

**Curso de Posgrado para el Doctorado en Física  
2do semestre de 2014**

**Solitones y sus aplicaciones**

*(en temas de supersimetría, holografía, dinámica de branas y materia condensada).*

**Profesor a cargo de Fidel A.Schaposnik**

Departamento de Física - UNLP

**Reunión para coordinar horarios: jueves 7 de agosto, 11 hs**

**Sobre el curso:**

El curso se basará en un artículo de “review” en preparación. Su índice al día de hoy es el siguiente

Solitons and their applications

*in Supersymmetry, Holography, Brane dynamics and Condensed Matter*

**Contents**

**1 Introduction and Definitions 5**

1.1 Introduction 5

1.2 Definitions 5

**2 Kinks 11**

2.1 The model 11

2.2 More spatial dimensions: Derrick’s theorem 15

2.3 The kink and a topological conservation law 16

2.4 The kink as an instanton 18

**3 Vortices 25**

3.1 The Abelian Brout-Englert-Higgs (ABEH) model 25

3.2 Nielsen-Olesen 27

3.3 Topological conservation laws and homotopy classes 30

3.4 The vortex solution 31

3.5 The Ginzburg-Landau phenomenological theory 35

3.5.1 Second-order phase transitions 35

3.6 Type I and Type II superconductivity 36

3.6.1 Type-I 37

3.6.2 Type II superconductivity 39

## **4 Monopoles 43**

### 4.1 The Dirac monopole 43

#### 4.1.1 Dirac modifies Maxwell equations 43

#### 4.1.2 Generalised gauge transformations and the derivation of the Dirac condition 46

### 4.2 The non-Abelian monopole 48

#### 4.2.1 Noether Theorem and $\theta$ -term 52

#### 4.2.2 Finding monopole and dyon solutions 56

#### 4.2.3 Dyon charge quantization . 61

#### 4.2.4 BPS equations and exact solutions 65

#### 4.2.5 Monopoles with charge $g > 1$ 66

## **5 Skyrmions 71**

### 5.1 Skyrmions in 3 + 1 space-time dimensions 71

### 5.2 The hedgehog

### 5.3 $B > 1$ skyrmions 74

### 5.4 Skyrmions in diverse dimensions: baby skyrmions and all that 75

#### 5.4.1 Kinks in the $O(3)$ nonlinear $\sigma$ model [5],[10] 76

#### 5.4.2 The baby Skyrme models [12]-[13] 79

## **6 Instantons 85**

### 6.1 Euclidean Yang-Mills configurations and topology 85

### 6.2 The BPST instanton solution 88

### 6.3 Witten cylindrically symmetric multi-instanton solution 91

### 6.4 Collective coordinates, zero modes and instanton moduli space 94

#### 6.4.1 Collective coordinates 94

#### 6.4.2 Bosonic zero-modes 95

#### 6.4.3 Fermion zero-modes 98

#### 6.4.4 Moduli spaces

## **7 Solitons and Supersymmetry**

## **8 Monopoles and Duality**

## **9 Monopoles and confinement/Vortices**

## **10 Solitons in condensed matter**

## **11 Solitons and Branes**

### 11.1 The relativistic strings

### 11.2 Branes

### 11.3 Branes become dynamical

## **12 Solitons in curved space**

## **13 Solitons and holography**