ECE770 T14/ QIC 885: Quantum Electronics & Photonics

Lecture 8

University of Waterloo, Instructor: A. H. Majedi, Winter 2013

Abstract and Objectives of Lecture 8

This lecture deals with a discussion of many-body system, as a system with a large number of either distinguishable or indistinguishable objects. We start by description of two-object system, introducing the concept of indistinguishability in quantum mechanics. Fermions and Bosons are introduced as two classes of the identical objects in quantum mechanics. We then discuss a purely quantum phenomenon known as exchange interaction for identical indistinguishable objects. Quantum statistical mechanics is briefly introduced to find the statistics of the large number of Fermions and Bosons. Our main task will be finding the probability of state occupancy by distinguished, and identical indistinguishable objects, e.g. fermion and boson objects. We then discuss the occupation number representation in the language of second quantization where the particle-like characters, such as numbering are associated with a wave-like behavior of the object and construct the creation and annihilation operators for fermions and bosons; Putting the first and second quantization together we introduce the important concept of field operators; the main ingredient of quantum field theory for many body systems.

Topics of Lecture 8

6) Identical Objects & Quantum Statistics

6-1) Two-Object System

6-2) Fermions and Bosons

6-3) Exchange Interaction

6-4) Quantum Statistical Mechanics

6-5) Occupation Number Representation

6-6) Operators in Occupation Number Representation

6-7) Field Operators

References & Suggested Readings

1-D.J. Griffith, *Introduction to Quantum Mechanics*, 2^{nd} ed., PH, 2005, section 5-4.

2- H. Kroemer, *Quantum Mechanics: For engineering, material sciences and applied physics*, JWS, 1994, Capter22.

3- A. Yariv,*An Introduction to Theory and Applications of Quantum Mechanics*, JW& S, 1982, Chapters 15 &16.

4- H. Bruus, K. Flensburg, *Many-Body Quantum Theory in Condensed Matter Physics*, Oxford Graduate Text, 2004, Chapter 1.

5- A. Atland, and B. Simons, *Condensed Matter Field Theory*, 2^{nd} edition, Cambridge, 2010.