

Annual Report

Funding Programme:	Helmholtz Young Investigators Groups
Project ID No.:	HZ-NG-603
Project Title:	Strings and Cosmology – an Interface for Testing Fundamental Theories
Group Leader:	Alexander Westphal
Helmholtz Centre:	DESY Hamburg
Participating University:	
Report Period (=Calendar Year):	05/2011-04/2012

1) Group Structure

Please report briefly on the structure and personnel development of your group.

Pascal Vaudrevange, who initially joined the group in October 2010, will complete his quite successful postdoc in September 2012. Then, in October 2012, Francisco Pedro, who is now finishing his PhD in the area of string cosmology under the supervision of J. P. Conlon at Oxford University, UK, will join the YIG in October 2012.

Koushik Dutta, the 2nd postdoc who became an effective member of the YIG since October 2010 as his funding proceed through him being a part of the DFG Collaborative Research Center SFB 676, project C6, has left us at the end of 2011, as he went on to his new position as an assistant professor of theoretical physics at the IISER Bhopal Institute in Bhopal, India.

Markus Rummel, who remains a PhD student in the YIG, having joined via the DFG Collaborative Research Center SFB 676, C6, in October 2010.

It continues to prove difficult to find further PhD students which fit the profile of the group: A candidate needs to combine sufficient mathematical training and knowledge in courses like advanced quantum field theory and general relativity, and an interest in more speculative theoretical work (i.e. not as closely connected to potential data as, say, SUSY phenomenology for the LHC), and this without being too strongly formal (as this can hinder the transfer of results and intuition due to the considerably different language used in the formal/pure mathematics, and theoretical physics). Such candidates are not easy to find – Markus Rummel was a lucky and excellent (!) coincidence so far (in particular in the wider German area; PhD candidates from, say, the US, where the combination of training and interests discussed is more easily found, are not easily wooed to take the transition to Europe).

2) Network

Please describe how you / your research group are integrated within the Helmholtz Centre and the partner university (e.g. as member of committees).

The YIG is fully integrated in the activities of the theory group at DESY, and collaborates very close with the II. Institute for Theoretical Physics of Hamburg University. In addition, the YIG group leader remains a PI of the DFG Collaborative Research Center SFB 676, C6.

The YIG has co-organized the recent workshop “Implications of the Early LHC for Cosmology”:

<https://indico.desy.de/conferenceDisplay.py?confId=5231>

at DESY, and it will co-organize the 2013 conference „String Phenomenology“ here at DESY.

3) Satisfaction

How satisfied are you with the general working conditions provided by the Helmholtz Centre / partner university? Is there anything that meets your criticism?

In general, I am quite satisfied with the working conditions at DESY. The interaction within the theory group, and with the work-related travel office (the part of administration I have to deal with by far the most often) is characterized by a very flexible and informal, friendly style, and almost absent hierarchies. This is very beneficial for the scientific work. I may also mention here, that DESY has a very general travel funding arrangement to the extent, that I have never seen any scientifically justified travel to a conference or seminar visit by any member of the theory group being denied. The funds available in particular for the travel of students and postdocs as well as for inviting short- and long-term visitors by DFG Collaborative Research Center SFB 676 add to this. This is significant, as reports in particular from the University situation of travel and visitor funds sound significantly worse. Consequently, this allows for a rich structure for international scientific exchange on conferences, and a lively local seminar and visitor program.

There are only two practical complaint I may have.

The first concerns the access to the Helmholtz-funded part of the materials budget of a YIG (like the acquisition of text books, computing hardware etc). It does not seem very useful and reasonable that acquisitions planned using the Helmholtz-funded part have to approved centrally by the relevant DESY directorate. This can lead to considerable delays, and has in my case, prevented me from providing my first postdoc in 2010 with a laptop computer for work (which given the frequent travel to conferences only seems practical). The theory group has remedied this meanwhile as a whole, by providing theory postdocs in general with access to DESY laptop computers – but it is not clear why this was blocked in the first place, and needed to be approved by the central DESY administration at all (as long as the Helmholtz-funded part of the YIG is concerned). In particular, there is information, that e.g. similarly structured Emmy-Noether groups at the University, or also YIGs in the experimental departments of DESY, do not seem to have the same administrative hurdle to clear when they provide group members with personal computing hardware. (One should also bear in mind, that providing quick and effortless access to the most recent and up-to-date personal computing hardware for scientists is a relevant criterion for future postdoc offers, as I know very well that most of the e.g. US-based excellent postdocs factor such things into their decision on whether to accept an offer!)

The other concerns the general structure of IT-related network structure and personal computing device acquisition: The heavy focus on extensively backed-up network structure everywhere, contrary to present-day personal computing practice (nobody wants her or his laptop being backed-up centrally anymore!), and on PC-only solutions is just kind of behind-the-times (there is heavy bias against non-PC machines, like e.g. Macs, or tablet devices, which however have become very quickly very widespread in the particle physics community AND very useful scientifically, too!). This is not unsurmountable in practice, but could structured much more user-friendly.

4) Scientific Progress / Milestones

How has your work plan progressed? Which important milestones could be achieved during the report period? Is the progress of your work in accordance with original planning or has the work plan been changed?

(arXiv:1107.2115) Together with my student Markus Rummel we derived a sufficient condition for realizing meta-stable de Sitter vacua with small positive cosmological constant within type IIB string theory flux compactifications with spontaneously broken supersymmetry. There are a number of 'lamp post' constructions of de Sitter vacua in type IIB string theory and supergravity. We showed that one of them -- the method of 'Kähler uplifting' by F-terms from an interplay between non-perturbative effects and the leading α' -correction -- allows for a more general parametric understanding of the existence of de Sitter vacua. The result is a condition on the values of the flux induced superpotential and the topological data of the Calabi-Yau compactification, which guarantees the existence of a meta-stable de Sitter vacuum if met. Our analysis explicitly includes the stabilization of all moduli, i.e. the Kähler, dilaton and complex structure moduli, by the interplay of the leading perturbative and non-perturbative effects at parametrically large volume.

(arXiv:1109.5182) With Koushik Dutta and Pascal Vaudrevange, we showed the absence of the usual parametrically large overshoot problem of small-field inflation if initiated by a Coleman-De Luccia (CDL) tunneling transition from an earlier vacuum in the limit of small inflationary scale compared to the tunneling scale. For low-power monomial exit potentials $V(\phi) \sim \phi^n$ with $n < 4$, the calculations yield an expression for the amount of overshoot. This is bounded from above by the width of the steep barrier traversed after emerging from tunneling and before reaching a slow-roll region of the potential. For $n \geq 4$ we showed that overshooting is entirely absent. The result extends through binomials to a general potential written as a series expansion, and to the case of arbitrary finite initial speed of the inflaton. This places the phase space of initial conditions for small-field and large-field inflation on the same footing in a landscape of string theory vacua populated via CDL tunneling.

(arXiv:1110.2380, arXiv:1202.2721) In two subsequent papers we calculated, together with Koushik Dutta, Cecelie Hector, Pascal Vaudrevange, and Thomas Konstandin, the first new exact tunneling solution with exact and explicit expression for the tunneling action integral $B = S_E(\phi) - S_E(\phi_0)$ in flat space, since the piecewise-linear potential solution by Duncan & Jensen in 1992, and the influence on tunneling by kinks in the potential energy of a scalar field which can arise in leading-order treatments of string theory solutions.

Several of these results in 2011 have enabled us now to perform a first statistical analysis of the relative prevalences of large-field and small-field inflation in Calabi-Yau flux landscapes of type IIB string theory. These results have been presented in several talks in the US in 2012, and will be published very soon. They lead to a final, mathematically well posed question on the distribution of certain microscopic properties on the space of elliptically-fibered Calabi-Yau 4-fold compactifications of F-theory, which will be studied concretely using the known formal methods of toric geometry during the coming months. This brings the completion of the first major milestone within reach: Acquiring an understanding about a possible statistical prediction of the expected level of primordial gravitational waves during inflation from an accessible and large part of the landscape of string theory.

Besides there are two more publications in preparation which will use explicit constructions of elliptically-fibered Calabi-Yau 4-folds in F-theory where the method of 'Kähler uplifting' described in the effective 4d supergravity in 2011 (see above) can be explicitly realized in a full F-theoretic string construction. Simultaneously, this construction also will also show the existence of potentially extremely large-rank non-Abelian ADE singularities in F-theory even on compact Calabi-Yau 4-folds.

5) Financial Plan / Time Schedule

Can you comply with the financial plan and time schedule or do you see a need for adjustment?

The budget proves so far fully sufficient for the research activities undertaken. The project is on track concerning the timeline which was initially set out. Several of the published results in 2011 have enabled us now to perform a first statistical analysis of the relative prevalences of large-field and small-field inflation in Calabi-Yau flux landscapes of type IIB string theory. These results have been presented in several talks in the US in 2012, and will be published very soon. They lead to a final, mathematically well posed question on the distribution of certain microscopic properties on the space of elliptically-fibered Calabi-Yau 4-fold compactifications of F-theory, which will be studied concretely using the methods of toric geometry during the coming months. This brings the completion of the first major milestone within reach: Acquiring an understanding about a possible statistical prediction of the expected level of primordial gravitational waves during inflation from an accessible and large part of the landscape of string theory.

6) Status

Do you hold a joint Junior Professorship or a W2/W3 Professorship? Do you aim for such a position? What is the status of your negotiations in this respect?

I do not currently hold a joint Junior or W2/W3 Professorship. I have not yet decided on whether to pursue a potential professorship in the future.

7) Teaching Activities of the Group Leader

Summer semester 2011:

- Advanced Placement Course (APC-T) “Theoretical Astroparticle Physics and Cosmology” (4+2), Hamburg University, summer term 2011
http://www.desy.de/~westphal/cosmology_2011/cosmology.html
- SFB lectures (3 x 90 mins): “From Inflation to the Planck Scale”, DESY, Hamburg, Germany, May 2011
http://www.iexp.desy.de/sfb676/events/sfb_lectures/
- lectures on “Inflation”, CP3-Origins/DESY/Göttingen Autumn School on Particle Physics and Cosmology, DESY, Hamburg, Germany, October 2011
<https://indico.desy.de/conferenceDisplay.py?confId=4623>

8) Publications of the Group

Papers:

- 1) "A sufficient condition for de Sitter vacua in type IIB string theory", M. Rummel & A. Westphal, JHEP **1201** (2012) 020, arXiv:1107.2115
- 2) "The Overshoot Problem in Inflation after Tunneling", K. Dutta, P.M. Vaudrevange & A. Westphal, JCAP **1201** (2012) 026, arXiv:1109.5182
- 3) "More Exact Tunneling Solutions in Scalar Field Theory", K. Dutta, C. Hector, P.M. Vaudrevange & A. Westphal, Phys. Lett. B **708** (2012) 309-313, arXiv:1110.2380
- 4) "On the Existence of Tunneling Bounce Solutions in Piecewise Linear Potentials", K. Dutta, C. Hector, T. Konstandin, P.M. Vaudrevange & A. Westphal, arXiv:1202.2721
- 5) "A Toy Model For Single Field Open Inflation", P.M. Vaudrevange & A. Westphal, arXiv:1205.1663

Talks:

- 1) "A sufficient condition for IIB/F-theory dS vacua", M. Rummel & A. Westphal, invited talk, String Theory and Precision Cosmology, Ithaca, USA, July 2011
<http://www.ins.cornell.edu/Events/StringCosmo11/Program.html>
- 2) "The overshoot problem in inflation after tunneling", K. Dutta, P.M. Vaudrevange, A. Westphal, invited talk, String Phenomenology, Madison, USA, August 2011
<http://conferencing.uwex.edu/conferences/stringpheno2011/PlenarySessions.cfm>
- 3) "The Overshoot Problem in Inflation after Tunneling", K. Dutta, P.M. Vaudrevange, A. Westphal, International Conference on Particle Physics and Cosmology - COSMO 11 (COSMO 2011), Porto, Portugal, August 2011
[poster \(pdf\)](#)
- 4) "A sufficient condition for IIB/F-theory dS vacua", M. Rummel & A. Westphal, DESY Theory workshop 2011, DESY, Hamburg, Germany, September 2011
<http://th-workshop2011.desy.de/e98837/e98839/>
- 5) "The Overshoot Problem in Inflation after Tunneling", K. Dutta, P.M. Vaudrevange & A. Westphal, DESY Theory workshop 2011, DESY, Hamburg, Germany, September 2011
<http://th-workshop2011.desy.de/e98837/e98839/>
- 6) "A sufficient condition for IIB/F-theory dS vacua", M. Rummel & A. Westphal, IRTG PhD days 2011, DESY, Hamburg, Germany, October 2011
<https://indico.desy.de/contributionDisplay.py?contribId=13&sessionId=1&confId=4734>
- 7) "A sufficient condition for IIB/F-theory dS vacua", M. Rummel & A. Westphal, CP3-Origins/DESY/Göttingen Autumn School on Particle Physics and Cosmology, DESY, Hamburg, Germany, October 2011
<https://indico.desy.de/conferenceDisplay.py?confId=4623>
- 8) "The Overshoot Problem in Inflation after Tunneling", K. Dutta, P.M. Vaudrevange, A. Westphal, Seminar Talk, Aachen, Germany, October 2011
- 9) "The Overshoot Problem in Inflation after Tunneling", K. Dutta, P.M. Vaudrevange, A. Westphal, Seminar Talk, Göttingen, Germany, November 2011
- 10) "A sufficient condition for IIB/F-theory dS vacua", M. Rummel & A. Westphal, poster at the "The 29th Jerusalem Winter School in Theoretical Physics", Jerusalem, Israel, December 2011
<http://www.as.huji.ac.il/schools/phys29>
- 11) "A sufficient condition for IIB/F-theory dS vacua", M. Rummel & A. Westphal, Nordic String Theory Meeting 2012, Copenhagen, Denmark, February 2012
<https://indico.nbi.ku.dk/conferenceTimeTable.py?confId=397#all>
- 12) "Tensors in the landscape", A. Westphal, invited seminar talk, Stanford University, USA, February 2012
<http://www.stanford.edu/group/sitp/SITP%20Seminar%20Table.htm>
- 13) "Inflation and the Landscape of String Theory", A. Westphal, invited seminar talk, SETI institute, Mountain View, California, USA, February 2012
<http://www.seti.org/weekly-lecture/inflation-and-landscape-string-theory-0>
<http://www.youtube.com/watch?v=t2Ov6KNZ7-Y>
- 14) "Tensors in the landscape", A. Westphal, invited seminar talk, UC Berkeley, USA, February 2012
http://www-theory.lbl.gov/cgi-bin/talks/plans.cgi?cal_id=0&cal_start_month=2&cal_start_year=2012
- 15) "The Overshoot Problem in Inflation after Tunneling", K. Dutta, P.M. Vaudrevange & A. Westphal, Beyond the Standard Model 2012, Bad Honnef, Germany, March 2012
<http://www.desy.de/uni-th/stringth/bad-honnef/2012/>
- 16) "A sufficient condition for IIB/F-theory dS vacua", M. Rummel & A. Westphal, Beyond the Standard Model 2012, Bad Honnef, Germany, March 2012
<http://www.desy.de/uni-th/stringth/bad-honnef/2012>
- 17) "Tensors in the landscape", A. Westphal, invited talk, The Particle Physics and Cosmology of Supersymmetry and String Theory, Philadelphia, USA, March 2012
http://www.physics.upenn.edu/Int_L_program/agenda.html

9) External Funding
The YIG group leader has access to additional funds for travel and visiting scholars from the DFG Collaborative Research Center SFB 676 by virtue of being a PI for project C6.
10) Patent Applications <i>No. of pending/granted patents</i>
11) Awards received by Group Members / Professorship Appointments offered to Group Leader