

Quantum Optics, IPT5340

Time: M3M4W4 (10:10-12:00, Monday, and 11:10-12:00, Wednesday), at Room 202, Delta Hall

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- **Text Book:** D.F. Walls and G.J. Milburn, "*Quantum Optics*", 2nd Ed. Springer (2008). (*e-book* in NTHU library)

- **References:**

1. M.O. Scully, and M.S Zubairy, "*Quantum Optics*", Cambridge (1997).
2. Y. Yamamoto and A. Imamoglu, "*Mesoscopic Quantum Optics*", Wiley (1999).
3. C. C. Gerry and P. L. Knight, "*Introductory Quantum Optics*," Cambridge (2005).
4. M. Fox, "*Quantum Optics, an introduction*," Oxford (2006).
5. U. Leonhardt, "*Essential Quantum Optics*," Cambridge (2010).

- **Teaching Method:**

in-class lectures with discussions and assignments.

- **Expected Outputs:**

- Quantum properties of Electromagnetic Fields;
- Non-classical light and its generation, measurement, and applications;
- Interaction between photon-atoms;
- Test of Quantum Mechanics by Optics;

- **Syllabus:**

1. Quantization of Electromagnetic Fields: 3 weeks, 9/19, 9/21, 9/26, 10/03, 10/05,
 - Normal modes in Maxwell's equation, (§ 2.1)
 - Simple Harmonic Oscillator and Number States, (§ 2.2)
 - Uncertainty Relations in Quantum Mechanics,
 - Coherent States, (§ 2.3)
 - Squeezed States, (§ 2.4)
 - Two-photon Coherent States, (§ 2.5)
 - Multimode Squeezed States, (§ 2.7)
2. Statistics and Coherent Properties of Electromagnetic Fields: 2 weeks, 10/12, 10/17, 10/19, 10/24,
 - Field Correlation Functions, (§ 3.1, 3.2, 3.3)
 - First-order Correlation Functions and Optical Coherence, (§ 3.4,3.5, 3.6, 3.7)
 - Photon Counting Measurements (§ 3.9)
 - Photon Statistics,
 - Second-order Correlation Functions and Photon Anti-bunching (§ 3.10),
 - Quasi-propability distributions (§ 4.1, 4.2)
3. Quantum Phenomena in Nonlinear Optics: 2 weeks, 10/26, 10/31, 11/02, 11/07,
 - Degenerate Parametric Amplifier, (§ 5.1)
 - Non-degenerate Parametric Amplifier, (§ 5.2)
4. **Mid-term Exam: 11/09**, (Chapters: 2-5 in the textbook)

5. Stochastic Methods: 1 weeks, 11/14, 11/16
 - Master Equation, (§ 6.1)
 - Fokker-Planck Equations, (§ 6.2)
 - Stochastic Differential Equations, (§ 6.3)
6. Optical Cavities and Generation of Squeezed Light: 2 weeks, 11/21, 11/23, 11/28, 11/30
 - Input-Output formulation of Optical Cavity, (§ 7)
 - Parametric Oscillation and Second Harmonic Generation, (§ 8.1)
7. Atom-Photon Interactions: 3 weeks, 12/05, 12/07, 12/12, 12/14, 12/19, 12/21
 - Quantization of Many-Electron System, (§ 10.1)
 - Interaction of a Single Two-Level Atom (§ 10.2)
 - Spontaneous Emission from a Two-Level Atom (§ 10.3)
 - Resonance Fluorescence (§ 10.4)
 - Cavity QED, (§ 11.1)
 - Circuit QED, (§ 11.2)
8. Test of quantum mechanics: 12/26, 12/28
 - Bell's Inequalities in Quantum Optics (§ 13)
 - Quantum Information (§ 16)
9. **Take-home Exam Report: 1/04**, (Chapters: 6-8, 10, 11, 13, 16 in the textbook)

• **Evaluation:**

1. Homework: 40%
2. Mid-term Exam on 11/09,: 30%
3. Take-home Exam Report on 1/04: 30%

• **Class suspended:**

~~9/14~~ (Setp. 14th, Mid-Autumn Festival), ~~9/28~~ (Sep. 28th, Teacher's Day), ~~10/10~~ (Oct. 10th, National Day), ~~1/02~~ (Jan. 2nd, New Year's Day);

• **Office hours:** 15:00-17:00, Monday, at Room 911, Delta Hall

• **More information:**

iLMS

<http://mx.nthu.edu.tw/~rkleee>

The field of quantum optics has made a revolution on modern physics, from laser, precise measurement, Bose-Einstein condensates, quantum information process, to the fundamental issues in quantum mechanics. Through this course, I want to provide an in-depth and wide-ranging introduction to the fundamental concepts for quantum optics, including physical concepts, mathematical methods, simulation techniques, basic principles and applications. Teaching Method: in-class lectures with discussion and project studies.

IPT5340, Spring 2009 p. 2/35. Reference Books. [Textbook]: D. F. Walls and Gerard J. Milburn, "Quantum Optics," 2nd Ed. Springer (2008); 1st Ed. (1993). Marlan O. Scully and M. Suhail Zubairy, "Quantum Optics," Cambridge (1997).