# REPORT

# Workshop on correlation functions in N = 4 SYM

**(http://faraday.fc.up.pt/cfp-pages/CorrelationFuncs/)**

## Summary

This workshop was intended to cover the subject of correlation functions in N = 4 SYM. There has been a great deal of activity in this area in the past two years and we aimed at bringing together some of the main experts in this field. This is a very rich field that covers field theory and integrability techniques, together with the gauge/gravity duality.

The workshop lasted 4 days (from December 17 to December 20) at Centro de Física do Porto. The format consisted on a morning and afternoon sessions, each with an one hour talk followed by one hour of discussion. The environment was very informal and relaxed which prompted a lot of discussions. Other recent works on AdS/CFT, related with the topic of correlation functions, were also presented.

## Description of the scientific content of and discussions at the event &

## Assessment of the results and impact of the event on the future directions of the field

There are presently two main approaches to the problem of computing correlation functions in N = 4 SYM which were both covered in the event. Namely, determining three and higher point correlation functions at weak coupling and at strong coupling.

At weak coupling, a new technique [1] based on the map of N = 4 SYM operators to spin chain states was designed to explore the integrability of the theory. Such ideas were previously used with success in the two point function or anomalous dimensions problem. Nevertheless new ingredients come into play for higher point functions. This line of research was reviewed in the workshop by Ivan Kostov and Nikolay Gromov. In the talk/discussion of Ivan Kostov, it was reviewed in detail the original work [1], which consisted in the computation of tree level structure constants in the SU(2) sector of N=4 SYM. Moreover, a compact expression for these objects in terms of a determinant was also presented. The discussion that followed the talk was mainly devoted to the classical limit of these results which is hoped to help to make the bridge with the strong coupling computations.

The talk/discussion by Nikolay Gromov was about the classical limit of weak coupling results. In particular, it was presented some ongoing work on the use of coherent states to describe the classical limit of spin chains and correlation functions, which turns out to involve some deep subtleties.

Still in the context of integrability at weak coupling, there was the talk and discussion led by Amit Sever on the relation between Null Polygon Wilson Loop and spin chains based on [2]. This work involves many concepts and techniques used in the correlation functions computations, and in particular weak/strong coupling connections in the classical limit also emerged in that context.

At strong coupling, the recent progress was reviewed by Jonathan Toledo, mainly based on the work [3]. In this regime, the results so far are limited to classical computation using string theory in AdS backgrounds. The problem of computing correlation function at classical level turns out to be the one of computing areas of minimal surfaces in AdS. In this talk, it was presented a general scheme to perform

these calculations which results in an elegant system of functional equations. The solution of this system of equations can then be used to

compute the area corresponding to the correlation function. Many open problems were discussed with the participants, namely the problem of extending these results to higher dimensional AdS spaces, studying the OPE of four point functions to extract some information on structure constants etc.

A different line of research which had as outcome some particular three point functions both at weak and strong coupling was presented by João Penedones based on the work [4]. This work consisted in an extension of the usual flat space Regge theory to AdS spaces (or CFT's by the AdS/CFT duality). As a result, some prediction for correlators were made, namely three point functions involving scalars and SL(2) operators.

The workshop still had a review on the recent progress of the AdS_3/CFT2 duality by Konstantin Zarembo and Diego Bombardelli.

During the workshop, recent advances of this field of research were reviewed. Moreover, one of the main interests of the workshop was the presentation of very relevant work in progress. It was also important to discuss some of the major problems in this field, just to mention a few:

- at weak coupling, one problem is to extend the tree level computations to other sectors of the theory, namely SU(3) and SL(2). Some of the participants are involved in this direction and in the particular case of the SU(3) problem, some ideas about its classical limit were discussed.
- Also at weak coupling, there is the problem of going beyond one loop in the SU(2) sector
- At strong coupling, the computation of the sphere part of the correlation functions at classical level is still lacking.
- Also at strong coupling, the quantum corrections to the classical results are still unknown, which constitutes one of the major challenges on the field.

[1] J. Escobedo, N. Gromov, A. Sever and P. Vieira, JHEP 1109, 028 (2011) [arXiv:1012.2475 [hep-th]].

[2] A.Sever, P.Vieira and T. Wang, JHEP 1212, 065 (2012) [arXiv:1208.0841 [hep-th]].

[3] J. Caetano and J. Toledo, arXiv:1208.4548 [hep-th].

[4] M. S. Costa, V. Goncalves and J. Penedones, arXiv:1209.4355 [hep-th]

# Annexes

**Program**

**Monday, December 17**

12:30 Registration and welcome

13:00 Lunch

15:00 A. Sever - From Polygon Wilson Loops to Spin Chains and Back

16:00 Discussion led by Amit Sever

**Tuesday, December 18**

10:30 I. Kostov – 3 Point Functions at weak coupling

11:30 Discussion led by I. Kostov

13:00 Lunch

15:00 N. Gromov – Classical limit of three point functions

16:00 Discussion

**Wednesday, December 19**

10:30 K. Zarembo – AdS_3/ CFT2 duality

11:30 Discussion led by K. Zarembo and D. Bombardelli

13:00 Lunch

15:00 J. Toledo – chi-Systems for Correlation Functions I

**Thursday, December 20**

10:30 J. Toledo – chi-Systems for Correlation Functions II

11:30 J. Penedones – Conformal Regge Theory I

13:00 Lunch

15:00 J. Penedones – Conformal Regge Theory II

16:00 Discussion

**Participants**

Inês Aniceto (Instituto Superior Técnico)

Diego Bombardelli (Universidade do Porto)

João Caetano (Universidade do Porto & Perimeter Institute)

Miguel Costa (Universidade do Porto)

Marko Djuric (Universidade do Porto)

Vasco Gonçalves (Universidade do Porto)

Lauren Greenspan (Universidade do Porto)

Nikolay Gromov (King's College)

Ivan Kostov (Institut de Physique Théorique CEA, IPhT)

João Penedones (Universidade do Porto)

Amit Sever (Perimeter Institute & Institute for Advanced Study)

Grigory Sizov (King's College)

Jonathan Toledo (Perimeter Institute)

Emilio Trevisani (Universidade do Porto)

Pedro Vieira (Perimeter Institute)

Konstantin Zarembo (Nordita)

Dimitris Zoakos (Universidade do Porto)