Strings, Intersecting Brane Worlds and Flux Compactifications ◇

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String theory provides a promising framework for a unified description of all forces and matter in nature, including a consistent formulation of quantum gravity. One of the main focus of our research was the investigation of intersecting brane worlds (for a review see [1]), which is a field that was mainly developed in our group. The general picture is that one uses type II orientifolds which various kinds of D-branes [2]. The background space is given by four-dimensional Minkowski space-time times an internal six-dimensional manifold, in the simplest case being a Calabi-Yau manifold. However also other spaces with torsion are possible, which can be classifided according to their so-called mathematical group structure [3,4]. The D-branes completely fill the four-dimensional Minkowski space-time and are wrapped on some cycles inside the compact six-dimensional space. Generically they intersect on some lower-dimensional submanifolds, which can be even points in the compact space. Using intersecting brane worlds one can incorporate non-Abelian gauge bosons, which are open strings living on the world volume of the D-branes. In addition, the matter fields are open strings living on lower-dimensional intersections of the D-branes. This scenario is depicted in the following figure.

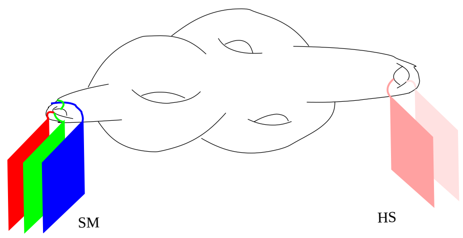

Fig. 1: The picture shows a six-dimensional space with D-branes wrapped around internal cycles which intersect each other. The left D-branes gives rise to the Standard Model, whereas the right D-branes correspond to some hidden sector. Standard Model D-branes and hidden D-branes do not have common intersections. The directions transversal to the six-dimensional space denote four-dimensional Minkowski space-time.

We could show that in intersecting brane worlds one can construct models which possess many features of the Minimal Supersymmetric Standard Model (MSSM). The embedding of the MSSM is still an ungoing research topic in string theory, also using other constructions like heterotic strings. We also addressed some other phenomenological questions like gauge coupling unification [5]. In addition we computed important parts of the low-energy effective action of intersecting branes by calculating string scattering amplitudes involving both closed and open strings [6,7]. Finally we also discussed the socalled statistics of brane constructions [8], i.e. how many possible string vacua with D-branes (and also fluxes – see below) can be constructed. This is indeed a very large number of order $10^{500-1000}$ or more, giving rise to the picture of the socalled string landscape. One expects that a considerable large number of vacua inside the string landscape have good phenomenological properties, even with a positive and small cosmological constant.

Besides the D-branes one can also add socalled 3-form fluxes inside the compact space. These fluxes have the nice property that they can fix many of the geometric moduli of the compact space. In addition certain fluxes can induce a spontaneous breaking of space-time supersymmetry. We discussed some of the general physical properties of flux compactifications [9], and combined fluxes with intersecting D-branes [10]. Using this and the results on the effective action we computed the pattern of the softly supersymmetry breaking parameters in type II orientifold compactifications with intersecting D-branes [11,12,13].

References

[1] D. Lüst, Class. Quant. Grav. **21** (2004) S1399, arXiv:hep-th/0401156
[2] R. Blumenhagen, V. Braun, B. Körs and D. Lüst, JHEP **0207** (2002) 026, arXiv:hep-th/0206038
[3] G.L. Cardoso, G. Curio, G. Dall'Agata, D. Lüst, P. Manousselis and G. Zoupanos, Nucl. Phys. **B652** (2003) 5, arXiv:hep-th/0211118]
[4] D. Lüst and D. Tsimpis, JHEP **0502** (2005) 027, arXiv:hep-th/0412250
[5] R. Blumenhagen, D. Lüst and S. Stieberger, JHEP **0307** (2003) 036, arXiv:hep-th/0305146
[6] D. Lüst and S. Stieberger, arXiv:hep-th/0302221
[7] D. Lüst, P. Mayr, R. Richter and S. Stieberger, Nucl. Phys. **B696** (2004) 205, arXiv:hep-th/0404134
[8] R. Blumenhagen, F. Gmeiner, G. Honecker, D. Lüst and T. Weigand, arXiv:hep-th/0411173
[9] G. Curio, A. Krause and D. Lüst, arXiv:hep-th/0502168
[10] R. Blumenhagen, D. Lüst and T. R. Taylor, Nucl. Phys. **B663** (2003) 319, arXiv:hep-th/0303016
[11] D. Lüst, S. Reffert and S. Stieberger, Nucl.Phys. **B706** (2005) 3, arXiv:hep-th/0406092
[12] D. Lüst, S. Reffert and S. Stieberger, arXiv:hep-th/0410074
[13] D. Lüst, P. Mayr, S. Reffert and S. Stieberger, arXiv:hep-th/0501139

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