Twistor approach to string compactifications

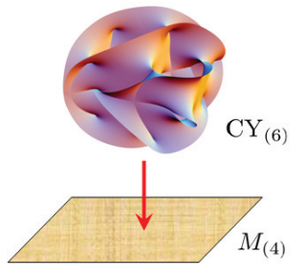
Using twistorial methods, we achieved a substantial progress in obtaining the low energy effective theory resulting from compactifications of string theory with N=2 supersymmetry. In particular, we found an exact description of non-perturbative effects generated by D-branes and NS5-branes, and discovered their relation to integrability.

One of the main problems in string theory is to find the low energy description of its compactifications down to four dimensions. A particularly interesting case corresponds to compactifications preserving N=2 supersymmetry, which for type II superstrings implies that the 6-dimensional space one compactifies on is a Calabi-Yau (CY) manifold. In this case the problem of finding the effective action can be reduced to the problem of finding a metric on the so-called hypermultiplet moduli space ⋮. It is this problem that we tried to solve.

There are two main difficulties: i) ⋮ is a quaternion-Kähler (QK) manifold which is a very complicated type of geometry ; ii) its metric receives quantum, including instanton, corrections. Due to this, several years ago only the classical metric was known together with a few scattered results on quantum corrections.

During last years we succeeded to make a great progress in describing the non-perturbative geometry of ⋮ (see [1]). The keystone of this progress was a twistorial description of QK manifolds which we have developed. The main advantage of this description is that it provides a very efficient way to parametrize them in terms of certain *holomorphic* data on their *twistor spaces*. As a result, all quantum corrections to ⋮ can be encoded in a set of holomorphic functions. Using symmetries and dualities of string theory, we found the functions responsible for all perturbative as well as most of non-perturbative corrections. In string theory, the latter are generated by branes wrapping nontrivial cycles of the compactification manifold. There are two very different types of them : D-branes and NS5-branes. In particular, the corrections they generate have completely different scaling : $exp(-1/g_s)$ and $exp(-1/g_s^2)$, respectively (g is string coupling). We succeeded to incorporate D-brane instantons to all orders and NS5-instantons in the linear approximation. Thus, the last remaining unknown piece of the full picture corresponds to multi-instanton contributions involving NS5-branes.

The twistor approach was also indispensable for several other results closely related to the non-perturbative description of CY compactifications. The most intriguing one is a relation to some integrable structures, such as thermodynamic Bethe ansatz, which led to a conjecture that the inclusion of NS5-instantons may be equivalent to quantization of an integrable system.



Compactification of string theory : one represents 10 dimensional space-time as a product of 4 dimensional Minkowski space and 6 dimensional Calabi-Yau manifold.

Besides, we have obtained a twistorial realization of the so-called wall-crossing phenomenon, calculated quantum corrections to the mirror map, discovered a a new mathematical duality dubbed «QK/HK correspondence», and obtained an explicit description of QK manifolds carrying an isometric action of SL(2,Z). These findings prove the power of the twistor approach and hint for the existence of a beautiful unifying structure behind gravitational theories with N=2 supersymmetry.

Reference

[1] *«Twistor Approach to String Compactifications : a Review»*, S. Alexandrov, Phys. Rept. 522 (2013) 1-57, 1111.2892 [hep-th]

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