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MILESTONES OF THE LECTURES IN ADVANCED ELECTRO-DYNAMICS LECTURES PART I

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- LAGRANGIAN AND HAMILTONIAN IN E.D.
- DERIVING THE FUNDAMENTAL LAWS OF E.D. FROM THE HAMILTON PRINCIPLE
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 - CONTINUUM DISTRIBUTION OF CHARGES AND CURRENTS
 - DEDUCING THE MAXWELL EQS FROM THE FIELD LAGRANGIAN
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- FROM CLASSICAL DYNAMICS TO Q.M. OF A CHARGE IN AN E.M. FIELD
- H ATOM IN A MAGNETIC FIELD (A CLASSICAL DESCRIPTION)
- ZEEMAN EFFECT: A CLASSICAL DESCR.

- HAMILTONIAN OF A CHARGE AND GAUGE INVARIANCE.
- THE ANOMALOUS-BOHM EFFECT AS A CONSEQUENCE OF THE GAUGE INVARIANCE.
- FREE ELECTRONS IN A MAGNETIC FIELD; THE LANDAU LEVELS. (A Q.M. DESCRIPTION)
- HALL EFFECT AND QUANTUM-HALL EFFECTS

PART II

- FROM THE BLACK-BODY RADIATION TO THE FERMI GOLDEN RULE
- CLASSICAL BLACK-BODY
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 - WIEN LAW
 - STEFAN-BOLTZMANN LAW
- THE RAYLEIGHT-JEANS LAW AS A RESULT OF STATISTICAL MECHANICS AND CLASSICAL E.D.
- CONCEPT AND DEFINITION OF E.M. CAVITY AND CAVITY MODES. THE RESONANT CONDITIONS.
- RECIPROCAL SPACE AND DENSITY OF THE STATES.
- PLANCK RADIATION LAW
 - BASIS; QUANTIZATION OF THE LORENTZ OSCILLATOR'S ENERGY. PLANCK DOES NOT QUANTIZE THE E.M. FIELD.

- PLAUCK LAWI RIVISITED
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- EINSTEIN TWO LEVEL MODEL
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TED EMISSION- SPOUTANEOUS EMISSION
- THE INTERACTION HAMILTONIAN
 - RIVISING FIELDS AND POTENTIALS
 - FROM THE INTERACTION HAMILTONIAN
TO THE MATRIX ELEMENT (A SEMICLAS
SICAL APPROACH).
 - TRANSITION PROBABILITY
 - SELECTION RULES.
 - PARITY OF THE ATOMIC STATES

PART III

- QUANTUM FORMULATION FOR THE E.M.
FIELD
- QUANTIZATION OF THE VECTOR POTENTIAL
 $\vec{A}(\vec{r}, t)$ REPRESENTING AN E.M WAVE
- CREATION AND ANNIHILATION OPERATORS.

- THE ZERO POINT ENERGY
- CHARGE PARTICLE IN A QUANTIZED E.M. FIELD, (OPTIONAL)
- ABSORPTION AND EMISSION TIME-DEPENDENT PERTURBATION THEORY
- \hat{Q}^+ , \hat{Q} BASIC PROPERTIES
- FULLY QUANTIZED RADIATION-MATTER INTERACTION (FIRST ORDER PERTURBATION THEORY) HAMILTONIAN
- MOMENTUM OF THE PHOTON (BASIC)

PART IV

- THE VALUE OF THE TRANSLATIONAL SYMMETRY: FROM LC LADDER NETWORK TO PHONONS
 - THE 1D LADDER LC NETWORK AND THE DEFINITION OF UNIT CELL
 - THE DISPERSION RELATION
 - EQUATION OF MOTION WITH ONE ATOM PER UNIT CELL: THE ACOUSTIC PHONON MODES.
 - EQUATION OF MOTION WITH TWO ATOMS PER UNIT CELL: THE OPTICAL PHONONS,
- REFLECTIVITY AND ABSORPTION IN POLAR SOLIDS
- PHONONS INTERACTION WITH LIGHT
- EFFECTS OF THE OPTICAL PHONONS ON THE $\hat{\epsilon}(\omega)$, THE LINEAR TERMS

LONGITUDINAL PHONONS, THE LYDDANE-SACHS-TELLETT LAW.

- THE "REST STRAHLEN GAP"
- POLARITONS - DISPERSION
- POLARON - BASIC CONCEPTS.

QUANTIZATION OF A 1D LATTICE VIBRATIONS.

- A GLANCE TO THE QUANTUM FIELD THEORY OF PHONONS.
- PHONONS LAGRANGIAN AND HAMILTONIA QUANTIZATION.

PART V

A GLANCE TO THE ELECTRON AND PHOTON SPIN

- THE STERN-GERLACH EXPERIMENT
- ELECTRON PRECESSION AND ORIENTATION IN A MAGNETIC FIELD.

SPIN OPERATORS

- THE DIRAC EQUATION AND THE SPINORS: FROM KLEIN-GORDON EQ. TO DIRAC EQ.
- DIRAC EQ. WITH THE ELECTRIC AND MAGNETIC FIELD
- ANTI-MATTER AND ANNIHILATION PROCESSES

- KLEIN-GORDON AND DIRAC EQS IN TENSORIAL FORM.

• NOTES ON THE DIRAC EQ.

• FORMAL EQUIVALENCE BETWEEN THE ELECTRON SPIN AND THE PHOTON SPIN

• STERN-GERLACH SEQUENTIAL MEASUREMENTS

• SPIN WAVEFUNCTIONS

• PAULI MATRICES REVISITED

• SPIN AND PHOTON CIRCULAR POLARIZATION ANALOGY.

PART VI

• SHORT NOTES ON PLASMA PHYSICS

• STANDARD DEFINITION

• THE WEAK COUPLING CASE

• THE DEBYE SHIELDING

• COLLISION IN PLASMA

• PLASMA CLASSIFICATION

• PLASMA OSCILLATIONS: THE PLASMA FREQUENCY.

• PLASMA CREATION

• RELATIVISTIC THRESHOLD

• WAVE PROPAGATION IN PLASMA

• EQS. GOVERNING THE PLASMA DYNAMICS FOR TWO-FLUIDS PLASMA

• LONGITUDINAL (LAUGUMIR) WAVES

• THE DISPERSION RELATIONS.

- TRANSVERSE WAVE
- NON-LINEAR PROPAGATION
- SINGLE PARTICLE MOTION IN A MAGNETIC FIELD
 - CYCLOTRON MOTION
 - HELICAL MOTION
 - DEFINITION OF GUIDING CENTER
 - DEFINITION OF PITCH ANGLE
 - THE $\vec{E} \times \vec{B}$ -DRIFT (UNIFORM FIELDS)
 - THE $\vec{E} \times \vec{B}$ -DRIFT (NON-UNIFORM FIELDS)
 - THE GRAD- \vec{B} FIELD
 - CURVED MAGNETIC DRIFT
- FLUID APPROACH TO PLASMA - BASIC OF MAGNETO HYDRODYNAMICS (MHD)
 - SINGLE FLUID THEORY (MHD)
 - BASIC CONSERVATION EQS
 - MASS AND CHARGE CONSERVATION
 - MHD EQ. OF MOTION
 - GENERALIZED OHM LAW



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- OSCILLATORY DESCRIPTION OF PHYSICS PHENOMENA -
 - PHYSICAL PHENOMENA IN \mathbb{R}^{-1}
 - PROBABILITY VS DETERMINISTIC DESCRIPTION OF THE PHYSICAL PROCESSES

• INVOLVED THEORIES

CLASSICAL { MECHANICS (\hat{L} AND \hat{H})
STATISTICAL PHYSICS (BOLTZMANN)
ELECTRODYNAMICS
SPECIAL RELATIVITY

QUANTUM

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 { QUANTUM MEC.
 QUANTUM STATISTICS
 QUANTUM E.D.
 DIRAC EQ.

WHAT DO WE GAIN?

- DESCRIPTION OF THE RADIATION-MATTER INTERACTION ON A QUANTITATIVE BASE (MATRIX ELEMENT - SELECTION RULES)
- MATHEMATICAL DESCRIPTION OF THE SPIN (PKULI - DIRAC)
- QUANTIZATION OF THE E.M. FIELD
SPONTANEOUS EMISSION - ZERO FIELD ENERGY (QUANTUM VACUUM FLUCTUATIONS)

BASIC CONCEPTS TO THE QUANTUM FIELD THEORIES.

- UNITARY VISION OF MASSIVE PARTICLES
SPIN AND ZERO-MASS PARTICLES
SPIN
- THE NOVEL CONCEPT OF COLLECTIVE
MOTIONS AND COLLECTIVE EXCITA
TIONS
 - PLASMA WAVES AND PLAS
MA FREQUENCY (IONIZED
GASES)
 - PHONON IN SOLIDS
 - RESONANCE PHENOMENA
 - STANDING WAVES → MODES →
STATES → DENSITY OF STATES.