
| 3.1      | Introduction . . . . .  | 29        |
| 3.2      | Basics in irreversible thermodynamics . . . . .                 | 31        |
| 3.3      | Quantum mechanics vs. irreversible thermodynamics . . . . .     | 35        |
| 3.4      | Beyond the harmonic approximation . . . . .                     | 38        |
| 3.5      | Quantum states as equivalence classes of classical trajectories | 40        |
| 3.6      | Quantum uncertainty <i>vs.</i> the second law . . . . .         | 45        |

|          |   |           |
|----------|---|-----------|
| 3.7      | Discussion . . . . .  | 46        |
| <b>4</b> | <b>Entropy, topological theories and emergent quantum mechanics</b> | <b>49</b> |
| 4.1      | Motivation . . . . .  | 49        |
| 4.2      | A quasistatic mechanics . . . . .                                   | 51        |
| 4.3      | The thermostatics dual to quasistatic mechanics . . . . .           | 52        |
| 4.4      | The quasistatic mechanics dual to thermostatics . . . . .           | 53        |
| 4.4.1    | The ideal gas . . . . .   | 53        |
| 4.4.2    | Motion along isoentropic surfaces . . . . .                         | 55        |
| 4.4.3    | Motion across isoentropic surfaces . . . . .                        | 56        |
| 4.4.4    | A metric free entropy . . . . .                                     | 59        |
| 4.4.5    | The quantum mechanical partition function . . . . .                 | 59        |
| 4.5      | Conclusions and outlook . . . . .                                   | 60        |
| <b>5</b> | <b>Conclusion</b>   | <b>63</b> |