Theory of Integrable Systems and Their Applications

David Karakhanyan

Yerevan Physics Institute, 2 Alikhanyan Brs. St., Yerevan, 0036, Armenia

56 hours, 28 lectures

1. **Integrability**(4 hours):
   Basic notions, Theorems, Inverse Scattering Method, Lax operator, Transfer Matrix
2. **Bäclund transformation**(4 hours):
   Toda chain, KdV hierarchy, KP-hierarchy
3. **Separation of Variables**(4 hours):
   Hamilton-Jacobi Method, Baxter Q-operator
4. **Spin Chains**(4 hours):
   Heisenberg magnet, Coordinate Bethe Ansatz
5. **Theory of Instanton**(6 hours):
   Self-dual Yang-Mills field, BPTS-instanton
6. **Soliton Solutions in Gravity**(2 hours):
   Belinskii-Zakharov solution to Einstein Equations
7. **Yang-Baxter Equation**(2 hours):
   Rational, Trigonometric and Elliptic R-matrices, Open Spin Chain, Gaudin Model.
8. **Lattice Models** (2 hours):
   Ising model, Square Lattice,
9. **Graphene**(4 hours):
   Hexagonal Lattice, Brillouin zone, Massless Dirac Fermions, Fullerene, Nanotubes
10. **Algebraic Bethe Ansatz**(4 hours):
    Unwanted Terms, Bethe Equations, Higher Spins, Fusion Method.
11. **Application to Quantum Chromodynamics**(6 hours):
    Regge Limit, Leading Logarithmic Approximation, Scattering Amplitudes.
12. **Application to Nuclear Physics**(2 hours):
    Singular Darboux transformations
13. **Calogero-Moser Model**(6 hours):
    Integrals of Motion, Additional Integrals, Matrix Model Reduction, Lax Operator, Dynamical R-matrix.
14. **Topological Models, Application to the Theory of Knots**(4 hours):
    Chern-Simons Theory, R-matrix Representation, Diagrammatic Approach.

References:

1. M. Gaudin. *Bethe wave function.*
2. A. M. Perelomov,*Integrable Systems of Classical Mechanics and Lie Algebras.*
3. L. A. Takhtajan, L. D. Faddeev, *Hamiltonian Approach in Soliton Theory.*