UNIVERSITÀ DEGLI STUDI DI MILANO

SCIENZE E TECNOLOGIE

Docente	Creazione	Stato	
STEFANO **FORTE**		Aperto	

Data di nascita	Codice fiscale
21/06/1961	FRTSFN61H21F205Q

Dipartimento di afferenza	Settore	Carriera	A.A.
DIPARTIMENTO DI FISICA	FIS/02-Fisica teorica, modelli e metodi matematici	I FASCIA	2016/17

Corso di Studio	Strutt.Responsabile	Insegnamento	Modulo
FISICA (Classe LM-17) (F95)	FISICA (Classe LM-17) (F95)	Fisica Teorica 1 (F95-61)	()

Forme didattiche previste dal Piano Didattico

- Lezioni(48 ore)

Note

Nessuna

Riepilogo Attività

Forma didattica	Stato	Numero	Ore
Lezioni	Da confermare	24	48

Dettaglio attività

Stato	Data	Ora inizio	Ore	Aula	Sede	Forma didattica	Argomento/Note
Da confermare	MER 08/03/2017	10:30	2	D	Dipartimento di Fisica	Lezioni	Introduction to this course. Need for infinite degrees of freedom in order to reconcile relativity and quantum mechanics. Different options: proper time vs space as a parameter. Brief historical introduction: from QED to renormalization. Infinities and the uncertainty principle. Dimensional analysis and natural units. Renormalization as a choice of resolution scale. Renormalization flow: renormalizable theories and the flow of couplings, nonrenormalizable theories and the flow of interactions. Outline and roadmap for the course.
Da confermare	GIO 09/03/2017	08:30	2	D	Dipartimento di Fisica	Lezioni	Introduction to classical field theory: a filed as the continuum limit of copupled oscillators. Review of coupled harmonic oscillators: normal coordinates. Oscillators with nearest-neighbor interaction. Equations of motion. Continuum limit. From rescaled coordinates to quantum fields. Dimensional analysis and the continuum limit. Langrangian density for the scalar field. Variational principles and equations of motion: reminder of the derivation of Lagrange's equations in point mechanics from a variational principle.
Da confermare	MER 15/03/2017	11:30	2	D	Dipartimento di Fisica	Lezioni	Derivation of the Eluer-Lagrange equations for classical field theory from a variational principle. Boundary conditions. Equations of motion for the field theory derived in the previous lecture and its 'massive' generalization. Solutions of the equation of motion: phase velocity and group velocity. Normal coordinates for a classical field theory and momentum eigenstates.
Da confermare	GIO 16/03/2017	08:30	2	D	Dipartimento di Fisica	Lezioni	Decoupling of the Lagrangian in momentum space. Reality conidtion for the field. Equations of motion again. Physical motivations for the Lorentz fgroup. The Lorentz group as a four-dimensional generalization of rotations. Definition of Lorentz and Poincare groups in terms of their action on the coordinates. Commutation relations between generators: the Lorentz and Poincare algebra. Lorentz generators in terms of rotations and boosts. Commutation relations for rotations, boosts and translations. The Lorentz group as a direct product of two rotation groups. Rotation representation content of a Lorentz four-vector.
Da confermare	MER 22/03/2017	11:30	2	D	Dipartimento di Fisica	Lezioni	Explicit expression of the Lorent generators in the fundamental representation. Constructions of higher representations as tensor products: Lorentz tensors and their rotation content. Dimension of the higher-order representations. Representation of transformation on fields. Representations on a Hilbert space: Poincare' irreps as elementary "particles". Casimir operators: Momentum and Pauli-Lubanski. Dimension of massive and massless representations.
Da confermare	GIO 23/03/2017	08:30	2	D	Dipartimento di Fisica	Lezioni	Noether's theorem: from point particles to fields. Conserved currents and conserved charges. Canonical structure in field theory and Poisson brackets of charges. Space-time translations: construction of the energy-momentum tensor.

Da confermare	MER 29/03/2017 11:30	2	D	Dipartimento di Fisica Lezioni	Rotations and boosts: construction of the conserved current and its expression in terms of energy momentum tensor. Generators of rotations and angular momentum operator. Conserved charge for boosts and the motion of the center of mass. Symmetrization of the energy-momentum tensor thorugh the Belinfante construction. Relativistic fields: construction of the scaler field. Definition of the kinetic term and dimensional analysis. Classical equations of motion and their solution. Energy momentum tensor. Normal coordinates: expression of the Hamiltonian. Quantization: creation and annihilation operators. Expression of the Hamiltonian in terms of creation and annihilation operators.
Da confermare	MER 05/04/2017 11:30	2	D	Dipartimento di Fisica Lezioni	Meaning of canonical quantization: commutation relations for creation and annihlation operators or for fields. The energy of the vacuum: normal ordering and the Casimir effect. Expression of the energy and momentum operators in terms of creation anjd annihilatikon operators. One-particle states. Fock space. Normalization of physical states. The charged scalar field: Lagrangian, equations of motion, energy-momentum tensor, U(1) current. Quantization: particles and antiparticles. The Maxwell field. Classical equations of motion. Gauge invariance and counting of degrees of freedom.
Da confermare	GIO 06/04/2017 08:30	2	D	Dipartimento di Fisica Lezioni	Normal mode expansion of the electromagnetic field. Transverse polarization states: covariant definition. Quantization: creation and annihilation operators. Energy, momentum and spin operators: explicit expressions. The Dirac field. Clifford algebra, gamma matrices and Lorentz generators. The bar spinor. Adjoint action of the Lorentz group on gamma matrices. Construction of scalars and vectors out of spinors. The spinor field and the minimal (free) Dirac Lagrangian. Energy-momentum tensor, energy and momentum. The classical equation of motion: the Dirac equation. Relation between Dirac and Klein-Gordon equations; the u and v spinors.
Da confermare	MER 12/04/2017 11:30	2	D	Dipartimento di Fisica Lezioni	Structure of the solutions of the Dirac equation. The gamma5 matrix. Chiral projectors. Chiral decomposition of a Dirac fermion and structure of the Dirac lagrangian. Solutions in the massive and massless case: helicity and chirality. Normalization of the Dirac spinors. The Dirac field and its quantization: expression of the field in terms of creation and annihilation operators. Expression of the Hamiltonian in terms of creation and annihiolation operators. Quantization with anticommutators. Energy spectrum and Fermi statistics. Canonical formalism for the Dirac field. Summary of field quantization. Transition amplitudes: interaction picture and Hamiltonian formalism vs Heisenberg picture and Lagrangian formalism. Meaning of the interaction picture for quantum fields and expression of the amplitude. The S matrix.
Da confermare	MER 19/04/2017 11:30	2	D	Dipartimento di Fisica Lezioni	Equivalence of the interaction picture and Heisenberg picture representations for the S matrix. Evolution of the vaccum and vacuum phase: general expression for transition matrix elements. The propagator in quantum mechanics. Propagator for an infinitesimal time

					evolution: expression in terms of the action. Finite time evolution: the sum over paths and the Feynman path integral.
Da confermare	GIO 20/04/2017 08:30	2	D	Dipartimento Lezioni di Fisica	Properties of the path integral: associativity and Schroedinger equation: the path integral as a wave function and as a transition amplitude. Evaluation of expectation values in the path integral and 'natural timje ordering'. The path integral in field theory. Path-integral expression for the S-Matrix. Convergence factro and in and out states as vacuum states. Expectation values from functional differentiation of a path integral with a sources: the partition function. Evaluation of the path integral for a free real scalar field: the path integral as a Gaussian integral.
Da confermare	MER 26/04/2017 11:30	2	D	Dipartimento Lezioni di Fisica	Summary of the expression of S-matrix elements in terms of n-point functions, of n-point functions in terms of the partition function and of the partition function in terms of a path integral. Computation of the path integral for a free field theory with source. Path integral for an interacting field theory in terms of the free-field expression. Computation of the two-point function for a free scalar field: Feynman boundary conditions and explicitly covariant expression. Operator (Hamiltonian) derivation and comparison with the path-integral result.
Da confermare	GIO 27/04/2017 08:30	2	D	Dipartimento Lezioni di Fisica	The two point Green function: comparison of the Hamiltonian and path integral approach result and interpretation. The two point function for the Maxwell field: Feynman gauge expression. The path integral for fermions. Grassmann numbers. Berezin integration. Gaussian integrals and fermion determinant. The path integral for the Dirac field. Functional derivation of the Dirac propagator. Interacting field theories: phi^4 and QED. The gamma->e+e- transition in QED.
Da confermare	MER 03/05/2017 11:30	2	D	Dipartimento Lezioni di Fisica	Computation of the gamma->e+e- amplitude to lowest nontrivial order in QED using the hamiltonian formalism. Runes for the wave functions of incoming and outgoing particles. The vertex. The reduction formula. Wronskian and inversion of the field in terms of creation and annihilation operators. In and out operators: the interaction picture vs the Heisenberg picture. Covariant expression of the reduction formula. Meaning of the in and out fields.
Da confermare	GIO 04/05/2017 08:30	2	D	Dipartimento Lezioni di Fisica	Momentum-space version of the reduction formula: singularities of Green functions and amplitudes as residues. Expression of the reduction formula in terms of amputated propagators. The reduction formula for gauge and fermion fields. Computation of the vertex using the path integral formalism: the interaction as functional differentiation. Need to eliminate all the explicit dependence on sources.
Da confermare	MER 10/05/2017 11:30	2	D	Dipartimento Lezioni di Fisica	The Feynman rules: derivation from the path integral. External particles; propagator; vertex. Graphical representation and its interpretation. Position space vs momentum space. Rules for fermions. Connected and disconnected diagrams. Relation to the Hailtonian approach and Wick's theorem.
Da confermare	GIO 11/05/2017 08:30	2	D	Dipartimento Lezioni di Fisica	QED with two species of fermions. The process e+e-->mu+mu-. Feynman diagrams. Amplitude. Invariant matrix elements: projectors over

					Dirac spinors and expression as a trace. Traces of gamma matrices. Computation of the squared amplitude. Counting of degrees of freedom. Mandelstam invariants.
Da confermare	MER 17/05/2017 11:30	2	D	Dipartimento di Fisica Lezioni	Expression of the amplitude in terms of Mandelstam invariants. Choices of reference frame: lab and center-of-mass frames. Expression of the amplitude in the CM frame. Dimensionful variable vs. dimensionless ratios: the importance of dimensional analysis. Relation between particle number, transition probability, and cross-section. The flux factor: the cross-section for Gaussian wave-packets.
Da confermare	GIO 18/05/2017 08:30	2	D	Dipartimento di Fisica Lezioni	Final expression for the flux factor for localized wave-packets. Uncertainty in position and momentum in realistic situations. Scalar expression for the flux factor: derivation and caveats. Computation of the flux factor for two incoming massless particles. The phase space: general definition and properties. Explicit computation for a pair of back-to-back massive particles with the same mass. Final expression for the cross section for e+e-->mu+mu-: differential vs total cross-section. The fine-structure constant. Understanding the cross-section: dimensional analysis and the massless limit. Angular dependence and angular momentum conservation in the massless limit. Introduction to renormalization. Elastic scalar scattering in the phi4 theory. Leading order computation. Next-to-leading order (one loop) diagrams.
Da confermare	MER 24/05/2017 11:30	2	D	Dipartimento di Fisica Lezioni	Expression of the cross-section in terms of a form factor. Computation of the form factor: funsamental loop integral. Feynman parameters and reduction to a scalar integral. D-dimensional scalar integrals: Wick rotation. Final expression for the form factor: cutoff regularization. Regularized cross-section. Meaning of the coupling constant: definition of the physical coupling.
Da confermare	GIO 25/05/2017 08:30	2	D	Dipartimento di Fisica Lezioni	Expression of the form factor in terms of the physical coupling: renormalization. Different definitions of the renormal;ized coupling: renormalization schemes. Freedom to perform a finite redefinition of the coupling. Reference scale and origin of the divergence as it is taken to infinity. Dimensional regularization. Computation of the dimensionally regularized one-loop form factor. The physica coupling again. Minimal subtraction: the MSbar renormalization scheme.
Da confermare	MER 31/05/2017 11:30	2	D	Dipartimento di Fisica Lezioni	Renormalization of the amplitude as the consequence of multiplicative or additive renormalization of the coupling. Renormalization constant and counterterm. Renormalization at the Lagrangian level: counterterm Laagrangian and its Feynman rules. Renormalized perturbation theory. General renormalization theory: computation of the degree nof divergence of a generica diagram in a theory with a single scalar field and phi^n interaction.
Da confermare	GIO 01/06/2017 08:30	2	D	Dipartimento di Fisica Lezioni	Degree of divergence and dimensional analysis: generic diagram with N amputated external lines. Classification of interactions based on the dimensionality of the coupling. Super-renormalizable, renormalizable and non-renormalizable theories. Renormalization of the

phi^4 theory in 4 dimensions. List of divergent amplitudes. Construction of the counterterms: coupling, mass, and wave function renormalization. Feynman rules for counterterms and their matching to the fundamental divergences. General argument for all order renormalizability. Distinction between superficial degree of divergence and actual divergence. Subdiagrams and BPHZ renormalization, Meaning of non-renormalizability. Naturalness.