TWO DIMENSIONAL MODELS AND STRING THEORIES pdf

1: Two-dimensional chiral matrix models and string theories | Ivan Kostov - www.enganchecubano.com

physics with a two-dimensional theory and even by itself this should provide a strong motivation for considering a theory based on one-dimensional entities rather than point particles.

We interpret the models as string the- ories characterized by a set of coupling constants associated to worldsheet rami cation points of various orders. Our approach is closely related to, but simpler than, the string theory describing two-dimensional Yang-Mills theory. Using recently developed character expansion methods we exactly solve the models for target space lattices of arbitrary internal connectivity and topology. Introduction The idea that the strong interactions are described by a string theory which is in some sense dual to perturbative QCD is a major challenge for high energy theory. The latter condition is equivalent to the condition that the embedded surfaces are not allowed to have folds. Rami cation points are however allowed, as it has been suggested in earlier studies [3]. Unfortunately, this construction is highly involved and does not easily reduce to a system of simple geometrical principles1. One can nevertheless speculate, using the analogy with the random-walk representation of the O N model, that there exists an underlying 2D string theory with clear geometrical interpretation. The YM2 string is obtained from the latter by tuning the interactions due to rami cation points and adding new contact interactions via microscopic tubes, etc. One is thus led to look for the most general 2D string theory whose path integral is given by branched covers of the target space. In addition to the topological coupling constant N 1 there is a set of couplings tn associated with the interactions due to rami cation points of order n. For example, the folds are not forbidden but their contribution vanishes as a result of cancellations. We will not try to establish a worldsheet description but instead construct and solve a class of equivalent matrix models. Our approach is thus analogous to quantizing Polyakov string theory by employing randomly triangulated surfaces. However, the matrices are no longer unitary: The model resembles very much the 2D Weingarten model [5] with the important di erence that the lattice action represents a sum over the positively oriented cells only. The latter restriction eliminates from the string path integral all surfaces containing folds which are believed to cause the trivial critical behavior of the standard Weingarten model [6]. We will demonstrate that these 2D matrix models are exactly solvable for any target space lattice and any N by employing the character expansion methods recently developed in [7], [8], [9], [10]. We pay special attention to the cases of spherical and toroidal topology. At the critical area a third-order transition takes place due to the entropy of the rami cation points. In the second case we nd the same partition function as the chirally perturbed conformal eld theory considered recently by R. In this letter we restrict our attention to the discrete case since it involves combinatorial problems interesting on their own. The continuum limit of an in nitely dense target lattice will be considered in detail elsewhere [12]. We will rst consider the simplest string theory with this target space, in which all rami cation points have Boltzmann weight one, and the corre- sponding matrix model. The generalized model, to be considered in sect. This is why we call the model with partition function 2. The model is invariant under complex conjugation of the matrix variables and reversing the orientation of the target space. The perturbative expansion of 2. All plaquettes should have the same orientation, which means that the surfaces cannot have folds. Exact solution by the character expansion method Applying to 2. Then one uses the formula 3. Having at hand 3. Using the fusion rule one pro- gressively eliminates links between adjoining cells until one is left with a single cell. The remaining links along that plaquette are integrated out by applying the ssion rule. We observe that, in accord with the surface representation 2. It is therefore clear that a given character expansion 3. As many, as we can form simplicial complexes di er- ing in their internal connectivity but constrained by the global data G, N0 and AT. This is a lattice version of the invariance with respect to area-preserving automorphisms. N 2 3 Fig. The target space of the e ective one-plaquette model. There is only one surface covering n times a sphere with two punctures and it contributes n1 e nAT to the free energy the factor n1 coming from the cyclic symmetry. No higher-genus surfaces are contributing. Here the sum 4. The saddlepoint i density is found by functionally varying 4. The sum over surfaces diverges if the area of the target manifold falls below AcT. A quite similar transition has already observed in Y M2 by Douglas and Kazakov [15]. We can understand the critical behavior by considering e. Its critical behavior is in the university class of pure gravity. The qualitative behavior remains the same: As seen from 4. It is therefore evident that the theory should be modi ed in order to have a sensible continuum limit. However, we can do even better in this case and immediately give a result to all orders in N Each term in the sum 3. Slicing the tableau through the diagonal and counting the fraction of boxes in the rows of the upper half and the columns of the lower half we can elegantly express 5. The contour integral ensures that an equal number of rows and columns emanate from the diagonal; it eliminates con gurations that cannot be interpreted as a tableau3. The leading order of the free energy gives the partition function of the noninteracting string. It is immediately extracted from either 5. These are in principle computable in terms of quasi modular forms as in [16],[18],[17],[11]. Again a network of square plaquettes corresponding to the vertices of 5. But here a local rule suppresses all positive curvature: The coor- dination numbers at the vertices of such a surface can take values 4; 8; 12; No local curvature uctu- ations, leading to pure quantum gravity behavior, are possible: The combinatorial derivation of 5. It is straightforward to appropriately modify the original matrix theory and solve it by repeating the same steps explained in sect. This should be done in the following way: For each point p we choose one of the cells c such that p 2 c and insert the matrix Hp into the corresponding trace. For example, the one-plaquette theory 3. We have constructed a discretization of the most general string eld theory of nonfolding surfaces immersed in a two-dimensional compact space- time. In the continuum limit the sum over the positions of a branch point should be replaced by an integral with respect to the area. The prop- erties of the expansion 6. The YM-string should be obtained by a special tuning of the coupling constants and by introducing contact tube-like interactions. These inter- actions can be implemented by considering the H-matrices as dynamical elds. We point out an interesting equivalence between ensembles of cover- ings of a sphere with xed number of punctures and an ensemble of abstract i. It is therefore not a miracle that we nd a third order phase transition as in the case of pure 2D gravity. In our case the transition is due to the entropy of surfaces with a large num- ber of rami cation points. A very similar transition has already observed in Y M2 by Douglas and Kazakov [15]. The chiral matrix models de ned on a torus give a nice geometri- cal interpretation of the general chiral deformation of topological theory studied by R. The sum over surfaces can again be inter- preted in terms of abstract planar graphs describing random surfaces with non-positive local curvature. Acknowledgements One of us I. B B ; D. B B ; V. B ; K. B ; I. B , , B B 90 B FS[12] 84

TWO DIMENSIONAL MODELS AND STRING THEORIES pdf

2: Kaluzaâ€“Klein theory - Wikipedia

We formulate and solve a class of two-dimensional matrix gauge models describing ensembles of non-folding surfaces covering an oriented, discretized, two-dimensional manifold. We interpret the models as string theories characterized by a set of coupling constants associated to worldsheet ramification points of various orders.

Little was known about string theory in the non-perturbative regime before Oetober when non-perturbative equations for the string partition functions were found by using methods based on the random triangulations of surfaees. This set of methods pro vides a deseription of non-eritical string theory or equivalently of the coupling of matter fields to quantum gravity in two dimensions. The Cargese meeting was very successful in that it provided the first opportunity to gather most of the active workers in the field for a fuH week of lectures and extensive informal discussions about these exeiting new developments. The main results were reviewed, recent advances were explained, new results and conjectures which appear for the first time in these proceedings were presented and discussed. Among the most important topics discussed at the workshop were: It covers topical problems in such domains as duality between gravity and gauge interactions, string field theory, tachyon condensation, non-commutative field theory, string cosmology and string phenomenology. Some presentations give an elementary introduction to their subject, while others are geared to the specialist Quantum field theory and string theory by Laurent Baulieu 2 editions published in in English and held by 50 WorldCat member libraries worldwide The Cargese Workshop "Quantum Field Theory and String Theory" was held from May 10 to May 21, The broad spectrum of the work presented at the Workshop was the reflec tion of a time of intensive search for new ways of solving some of the most fun damental problems in string theory, quantum gravity and non-perturbative field theory. A number of talks indicated the emergence of new promising domains of investigation. It is this very diversity of topics which, in our opinion, represents one of the most attractive features of the present volume which we hope will provide a good orientation in the abundant flow of ideas and publications in modern quantum field theory. Many contributions to the present proceedings are concerned with two di mensional quantum field theory. The continuous advances in the domain of two dimensional integrable theories on the lattice as well as in the continuum, including conformal field theories, Liouville field theory and matrix models of two dimensional quantum gravity are very well represented. Other papers address physically realistic and therefore very complicated problems like de veloped turbulence, the Hofstadter problem, higher dimensional gravity and phenomenological strings. A new elegant class of topological field theories is presented. New ideas in the string representation of multicolor quantum chromo dynamics were widely discussed at the Workshop, more particularly the example of the exactly solvable two dimensional case Low-dimensional applications of Quantum field theory by Laurent Baulieu 3 editions published in in English and held by 4 WorldCat member libraries worldwide The Cargese Summer School "Low Dimensional Applications of Quantum Field Theory" was held in July The School was dedicated to the memory of Claude Itzykson. This session focused on the recent progress in quantum field theory in two dimen sions with a particular emphasis on integrable models and applications of quantum field theory to condensed matter physics. A large fraction of the school was also devoted to a detailed review of the exciting developments in four dimensional super symmetric Yang-Mills theory. The diversity of the topics presented constitute, in our opinion, one of the most attractive features of these proceedings. Some contributions constitute a very thor ough introduction to their subject matter and should be helpful to advanced students in the field while others present entirely new research, not previously published, and should be of considerable interest to the specialist. There were in depth introductory lectures on the application of conformal field theory techniques to disordered systems, on the quantum Hall effect, on quantum in tegrable systems, on the thermodynamic Bethe Ansatz and on the new developments in supersymmetric gauges theories.

3: CiteSeerX â€” Two-dimensional chiral matrix models and string theories,â€• Phys

We study a myriad of topics related to string theories in two dimensions and/or to heterotic string theories. In chapter 2, we use the duality of two-dimensional string.

Fundamentals The fundamental objects of string theory are open and closed string models. In the twentieth century, two theoretical frameworks emerged for formulating the laws of physics. The other is quantum mechanics which is a completely different formulation to describe physical phenomena using the known probability principles. By the late s, these two frameworks had proven to be sufficient to explain most of the observed features of the universe , from elementary particles to atoms to the evolution of stars and the universe as a whole. One of the deepest problems in modern physics is the problem of quantum gravity. A quantum theory of gravity is needed in order to reconcile general relativity with the principles of quantum mechanics, but difficulties arise when one attempts to apply the usual prescriptions of quantum theory to the force of gravity. The starting point for string theory is the idea that the point-like particles of particle physics can also be modeled as one-dimensional objects called strings. String theory describes how strings propagate through space and interact with each other. In a given version of string theory, there is only one kind of string, which may look like a small loop or segment of ordinary string, and it can vibrate in different ways. On distance scales larger than the string scale, a string will look just like an ordinary particle, with its mass , charge , and other properties determined by the vibrational state of the string. In this way, all of the different elementary particles may be viewed as vibrating strings. In string theory, one of the vibrational states of the string gives rise to the graviton , a quantum mechanical particle that carries gravitational force. Thus string theory is a theory of quantum gravity. Physicists studying string theory have discovered a number of these dualities between different versions of string theory, and this has led to the conjecture that all consistent versions of string theory are subsumed in a single framework known as M-theory. There are certain paradoxes that arise when one attempts to understand the quantum aspects of black holes, and work on string theory has attempted to clarify these issues. One of the goals of current research in string theory is to find a solution of the theory that reproduces the observed spectrum of elementary particles, with a small cosmological constant , containing dark matter and a plausible mechanism for cosmic inflation. While there has been progress toward these goals, it is not known to what extent string theory describes the real world or how much freedom the theory allows in the choice of details. The scattering of strings is most straightforwardly defined using the techniques of perturbation theory , but it is not known in general how to define string theory nonperturbatively. String physics Interaction in the quantum world: The application of quantum mechanics to physical objects such as the electromagnetic field , which are extended in space and time, is known as quantum field theory. In particle physics, quantum field theories form the basis for our understanding of elementary particles, which are modeled as excitations in the fundamental fields. Developed by Richard Feynman and others in the first half of the twentieth century, perturbative quantum field theory uses special diagrams called Feynman diagrams to organize computations. One imagines that these diagrams depict the paths of point-like particles and their interactions. At the level of Feynman diagrams, this means replacing the one-dimensional diagram representing the path of a point particle by a two-dimensional surface representing the motion of a string. One of the vibrational states of a string corresponds to the graviton, a quantum mechanical particle that carries the gravitational force. Bosonic string theory was eventually superseded by theories called superstring theories. These theories describe both bosons and fermions, and they incorporate a theoretical idea called supersymmetry. This is a mathematical relation that exists in certain physical theories between the bosons and fermions. In theories with supersymmetry, each boson has a counterpart which is a fermion, and vice versa. The different theories allow different types of strings, and the particles that arise at low energies exhibit different symmetries. For example, the type I theory includes both open strings which are segments with endpoints and closed strings which form closed loops , while types IIA, IIB and heterotic include only closed strings. At large distances, a two dimensional surface with one circular dimension looks one-dimensional. In everyday life, there are three familiar dimensions of space: In this framework, the phenomenon of gravity is viewed as a consequence of the geometry of spacetime. In some cases, by modeling spacetime in a different number of dimensions, a theory becomes more mathematically tractable, and one can perform calculations and gain general insights more easily. In bosonic string theory, spacetime is dimensional, while in superstring theory it is dimensional, and in M-theory it is dimensional. In order to describe real physical phenomena using string theory, one must therefore imagine scenarios in which these extra dimensions would not be observed in experiments. In compactification, some of the extra dimensions are assumed to "close up" on themselves to form circles. A standard analogy for this is to consider a multidimensional object such as a garden hose. If the hose is viewed from a sufficient distance, it appears to have only one dimension, its length. However, as one approaches the hose, one discovers that it contains a second dimension, its circumference. Thus, an ant crawling on the surface of the hose would move in two dimensions. However, not every way of compactifying the extra dimensions produces a model with the right properties to describe nature. In a viable model of particle physics, the compact extra dimensions must be shaped like a Calabiâ€”Yau manifold. In this approach, physicists assume that the observable universe is a four-dimensional subspace of a higher dimensional space. In such models, the force-carrying bosons of particle physics arise from open strings with endpoints attached to the four-dimensional subspace, while gravity arises from closed strings propagating through the larger ambient space. This idea plays an important role in attempts to develop models of real world physics based on string theory, and it provides a natural explanation for the weakness of gravity compared to the other fundamental forces. S-duality and T-duality One notable fact about string theory is that the different versions of the theory all turn out to be related in highly nontrivial ways. One of the relationships that can exist between different string theories is called S-duality. This is a relationship which says that a collection of strongly interacting particles in one theory can, in some cases, be viewed as a collection of weakly interacting particles in a completely different theory. Roughly speaking, a collection of particles is said to be strongly interacting if they combine and decay often and weakly interacting if they do so infrequently. Type I string theory turns out to be equivalent by S-duality to the SO 32 heterotic string theory. Similarly, type IIB string theory is related to itself in a nontrivial way by S-duality. Here one considers strings propagating around a circular extra dimension. For example, a string has momentum as it propagates around a circle, and it can also wind around the circle one or more times. The number of times the string winds around a circle is called the winding number. If a string has momentum p and winding number n in one description, it will have momentum n and winding number p in the dual description. For example, type IIA string theory is equivalent to type IIB string theory via T-duality, and the two versions of heterotic string theory are also related by T-duality. Two theories related by a duality need not be string theories. For example, Montonenâ€”Olive duality is example of an S-duality relationship between quantum field theories. If two theories are related by a duality, it means that one theory can be transformed in some way so that it ends up looking just like the other theory. The two theories are then said to be dual to one another under the transformation. Put differently, the two theories are mathematically different descriptions of the same phenomena. Brane Open strings attached to a pair of D-branes. In string theory and other related theories, a brane is a physical object that generalizes the notion of a point particle to higher dimensions. For instance, a point particle can be viewed as a brane of dimension zero, while a string can be viewed as a brane of dimension one. It is also possible to consider higher-dimensional branes. In dimension p, these are called p-branes. The word brane comes from the word "membrane" which refers to a two-dimensional brane. They have mass and can have other attributes such as charge. Physicists often study fields analogous to the electromagnetic field which live on the worldvolume of a brane. As an open string propagates through spacetime, its endpoints are required to lie on a D-brane. The letter "D" in D-brane refers to a certain mathematical condition on the system known as the Dirichlet boundary condition. M-theory Prior to , theorists believed that there were five consistent versions of superstring theory type I, type IIA, type IIB, and two versions of heterotic string theory. This understanding changed in when Edward Witten suggested that the five theories were just special limiting cases of an eleven-dimensional theory called M-theory. His announcement led to a flurry of research activity now known as the second superstring revolution. The shaded region represents a family of different physical scenarios that are possible in M-theory. In certain limiting cases corresponding to the cusps, it is natural to describe the physics using one of the six theories labeled there. In the s, many physicists became interested in supergravity theories, which combine general relativity with supersymmetry. Whereas general relativity makes sense in any number of dimensions, supergravity places an upper limit on the number of dimensions. The hope was that such models would provide a unified description of the four fundamental forces of nature: Interest in eleven-dimensional supergravity soon waned as various flaws in this scheme were discovered. One of the problems was that the laws of physics appear to distinguish between clockwise and counterclockwise, a phenomenon known as chirality. Edward Witten and others observed this chirality property cannot be readily derived by compactifying from eleven dimensions. Unlike supergravity theory, string theory was able to accommodate the chirality of the standard model, and it provided a theory of gravity consistent with quantum effects. In ordinary particle theories, one can consider any collection of elementary particles whose classical behavior is described by an arbitrary Lagrangian. In string theory, the possibilities are much more constrained: They found that a system of strongly interacting strings can, in some cases, be viewed as a system of weakly interacting strings. This phenomenon is known as S-duality. It was studied by Ashoke Sen in the context of heterotic strings in four dimensions [39] [40] and by Chris Hull and Paul Townsend in the context of the type IIB theory. This duality implies that strings propagating on completely different spacetime geometries may be physically equivalent. In , Eric Bergshoeff, Ergin Sezgin, and Paul Townsend showed that eleven-dimensional supergravity includes two-dimensional branes. Shortly after this discovery, Michael Duff , Paul Howe, Takeo Inami, and Kellogg Stelle considered a particular compactification of eleven-dimensional supergravity with one of the dimensions curled up into a circle. If the radius of the circle is sufficiently small, then this membrane looks just like a string in ten-dimensional spacetime. In fact, Duff and his collaborators showed that this construction reproduces exactly the strings appearing in type IIA superstring theory. Matrix theory physics In mathematics, a matrix is a rectangular array of numbers or other data. In physics, a matrix model is a particular kind of physical theory whose mathematical formulation involves the notion of a matrix in an important way. A matrix model describes the behavior of a set of matrices within the framework of quantum mechanics. This theory describes the behavior of a set of nine large matrices.

4: Long strings in two dimensional string theory and non-singlets in the matrix model - IOPscience

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5: One-Dimensional Versus Two-Dimensional Modeling Â» Hydraulically Inclined

We interpret the models as string theories characterized by a set of coupling constants associated to worldsheet ramification points of various orders. Our approach is closely related to, but simpler than, the string theory describing two-dimensional Yang-Mills theory.

6: Windey, Paul [WorldCat Identities]

() Long strings in two dimensional string theory and non-singlets in the matrix model. Journal of High Energy Physics , Online publication date: 1-Sep

7: String theory - Wikipedia

In physics, Kaluza-Klein theory (KK theory) is a classical unified field theory of gravitation and electromagnetism built around the idea of a fifth dimension beyond the usual four of space and time and considered an important precursor to string theory.

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