Alex Zarechnak's Oral Exam Syllabus

May 13, 2003

I. Bohmian Mechanics

- A. Quantum Mechanics: Standard Formalism
  1. Postulates
  2. Ehrenfest's Theorem
  3. Uncertainty Principle
  4. Propagator for free particle (1-d)
  5. Standard examples of solving time ind. Schrodinger Eq.
  6. Formulation of Spin
  7. Formulation of Identical Particles without spin
  8. Decoherence
- B. Quantum Mechanics: Foundational Issues
  1. Measurement Problem
  2. Interpretations of Quantum Mechanics (non-Bohmian)
     - a. Copenhagen Interpretation
     - b. Decoherent Histories
     - c. Spontaneous Localization
     - d. Many Worlds
  3. Hidden Variables
     - a. Nonlocality
       - i. EPR paradox
       - ii. Bell's Inequality
     - b. Other Impossibility Theorems
       - i. Hardy's Theorem
       - ii. Von Neuman's Theorem
       - iii. Kochen-Specker Theorem
- C. Bohmian Mechanics
  1. Postulates
  2. Formulation of Spin
  3. Formulation of Identical Particles without spin
  4. Bohmian Mechanics and the Measurement Problem
  5. Global Existence and Uniqueness of Trajectories
  6. The Quantum Potential
  7. Emergence of Standard Formalism
     - a. Quantum Equilibrium Hypothesis (QEH)
     - b. Equivariance
     - c. Conditional Wave Function
     - d. Effective Wave Function
     - e. Emergence of Born Statistics
     - f. Absolute Uncertainty
     - g. The Foundation of QEH
     - h. The Role of Operators
       - i. Bohmian Experiments

II. Differential Geometry

A. Basic Definitions and examples
   1. Definitions of Manifolds, tangent vectors, vector fields, vector bundles
   2. Examples: Surfaces, Lie groups-Matrix groups, submanifolds
   3. Various mappings such as immersions, induced maps

B. Tensors and differential forms
   1. Tensors of all types, tensor fields, maps and tensors
   2. Exterior algebra, exterior derivative, differential forms
   3. Orientability and n-forms
   4. Symmetrizing, alternating, contracting, and multiplying tensors
   5. Tensor Derivations
   6. Lie Derivatives
   7. Poincare Lemma and its partial converse

C. Vector fields
   1. Existence and Uniqueness Theorems for ODE
   2. One-Parameter groups
   3. Vector Fields as flows and as differential operators
   4. Lie algebra of vector fields

D. Metrics and Connections
   1. Definition of Metrics and Connections
   2. Covariant Derivative
   3. The Levi-Civita connection
   4. Parallel Translation
   5. Variations
   6. Geodesics
   7. Frame fields
   8. Cartan Structural Equations
   9. Exponential Map
   10. Hopf-Rinow-De Rham Theorem
   11. Curvature
       a. Riemann Curvature Tensor
       b. Sectional Curvature
       c. Bianchi Identities

E. Integration on Manifolds
   1. Definition of the integral
   2. Manifolds with boundary
   3. Stokes' Theorem

F. Surface theory
   1. Fundamental Forms, Gauss Curvature, Principal Curvature
   2. The Gauss Equation and Codazzi-Mainardi Equations
   3. Gauss-Bonnet Theorem