TOPOLOGICAL OBJECTS IN FIELD THEORY

11am Monday and 10am Tuesday, Weeks 1-5 Hilary Term : Fisher Room
10am Tuesday, Weeks 6-8 Hilary Term : Fisher Room

This course will introduce solitons and instantons together with the related topological notions. It counts as a half-unit. There will be one set of problems.

TOPICS

(A) Solitons

- introduction and definition
- single scalar field in $D = 1 + 1$: the kink
- scalar fields in higher D and Derrick's Theorem
  - physical meaning
  - strings and walls
  - ways out
- homotopy classes, topology, topological currents and charges
- complex scalar field in $D = 2 + 1$
  - homotopy classes and vortices
  - finite T: why Derrick's theorem does not always matter
- Abelian-Higgs model in $D = 2 + 1$
  - 'magnetic monopole-like' vortices
  - Meissner effect in $D = 3 + 1$; colour confinement
- Generalised solitons: textures, particles, strings, domain walls ...
- Homotopy groups

(B) Instantons

- definition and uses: better calculations and tunnelling
- Abelian-Higgs model in Euclidean $D = 1 + 1$
  - dilute gas approximation and vacuum energy
  - θ-vacua and n-vacua
  - linear confinement from instantons
- SU(2) gauge fields in Euclidean $D = 3 + 1$
  - instantons, topological charge, current and Chern-Simons
  - dilute gas calculations
  - singular and non-singular
  - θ-vacua, n-vacua, intertwined θ-vacua
  - fermions and zero modes
  - $U_A(1)$ problem; anomalies; chiral symmetry breaking.

Some references:

S. Coleman, Aspects of Symmetry (CUP): Chaper 6 on Solitons and Chapter 7 on Instantons.

V. Rubakov, Classical Thoery of Gauge Fields (Princeton).

R. Rajaraman, Solitons and Instantons (North-Holland 1982)

C. Nash amd S. Sen, Topology and Geometry for physicists (Acad Press)

see also:

P. Goddard and P. Mansfield, Reports Prog. Phys. 49 (1986) 725.

D. Tong, TASI Lectures hep-th/0509216.

N. Dorey et al : hep-th/0206063.

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