ECE 770 T14/ QIC 885: Quantum Electronics & Photonics

Lecture 5

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Abstract and Objectives of Lecture 5

This lecture consists of three parts; First we will talk about the generalized statistical interpretation in QM, followed by notes in commutator algebra and generalized uncertainty principle or Heisenberg uncertainty. Summing up all the concepts and tools, the postulates of QM are stated and discussed in detail. Some important notes about the state vectors in composite systems, such as entangled states are elaborated, and by introducing the concepts of a density operator, the formal treatment of quantum dynamics is presented. We will discuss three types of representations that take care of time evolution in QM, where the Hamiltonian is explicitly time-dependent. Schrodinger, Heisenberg and Dirac (Interaction) Pictures will specifically discussed. In the second part we review Lagrangian and Hamiltonian mechanics based on the principle of least action. By introducing the Poisson bracket, we formally establish a connection between QM and CM. Since QM is more general than CM, we will talk about CM as a limiting case of QM and correspondence principle proposed by N. Bohr. Finally, the quantization problem is addressed. We will introduce some techniques to do the quantization and mention about probable pitfalls.

Topics of Lecture 5

3-12-2 Properties of Tensor Product

3-12-3 Entangled States

3-13 Density Operator

3-14 Quantum Dynamics

3-15 Schrodinger Picture & Density Operator

3-16 Heisenberg Picture & equation of Motion

3-17 Dirac (Interaction) Picture

3-18 Connection between Quantum Mechanics & Classical Mechanics

3-18-1 Principles of Least Action & Lagrangian Mechanics

3-18-2 Hamiltonian Mechanics

3-18-3 System's Dynamics in Hamiltonian & Quantum Mechanics

3-18-4 Quantization

3-19 Correspondence Principle

References & Suggested Readings

1-D. Marcuse, *Principles of Quantum Electronics*, Ap, 1980, Chapter 1.

2- R. Shankar, *Principles of Quantum Mechanics*, 2^{nd}*ed.*, Springer, 1994, Chapter 2.

3- A.F.J. Levi, *Applied Quantum Mechanics*, 2^{nd}*ed.*, Cambridge Press, 2006, Chapter 6.

4- D.J. Griffith, *Introduction to Quantum Mechanics*, 2^{nd} ed., PH, 2005, Section 2.3.

5- N. Zettili, *Quantum Mechanics, Concepts and Applications*, JW&S, 2001, Chapter 3, and Sections 10.1 and 10.2.

6- J. Emerson, *Open Quantum Systems*, U. Waterloo, AMATH 876, Winter 2009

7- A. Peres, *Quantum Theory, Concepts and Methods*, AP, 1995.

8- D.A.B. Miller, *Quantum Mechanics for Scientists and Engineers*, Cambridge, 2008, chapter 14.