

## Recommended References by Project

Supplementary reading list for MSc projects in Complementary Quantum Mechanics. The official course bibliography is used as the common foundation where relevant; the references below add project-specific textbooks, reviews and selected original papers.

### Project 1. Quantum Algorithms: Interference as Computation

#### Main References:

- M.A. Nielsen & I.L. Chuang, \*Quantum Computation and Quantum Information\* (Cambridge University Press).
- N.D. Mermin, \*Quantum Computer Science: An Introduction\* (Cambridge University Press).

#### Supplementary References:

- L.K. Grover, "Quantum mechanics helps in searching for a needle in a haystack," \*Phys. Rev. Lett.\* 79, 325 (1997).
- Cohen-Tannoudji, Diu & Laloë, \*Quantum Mechanics\* — for two-level systems, unitary evolution and measurement.

**Level:** Intermediate

### Project 2. Quantum Cryptography: Detecting an Eavesdropper

#### Main References:

- M.A. Nielsen & I.L. Chuang, \*Quantum Computation and Quantum Information\* (Cambridge University Press).
- V. Scarani et al., "The security of practical quantum key distribution," \*Rev. Mod. Phys.\* 81, 1301 (2009).

#### Supplementary References:

- C.H. Bennett & G. Brassard, "Quantum cryptography: Public key distribution and coin tossing," Proc. IEEE Int. Conf. on Computers, Systems and Signal Processing, Bangalore, 175–179 (1984).
- N. Gisin et al., "Quantum cryptography," \*Rev. Mod. Phys.\* 74, 145 (2002).

**Level:** Intermediate

### Project 3. Bell Inequalities: Quantum Correlations Beyond Local Hidden-Variable Models

#### Main References:

- J.S. Bell, \*Speakable and Unspeakable in Quantum Mechanics\* (Cambridge University Press).
- N. Brunner et al., "Bell nonlocality," \*Rev. Mod. Phys.\* 86, 419 (2014).

#### Supplementary References:

- J.F. Clauser, M.A. Horne, A. Shimony & R.A. Holt, "Proposed experiment to test local hidden-variable theories," \*Phys. Rev. Lett.\* 23, 880 (1969).
- M.A. Nielsen & I.L. Chuang, \*Quantum Computation and Quantum Information\* — sections on entanglement and Bell inequalities.

**Level:** Intermediate

### Project 4. Symmetries and Conservation Laws: Hidden Symmetry in the Hydrogen Atom

#### Main References:

- W. Greiner & B. Müller, \*Quantum Mechanics: Symmetries\* (Springer-Verlag).
- V. Heine, \*Group Theory in Quantum Mechanics\*.

#### Supplementary References:

- M. Bander & C. Itzykson, "Group Theory and the Hydrogen Atom (I)," \*Rev. Mod. Phys.\* 38, 330 (1966).
- J.P. Elliott & P.G. Dawber, \*Symmetry in Physics\* (Oxford University Press).

**Level:** Advanced

### **Project 5. Angular Momentum, $SO(3)$ and $SU(2)$ : Why Does a $2\pi$ Rotation Change the Sign of a Spinor?**

**Main References:**

- D.M. Brink & G.R. Satchler, \*Angular Momentum\* (Clarendon Press).
- A.R. Edmonds, \*Angular Momentum in Quantum Mechanics\* (Princeton University Press).

**Supplementary References:**

- V. Heine, \*Group Theory in Quantum Mechanics\*.
- Cohen-Tannoudji, Diu & Laloë, \*Quantum Mechanics\* — angular momentum, spin and addition of angular momenta.

**Level:** Intermediate

### **Project 6. The Helium Atom: Exchange Symmetry and the Two-Electron Spectrum**

**Main References:**

- Cohen-Tannoudji, Diu & Laloë, \*Quantum Mechanics\* — identical particles, perturbation and variational methods.
- B.H. Bransden & C.J. Joachain, \*Physics of Atoms and Molecules\* (Pearson).

**Supplementary References:**

- A.S. Davydov, \*Quantum Mechanics\* — approximate methods and two-electron systems.
- H.A. Bethe & E.E. Salpeter, \*Quantum Mechanics of One- and Two-Electron Atoms\* (Springer).

**Level:** Intermediate

### **Project 7. Van der Waals Forces: Why Do Neutral Atoms Attract?**

**Main References:**

- Cohen-Tannoudji, Diu & Laloë, \*Quantum Mechanics\* — stationary perturbation theory.
- A.J. Stone, \*The Theory of Intermolecular Forces\*, 2nd ed. (Oxford University Press).

**Supplementary References:**

- B.H. Bransden & C.J. Joachain, \*Physics of Atoms and Molecules\*.
- A.S. Davydov, \*Quantum Mechanics\* — perturbative treatment of intermolecular interactions.

**Level:** Intermediate

### **Project 8. Molecules and Chemical Bonds: Why Is $H_2$ Strongly Bound while $He_2$ Is Only Weakly Bound?**

**Main References:**

- P.W. Atkins & R.S. Friedman, \*Molecular Quantum Mechanics\* (Oxford University Press).
- B.H. Bransden & C.J. Joachain, \*Physics of Atoms and Molecules\*.

**Supplementary References:**

- Cohen-Tannoudji, Diu & Laloë, \*Quantum Mechanics\* — identical particles and approximation methods.
- A.J. Stone, \*The Theory of Intermolecular Forces\* — for the weak long-range binding of  $He_2$ .

**Level:** Intermediate

### **Project 9. Spin and Statistics: From the Pauli Principle to Degenerate Matter**

**Main References:**

- Cohen-Tannoudji, Diu & Laloë, \*Quantum Mechanics\* — identical particles and permutation symmetry.
- F. Schwabl, \*Advanced Quantum Mechanics\* (Springer-Verlag).

**Supplementary References:**

- S.L. Shapiro & S.A. Teukolsky, \*Black Holes, White Dwarfs, and Neutron Stars\* (Wiley) — electron degeneracy in compact stars.

- L.D. Landau & E.M. Lifshitz, \*Statistical Physics, Part 1\* — ideal Fermi gas and degeneracy.

**Level:** Intermediate

### **Project 10. Bose–Einstein Condensation in Trapped Gases: Macroscopic Matter Waves**

**Main References:**

- C.J. Pethick & H. Smith, \*Bose–Einstein Condensation in Dilute Gases\* (Cambridge University Press).
- L.P. Pitaevskii & S. Stringari, \*Bose–Einstein Condensation and Superfluidity\* (Oxford University Press).

**Supplementary References:**

- F. Dalfovo, S. Giorgini, L.P. Pitaevskii & S. Stringari, “Theory of Bose-Einstein condensation in trapped gases,” \*Rev. Mod. Phys.\* 71, 463 (1999).
- Cohen-Tannoudji, Diu & Laloë, \*Quantum Mechanics\* — bosons and identical-particle states.

**Level:** Intermediate

### **Project 11. Second Quantisation: From Fock States to Two-Photon Interference**

**Main References:**

- F. Schwabl, \*Advanced Quantum Mechanics\* (Springer-Verlag) — second quantisation and Fock-space methods.
- R. Loudon, \*The Quantum Theory of Light\* (Oxford University Press).

**Supplementary References:**

- C.K. Hong, Z.Y. Ou & L. Mandel, “Measurement of subpicosecond time intervals between two photons by interference,” \*Phys. Rev. Lett.\* 59, 2044 (1987).
- C. Cohen-Tannoudji, J. Dupont-Roc & G. Grynberg, \*Photons and Atoms: Introduction to Quantum Electrodynamics\* (Wiley).

**Level:** Intermediate

### **Project 12. Atomic Transitions and Stellar Spectral Lines: Reading Quantum Mechanics in Starlight**

**Main References:**

- Cohen-Tannoudji, Diu & Laloë, \*Quantum Mechanics\* — time-dependent perturbation theory and angular momentum.
- I.I. Sobelman, \*Atomic Spectra and Radiative Transitions\* (Springer).

**Supplementary References:**

- G.B. Rybicki & A.P. Lightman, \*Radiative Processes in Astrophysics\* (Wiley).
- B.H. Bransden & C.J. Joachain, \*Physics of Atoms and Molecules\*.

**Level:** Intermediate

### **Project 13. Microscopic Origin of Stellar Opacity: From Atomic Cross Sections to Radiation Transport**

**Main References:**

- G.B. Rybicki & A.P. Lightman, \*Radiative Processes in Astrophysics\* (Wiley).
- I. Hubeny & D. Mihalas, \*Theory of Stellar Atmospheres\* (Princeton University Press).

**Supplementary References:**

- I.I. Sobelman, \*Atomic Spectra and Radiative Transitions\*.
- Cohen-Tannoudji, Diu & Laloë, \*Quantum Mechanics\* — transition probabilities and continuum states.

**Level:** Advanced

### **Project 14. Hyperfine Structure and the 21-cm Hydrogen Line: Mapping Invisible Hydrogen**

**Main References:**

- C.J. Foot, \*Atomic Physics\* (Oxford University Press).

- B.T. Draine, *\*Physics of the Interstellar and Intergalactic Medium\** (Princeton University Press).

#### **Supplementary References:**

- S.R. Furlanetto, S.P. Oh & F.H. Briggs, “Cosmology at low frequencies: The 21 cm transition and the high-redshift Universe,” *\*Phys. Rep.\** 433, 181 (2006).
- Cohen-Tannoudji, Diu & Laloë, *\*Quantum Mechanics\** — addition of angular momenta and magnetic interactions.

**Level:** Intermediate

### **Project 15. Zeeman Effect and Stellar Magnetic Fields: Measuring a Magnetic Field from a Spectral Line**

#### **Main References:**

- I.I. Sobelman, *\*Atomic Spectra and Radiative Transitions\** (Springer).
- Cohen-Tannoudji, Diu & Laloë, *\*Quantum Mechanics\** — angular momentum and perturbations by magnetic fields.

#### **Supplementary References:**

- E. Landi Degl’Innocenti & M. Landolfi, *\*Polarization in Spectral Lines\** (Kluwer Academic Publishers).
- C.J. Foot, *\*Atomic Physics\**.

**Level:** Intermediate

### **Project 16. Neutrino Oscillations in Vacuum and Matter: The Solar Neutrino Problem**

#### **Main References:**

- C. Giunti & C.W. Kim, *\*Fundamentals of Neutrino Physics and Astrophysics\** (Oxford University Press).
- L. Wolfenstein, “Neutrino oscillations in matter,” *\*Phys. Rev. D\** 17, 2369 (1978).

#### **Supplementary References:**

- S.P. Mikheyev & A.Yu. Smirnov, “Resonance amplification of oscillations in matter and spectroscopy of solar neutrinos,” *\*Sov. J. Nucl. Phys.\** 42, 913 (1985).
- Cohen-Tannoudji, Diu & Laloë, *\*Quantum Mechanics\** — two-level systems and time evolution.

**Level:** Advanced

### **Project 17. Superfluidity and Quantised Vortices: How Does a Superfluid Respond to Rotation?**

#### **Main References:**

- C.J. Pethick & H. Smith, *\*Bose–Einstein Condensation in Dilute Gases\** (Cambridge University Press).
- L.P. Pitaevskii & S. Stringari, *\*Bose–Einstein Condensation and Superfluidity\** (Oxford University Press).

#### **Supplementary References:**

- A.L. Fetter, “Rotating trapped Bose-Einstein condensates,” *\*Rev. Mod. Phys.\** 81, 647 (2009).
- A.J. Leggett, *\*Quantum Liquids\** (Oxford University Press).

**Level:** Advanced

### **Project 18. Quantum Phase Transitions in Optical Lattices: Superfluid or Mott Insulator?**

#### **Main References:**

- S. Sachdev, *\*Quantum Phase Transitions\** (Cambridge University Press).
- I. Bloch, J. Dalibard & W. Zwerger, “Many-body physics with ultracold gases,” *\*Rev. Mod. Phys.\** 80, 885 (2008).

#### **Supplementary References:**

- M. Lewenstein et al., “Ultracold atomic gases in optical lattices: Mimicking condensed matter physics and beyond,” *\*Adv. Phys.\** 56, 243 (2007).

- C.J. Pethick & H. Smith, *\*Bose–Einstein Condensation in Dilute Gases\** — optical lattices and interacting condensates.

**Level:** Advanced

### **Project 19. Cooper Pairing and the Origin of Superconductivity: Why Does Weak Attraction Matter at the Fermi Surface?**

**Main References:**

- M. Tinkham, *\*Introduction to Superconductivity\** (Dover).
- L.N. Cooper, “Bound electron pairs in a degenerate Fermi gas,” *\*Phys. Rev.\** 104, 1189 (1956).

**Supplementary References:**

- J.R. Schrieffer, *\*Theory of Superconductivity\** (Westview Press).
- F. Schwabl, *\*Advanced Quantum Mechanics\** — many-fermion methods and second quantisation.

**Level:** Advanced

### **Project 20. Casimir Effect: From Quantised Electromagnetic Modes to a Measurable Force**

**Main References:**

- P.W. Milonni, *\*The Quantum Vacuum: An Introduction to Quantum Electrodynamics\** (Academic Press).
- M. Bordag, G.L. Klimchitskaya, U. Mohideen & V.M. Mostepanenko, *\*Advances in the Casimir Effect\** (Oxford University Press).

**Supplementary References:**

- S.K. Lamoreaux, “Demonstration of the Casimir force in the 0.6 to 6  $\mu\text{m}$  range,” *\*Phys. Rev. Lett.\** 78, 5 (1997).
- C. Cohen-Tannoudji, J. Dupont-Roc & G. Grynberg, *\*Photons and Atoms: Introduction to Quantum Electrodynamics\**.

**Level:** Advanced

### **Project 21. Quantum Scattering Resonances and Ramsauer–Townsend Transparency**

**Main References:**

- J.R. Taylor, *\*Scattering Theory: The Quantum Theory of Nonrelativistic Collisions\** (Dover).
- B.H. Bransden & C.J. Joachain, *\*Physics of Atoms and Molecules\** — electron-atom scattering and phase shifts.

**Supplementary References:**

- L.D. Landau & E.M. Lifshitz, *\*Quantum Mechanics: Non-Relativistic Theory\** — partial-wave scattering.
- Cohen-Tannoudji, Diu & Laloë, *\*Quantum Mechanics\** — scattering theory and phase shifts.

**Level:** Intermediate

### **Project 22. Isospin and SU(2): Why Do Proton and Neutron Form an Isospin Doublet?**

**Main References:**

- W. Greiner & B. Müller, *\*Quantum Mechanics: Symmetries\** (Springer-Verlag).
- J.P. Elliott & P.G. Dawber, *\*Symmetry in Physics\** (Oxford University Press).

**Supplementary References:**

- V. Heine, *\*Group Theory in Quantum Mechanics\**.
- D. Griffiths, *\*Introduction to Elementary Particles\** (Wiley) — isospin and hadron multiplets.

**Level:** Intermediate