A personal selection of Jean-Loup Gervais's main contributions

- 1) Renormalization of the sigma model (ii) fermion fields and renormalization
- Jean-Loup-Gervais and B .W. Lee, *Nucl.Phys.B12* (1969) 627-646

- The renormalization of the σ-model is discussed. The results presented here generalize a previou study of one of us (B.W.L.) who considered only the boson terms. It is emphasized that a consistent renormalization, namely one which is obtained by a mere redefinition of the bare constants of the Lagrangian, and by introducing chiral symmetric mass counter terms, can only be achieved by an appropriate choice of the regularization procedure. It is shown that this will be the case only if the same regularization can be applied to the chiral symmetric theory, i.e. the one where the scalar tadpoles are absent (in particular, the fermion mass is zero). As a consequence we show that one cannot regularize by adding fermion fields with the same chiral properties as the nucleon. In particular we exclude Bell and Jackiw's prescription as inconsistent. A new regularization procedure is proposed based on parity doublets. It is shown to lead to a consistent renormalization of the σ-model, in particular PCAC is obtained among renormalized quantities. This method, however, does not regularize the triangle graph discussed by Bell and Jackiw and Adler. We thus conclude that two types of regulators are needed in the σ-model when electromagnetism is superimposed.

2) Field Theory interpretation of Supergauges in dual models
Jean-Loup Gervais and B. Sakita *Nucl.Phys.B* 34 (1971) 632-639

Possible new invariances of generalized dual models are discussed in the context of the functional integral formulation. The operators relevant to new gauges of those models, such as those obtained by Neveu and Schwarz, are derived as infinitesimal generators of new field transformations which leave the action integral invariant.

3) Functional Integral Approach to Dual-Resonance Theory
Jean-Loup Gervais and B. Sakita *Nucl.Phys.B* 34 (1971) 632-639

It is shown that dual-resonance amplitudes can be expressed in terms of rudimental amplitudes defined by functional integrals which correspond to transition amplitudes of quantum-mechanical systems of strings with imaginary time. The equivalence between the path-integral and operator formulation of quantum mechanics is used to establish the connection between this approach and the usual operator approach. The factorization of rudimental amplitudes is studied to obtain the Feynman-like rules for dual-resonance amplitudes. This allows us to express N-Reggeon vertices in terms of rudimental amplitudes, and to determine the propagator, which is shown to be the usual spurious-free twisted propagator. N-loop orientable diagrams are calculated. In general, the functional integrals considered can be calculated by solving appropriate Neuman's boundary-value problems of corresponding bounded Riemann surfaces. This provides a generalization of the analog model to the case of external Reggeons which are described by extended momentum distributions on the boundaries.

4) Feynman Rules for Massive Gauge Fields with Dual Diagram Topology

Jean-Loup Gervais and A. Neveu *Nucl.Phys.B* 46 (1972) 381-401

- We study through the zero slope limit the relationship of dual models with renormalizable theories of massive Yang-Mills fields of the type recently proposed by 't Hooft. We clarify the field theoretic meaning of the twisting operator and the topology of dual models: these features result from the choice of a special non-Hermitian gauge condition in the underlying field theory. The local gauge invariance of that theory is the exact reflexion of the first set of “gauge identities” appearing in the dual theory.

- ## 5) Combining and Splitting Relativistic Strings

- E. Cremmer and Jean-Loup Gervais *Nucl.Phys.B* 76 (1974)

- It is shown how the three-reggeon vertex of Ademollo, Del Guidice, Di Vecchia and Fubini is obtained from overlap conditions of three relativistic strings.

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- 6) Infinite Component Field Theory of Interacting Relativistic Strings and Dual Theory

E. Cremmer and Jean-Loup Gervais *Nucl.Phys.B* 90 (1975) 410-460

Using light-cone quantization, the multistring formalism is unambiguously established from operator formalism, by introducing an infinite component field Φ which is a ket vector in the Fock space of transverse oscillators and the Φ 3 interaction corresponding to the dual vertex of ADDF. A functional multistring field is naturally obtained as the component of Φ in the basis { x } where the string operator X is diagonal. It differs from Kaku and Kikkawa's one by an infinite phase factor which does not allow them to take the value of the intercept into account. In this way, we recover the functional approach to the dual amplitude with a well-defined functional measure which could not have been guessed a priori , and which is determined from our previously established expression of the vertex in the { x } basis. The scattering amplitudes are deduced from field-theory asymptotic conditions and perturbation theory. On-shell amplitudes are shown to agree with the form proposed by Mandelstam integrated over time differences instead of Koba-Nielsen variables. Two prescriptions for off-shell amplitudes are discussed. One of them agrees

with Mandelstam's while the other one is deduced from reduction formulae. The latter prescription is time-translation invariant whereas the former is not. For the four-string amplitude, it is proved that the part of the integrand which does not depend on the external states is at 26 space-time dimensions, precisely the one required to change variables from time differences to Koba-Nielsen variables. This allows us to determine unambiguously the Φ 4 term which is needed to reproduce the complete tree dual amplitude.

7) Perturbation Expansion Around Extended Particle States in Quantum Field Theory

- Jean-Loup Gervais, A. Jevicki and B. Sakita *Phys.Rev.D* 12 (1975) 1038
- The quantum mechanics of solitary-wave classical solutions of nonlinear wave equations is discussed in detail for the kink solution of two-dimensional φ4 field theory. The formalism provides a natural interpretation of an extended particle, the *soliton*, for the classical kink. The perturbation theory around the extended particle is developed and used to calculate the radiative corrections for the mass of soliton up to one loop. The mass renormalization is discussed in detail to show that the mass counterterm to the nonsoliton sector also does the job for the present case, i.e. one-soliton sector. Although our formalism is not manifestly Lorentz-covariant, the Lorentz covariance is shown explicitly by calculating the soliton energy for a fixed momentum. The paper also contains the perturbation calculation of matrix element of φ fields between one-soliton states.

- 8) The Quantum Dual String Wave Functional in Yang-Mills theory

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. Jean-Loup Gervais and A. Neveu *Phys.Lett.B* 80 (1979) 255-258

From any solution of the classical Yang-Mills equations, we define a string wave functional based on the Wilson loop integral. Its precise definition is given by replacing the string by a finite set of N points, and taking the limit $N \to \infty$. We show that this functional satisfies the Schrödinger equation of the relativistic dual string to leading order in N. We speculate about the relevance of this object to the quantum problem.

9) The Dual String Spectrum in Polyakov's Quantization. 1.
Jean-Loup Gervais and A. Neveu *Nucl. Phys.B* 199 (1982) 59

We construct the quantum mechanical field operator of the two-dimensional Liouville theory in a finite box. This leads us to the discovery of a new type of triangle relation which does not reduce to the already known ones. We apply our result to the construction of the string model in an arbitrary number of space-time dimensions D . We show that there are no tachyons in $-\infty < D \leqslant 1$, and we indicate how to continue to $D > 1$, which is a strong-coupling region for the Liouville field theory.

10) Dual String Spectrum in Polyakov's Quantization. 2. Mode Separation

Jean-Loup Gervais and A. Neveu *Nucl. Phys.B* 209 (1982) 125-145

The analysis of our first paper is completed by (a) explicitly working out the set of ground state classical motions, (b) separating the modes into equally spaced harmonic oscillators. The Virasoro generators are obtained as quadratic expressions of these modes providing a spectrum generating algebra. The quantum spectrum is shown to be similar to a standard string spectrum with a new kind of zero mode associated with a representation of a dynamical SU(2) group.

- 11) Novel Triangle Relation and Absence of Tachyons in Liouville String Field Theory

  Jean-Loup Gervais and A. Neveu *Nucl.Phys.B* 238 (1984) 125-141

We construct the quantum mechanical field operator of the two-dimensional Liouville theory in a finite box. This leads us to the discovery of a new type of triangle relation which does not reduce to the already known ones. We apply our result to the construction of the string model in an arbitrary number of space-time dimensions D . We show that there are no tachyons in $-\infty < D \leqslant 1$, and we indicate how to continue to $D > 1$, which is a strong-coupling region for the Liouville field theory.

12) Infinite Family of Polynomial Functions of Virasoro Generators with Vanishing Poisson Brackets
Jean-Loup Gervais *Phys.Lett.B* 160 (1985) 277-278

An infinite family of polynomial functions of the Virasoro generators, with vanishing Poisson brackets, is constructed by exploiting the relationship between the Poisson bracket realization of the Virasoro algebra and the Korteweg-de Vries canonical structure.

13) New critical dimensions for String Theories

A. Bilal and Jean-Loup Gervais *Nucl.Phys.B* 284 (1987) 397-422

The open string dynamics which include the Liouville field theory following Polyakov and Gervais-Neveu are shown to enjoy the same remarkable properties as the celebrated string theories in D = 26 or D = 10 dimensions, provided D is changed to D = 7 or 13 for the purely bosonic string and to D = 3 or 5 for superstrings. For these new critical dimensions all four models have a free open string partition function which is such that the closed string singularities in the one-loop open string amplitude are poles. For superstrings, the partition functions in the Neveu-Schwarz and Ramond sectors are shown to coincide after the appropriate GOS projection has been carried out, and the new models are presumably space-time supersymmetric. These new critical dimensions are, in each model, the lowest two of the three special values already derived by Gervais and Neveu from their study of the Liouville dynamics per se.

14) Extended C=Infinity Conformal Systems from Classical Toda Field Theories

A. Bilal and Jean-Loup Gervais *Nucl.Phys.B 314 (1989) 646-686*

In a recent article [1] we showed that the bosonic Toda field theories obey extended Virasoro symmetries which involve generators of spins higher than two; and that their quantization gives a systematic treatment of generalized conformal bosonic models. Their Virasoro central charges are such that they become infinite in the classical limit. This latter situation is studied in detail in the present paper, where a simple form of the general solution of the Toda field equations is given, that allows one to separate the modes and to study the Poisson bracket structure of the generators of the extended symmetry in a systematic way. Besides its relevance to the study of integrable classical systems this paves the way to the quantum case, already discussed by the authors and to be worked out in full detail in a separate publication.

15) Systematic Construction of Conformal Theories with Higher Spin Virasoro Symmetries

A. Bilal and Jean-Loup Gervais *Nucl.Phys.B* 318 (1989) 579-630

The conformally invariant Toda theories are quantized following our earlier proposal [1] and starting from our classical mode separation [2]. As part of our general derivation of conformal theories associated with simple Lie algebras, the following new results are presented:

(a) The operator realizations of the extended (higher-spin) Virasoro algebras for arbitrary values of the Virasoro central charge C, and their highest-weight representations.
(b) The basic family of intertwining operators and the associated generalized Kac formulae, both for simply-laced and non-simply-laced Lie algebras.
(c) The novel features of the rational theories associated with non-simply-laced Lie algebras.
(d) The family of equivalent free fields and the associated Galois canonical transformations.
(e) The covariance properties of the intertwining operators under the extended Virasoro transformations.
(f) The operator differential equations satisfied by these primary operators, and the corresponding c-number differential equations for their Green functions
(g) The Coulomb gas picture and the reduction to the hypergeometric type of the two-point function.
(h) The solution of the Yang-Baxter equations describing the braid properties of the conformal field theories so constructed