Physics GR6037 Professor Christ

12/09/2019

Tentative Schedule and Suggested Reading

I Fundamentals			
A	**Theory of Measurement** 1. position and momentum space 2. Hilbert space 3. projection operators 4. eigenvalues and eigenvectors 5. continuous spectrum and resolution of the identity	• Baym: Ch. 3 (Ch 1. and 2. would good too) • G&Y: Ch. 2.1 and 2.2 • Lorch is a readable and short math book • Wikipedia discussion of hermitian and self-adjoint operators • Lorch, Reisz and Nagy and the Wikipedia article all discuss resolutions of the identity	*Sep 4, 9, 16*
B	**Commutation and Uncertainty Relations** 1. Gaussian wave functions 2. $[x_{\mathbf{op}}, p_{\mathbf{op}}] = i\hbar$ and the uncertainty principle 3. thought experiments	• G&Y Ch. 2.3 • Einstein-Bohr debates: Wikipedia	*Sep 18, 20*
C	**Time Development** 1. Translations in space 2. Translations in time and the Schrödinger equation 3. Canonical quantization	• Baym: Ch. 5 • G&Y: Ch. 2.3, 2.4 and 2.5 • Useful to review classical Hamiltonian mechanics, perhaps in Goldstein: - Hamilton's equations, p 215 - Cannonical transformations, p 237	*Sep 20, 23*
D	**Simple Harmonic Oscillator** 1. Eigenstates and eigenvalues of H 2. Coherent states	• Baym: Ch 4 • G&Y Ch 4.2 (a)-(d) • Power series solution: Schiff: pp 60-65	*Sep 25, 30,*
E	**Semiclassical Limit. (WKB method)** 1. propagating solutions 2. stationary phase approx. 3. Hamilton Jacobi theory 4. connection formulae a) Airy equation b) Stokes phenomena 5. Tunneling 6. 1-dimensional bound states	• G&Y Ch 4.5 • J. Heading • Goldstein: Ch 9 • Bender and Orszag: Ch 6.5, 6.6 • Understanding solutions to the Hamilton-Jacobi equations: Courant and Hilbert V II. Section II.	*Oct 2, 7, 11*

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II Applications		
A **Angular momentum** 1. Rotations, $O(3)$ and $SO(3)$ 2. Geometry of $SO(3)$ 3. Generators of $SO(3)$ 4. Spin-1/2 and $SU(2)$ 5. Spherical harmonics	• Baym: Ch 6, Ch 14. • G&Y: Ch 2.5, 3.1-3.4 • The topology of $SO(3)$: Wikipedia • General group theory: Hamermesh, Chevalley	*Oct 11, 14, 16, 21*
B **α decay**	• Mentioned in Shankar: Ch. 16.2	*Oct 23, 28*
C **Hydrogen atom** Summary of hydrogen bound states.	• G&Y: Ch. 5.1-5.2 • Baym: Ch. 7	*Oct 30*
D **Magnetic field and vector potential** 1. Local gauge symmetry 2. Magnetic monopoles 3. Aharonov-Bohm effect	• Wikipedia discussion: "Mathematical formulation" • G&Y: Ch 4.3.d, p 196	*Oct 30, Nov 11*
Midterm		**Nov 6**
E **Hydrogen atom with $\vec{B}$** 1. Size of $\vec{A}^2$ term 2. Van Leewen's theorem 2. Energy from orbital and spin magnetic moments	• G&Y: Ch 5.4 • Baym: Ch 14 • Huang: problem 7.4 and Sec 11.3	*Nov 11*
III Perturbation Theory		
A **Perturbation theory (non-degenerate)** 1. Rayleigh-Schrodinger 2. Wigner-Brillouin 3. He atom electron-electron interaction 4.He ionization energy & variational method	• Baym: Ch 11 • G&Y: Ch 3.7(a) • Baym. pp. 242-244, G&Y: Ch 3.7(e)	*Nov 11, 13, 18*
B **Perturbation theory (degenerate)** 1. 1st and 2nd order 2. Stark effect in Hydrogen 3. Polar molecules	• Notes posted on the class website • G&Y: Ch 3.7(b) • Baym: pp 231-234 • G&Y: p 260 (complicated by inclusion of fine structure)	*Nov 25, Dec 2,*

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IV Relativistc corrections to Hydrogen		
A. Coupling angular momenta 1. Spin-orbit coupling 2. Tensor products 3. Decomposing products states $\|j_1, m_1\rangle \otimes \|j_2, m_2\rangle$	• Baym: Ch 15 • G&Y: Ch 3.5	*Dec 2, 4*
B. Fine structure of Hydrogen 1. Relativistic kinetic energy 2. Thomas precession 3. Spin-orbit coupling	• G&Y: Ch 5.3	*Dec 9*