Summary on BIRS Focused Research Group

"String Field Camp"

July 8-24, 2004.

This was an intensive study group of some issues of current interest in string theory and string field theory. Most of the participants of the Camp gave a free form, informal lecture. Typically the lectures lasted for two hours and they inspired lively discussion. Below is a list of the titles and abstracts of the discussions:

1. Dominic Brecher and Mark van Raamsdonk, University of British Columbia: Generally Covariant Actions for Multiple D-branes: We develop a formalism that allows us to write actions for multiple D-branes with manifest general covariance. While the matrix coordinates of the D-branes have a complicated transformation law under coordinate transformations, we find that these may be promoted to (redundant) matrix fields on the transverse space with a simple covariant transformation law. Using these fields, we define a covariant distribution function (a matrix generalization of the delta function which describes the location of a single brane). The final actions take the form of an integral over the curved space of a scalar single-trace action built from the covariant matrix fields, tensors involving the metric, and the covariant distribution function. For diagonal matrices, the integral localizes to the positions of the individual branes, giving N copies of the single-brane action.

2. Anastasia Volovich, KITP: On the Tree-Level S-Matrix of Yang-Mills Theory: We investigate the procedure for computing tree-level amplitudes in Yang-Mills theory from connected instantons in the B-model on $P^{3|4}$, emphasizing that the problem of calculating Feynman diagrams is recast into the problem of finding solutions to a certain set of algebraic equations. We show that the B-model correctly reproduces all 6-particle amplitudes, including non-MHV amplitudes with three negative and three positive helicity gluons. As a further check, we also show that n-particle amplitudes obtained from the B-model obey a number of properties required of gauge theory, such as parity symmetry (which

relates an integral over degree d curves to one over degree n-d-2 curves) and the soft and collinear gluon poles.

3. Marcus Spradlin, KITP: A Googly Amplitude from the B-model in Twistor Space: Recently it has been proposed that gluon scattering amplitudes in gauge theory can be computed from the D-instanton expansion of the topological B-model on $P^{3|4}$, although only maximally helicity violating (MHV) amplitudes have so far been obtained from a direct B-model calculation. In this note we compute the simplest non-MHV gluon amplitudes (++— and +-+–) from the B-model as an integral over the moduli space of degree 2 curves in $P^{3|4}$ and find perfect agreement with Yang-Mills theory.

4. David Berenstein (University of California at Santa Barbara): Deformations of N=4 SYM and integrable spin chain models: Beginning with the planar limit of N=4 SYM theory, we study planar diagrams for field theory deformations of N=4 which are marginal at the free field theory level. We show that the requirement of integrability of the full one loop dilatation operator in the scalar sector, places very strong constraints on the field theory, so that the only soluble models correspond essentially to orbifolds of N=4 SYM. For these, the associated spin chain model gets twisted boundary conditions that depend on the length of the chain, but which are still integrable. We also show that theories with integrable subsectors appear quite generically, and it is possible to engineer integrable subsectors to have some specific symmetry, however these do not generally lead to full integrability. We also try to construct a theory whose spin chain has quantum group symmetry $SO_q(6)$ as a deformation of the SO(6) R-symmetry structure of N=4 SYM. We show that it is not possible to obtain a spin chain with that symmetry from deformations of the scalar potential of N=4 SYM. We also show that the natural context for these questions can be better phrased in terms of multi-matrix quantum mechanics rather than in four dimensional field theories.

5. David Berenstein: University of California at Santa Barbara: A toy model for the AdS/CFT correspondence: We study the large N gauged quantum mechanics for a single Hermitian matrix in the Harmonic oscillator potential well as a toy model for the AdS/CFT correspondence. We argue that the dual geometry should be a string in two dimensions

with a curvature of stringy size. Even though the dual geometry is not weakly curved, one can still gain knowledge of the system from a detailed study of the open-closed string duality. We give a mapping between the basis of states made of traces (closed strings) and the eigenvalues of the matrix (D-brane picture) in terms of Schur polynomials. We connect this model with the study of giant gravitons in $AdS_5 x S^5$. We show that the two giant gravitons that expand along AdS_5 and S^5 can be interpreted in the matrix model as taking an eigenvalue from the Fermi sea and exciting it very much, or as making a hole in the Fermi sea respectively. This is similar to recent studies of the c=1 string. This connection gives new insight on how to perform calculations for giant gravitons.

6. Taejin Lee, Asia Pacific Center for Theoretical Physics, Seoul: Fermion Representation of the Rolling Tachyon Boundary Conformal Field Theory: A free fermion representation of the rolling tachyon boundary conformal field theory is constructed. The representation is used to obtain an explicit, compact, exact expression for the boundary state. By explicit computation, we show that this boundary state correctly depicts the time evolution of the unstable D-brane in the scalar sector.

7. Yutaka Matsuo, University of Tokyo: Cardy states as idempotents of fusion ring in string field theory: With some assumptions, the algebra between Ishibashi states in string field theory can be reduced to a commutative ring. From this viewpoint, Cardy states can be identified with its idempotents. The algebra can be identified with a fusion ring for the rational conformal field theory and a group ring for the orbifold. This observation supports our previous observation that boundary states satisfy a universal idempotency relation under closed string star product.

8. Yoshi Kitazawa, KEK Lab, Tsukuba, Japan: Correlators of Matrix Models on Homogeneous Spaces: We investigate the correlators of $TrA_{mu}A_{nu}$ in matrix models on homogeneous spaces: S^2 and $S^2 x S^2$. Their expectation value is a good order parameter to measure the geometry of the space on which non-commutative gauge theory is realized. They also serve as the Wilson lines which carry the minimum momentum. We develop an efficient procedure to calculate them through 1PI diagrams. We determine the large N scaling behavior of the correlators.

The order parameter shows that fuzzy $S^2 x S^2$ acquires a 4 dimensional fractal structure in contrast to fuzzy S^2. We also find that the two point functions exhibit logarithmic scaling violations.

9. Washington Taylor, MIT: Abelian and nonabelian vector field effective actions from string field theory: The leading terms in the tree-level effective action for the massless fields of the bosonic open string are calculated by integrating out all massive fields in Witten's cubic string field theory. In both the abelian and nonabelian theories, field redefinitions make it possible to express the effective action in terms of the conventional field strength. The resulting actions reproduce the leading terms in the abelian and nonabelian Born-Infeld theories, and include (covariant) derivative corrections.

10. Amanda Peet, University of Toronto: Brane-antibrane systems and the thermal life of neutral black holes: A brane-antibrane model for the entropy of neutral black branes is developed, following on from the work of Danielsson, Guijosa and Kruczenski. The model involves equal numbers of Dp-branes and anti-Dp-branes, and arbitrary angular momenta, and covers the cases p=0,1,2,3,4. The thermodynamic entropy is reproduced by the strongly coupled field theory, up to a power of two. The strong-coupling physics of the p=0 case is further developed numerically, using techniques of Kabat, Lifschytz et al., in the context of a toy model containing the tachyon and the bosonic degrees of freedom of the D0-brane and anti-D0-brane quantum mechanics. Preliminary numerical results show that strong-coupling finite-temperature stabilization of the tachyon is possible, in this context.

11. Shiraz Minwalla, Harvard University: Black hole-black string phase transitions in thermal 1+1-dimensional supersymmetric Yang-Mills theory on a circle: We review and extend earlier work that uses the AdS/CFT correspondence to relate the black hole-black string transition of gravitational theories on a circle to a phase transition in maximally supersymmetric 1+1-dimensional SU(N) gauge theories at large N, again compactified on a circle. We perform gravity calculations to determine a likely phase diagram for the strongly coupled gauge theory. We then directly study the phase structure of the same gauge theory, now at weak 't Hooft coupling. In the interesting temperature regime for the phase transition, we may reduce the 1+1-dimensional theory to

a 0+1-dimensional bosonic theory, which we solve using Monte Carlo methods. We find strong evidence that the weakly coupled gauge theory also exhibits a black hole-black string like phase transition in the large N limit. We demonstrate that a simple Landau-Ginzburg like model describes the behaviour near the phase transition remarkably well. The weak coupling transition appears to be close to the cusp between a first order and a second order transition.

12. Andre Mikhailov, CALTECH: Supersymmetric null-surfaces: Single trace operators with the large R-charge in supersymmetric Yang-Mills theory correspond to the null-surfaces in $AdS_5 \times S^5$. We argue that the moduli space of the null-surfaces is the space of contours in the super-Grassmanian parametrizing the complex $(2|2)$-dimensional subspaces of the complex $(4|4)$-dimensional space. The odd coordinates on this super-Grassmanian correspond to the fermionic degrees of freedom of the superstring.

A number of research collaborations were either initiated or pursued during the camp. Mark van Raamsdonk, Anastasia Volovich and Marcus Spradlin initiated a project on studying a comparison of the spectrum of the plane wave matrix model and the dilatation operator in a certain sector of supersymmetric Yang-Mills theory. Gordon Semenoff and Taejin Lee worked on fermionization of the rolling tachyon conformal field theory.