ECE 770 T14/QIC 885: Quantum Electronics & Photonics

Lecture 7

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Abstract and Objectives of Lecture 7

In the first part of the lecture, we introduce the quantization of intrinsic angular momentum for electrons or spins and show how spin of electron can be described by spinor formalism and commutation properties similar to angular momentum.

In the second part of the lecture, we formulate the SE in the presence of EM field that is described by the potential fields. The concept of field momentum is introduced in light of Hamiltonian dynamics of EM interaction with a single quantum object. Four applications will be discussed starting by the description of quantized energy levels of the free electron in a uniform magnetic field when the spin of electron is ignored. The same problem will be addressed when the electron is bound by the presence of a spherically-symmetric potential. The quantum dynamics of these systems will be discussed. These two problems will be briefly studied when the spin of the electron is considered. We will then continue this section by studying the implication of the EM field gauge transformation on the double slit experiments and its immediate consequence resulting in the Aharonov-Bohm effect. In conclusion, the first quantization method of a single elementary object is formally established and some concluding remarks will be made.

Topics of Lecture 7

4-6) Electron Spin

5-1) Schrodinger Equation in the Presence of EM Field

5-2) Free-electron in Uniform Magnetic Field (Spinless case)

5-3) Bound Electron By A Central Potential in Uniform Magnetic Field (Spinless case)

5-4) Free-electron in Uniform Magnetic Field (With Spin)

5-5) Pauli-Schrodinger Equation

5-6) Gauge Transform and Aharonov-Bohm Effect

5-7) First Quantization & Concluding Remarks

References & Suggested Readings

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

2-A.F.J. Levi, *Applied Quantum Mechanics*, 2^{nd}*ed.*, Cambridge Press, 2006, Chapter 11.

3- H. Kroemer, *Quantum Mechanics: For engineering, material sciences and applied physics*, JWS, 1994, Chapters 18 and 21.

4- Greiner, *Quantum Mechanics, An Introduction*, 4^{th}*ed.*, Springer, 2001, Chapter 12.

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