CURRICULUM VITAE

Avihay Kadosh

Personal

Name: Avihay Kadosh	Place of birth: Haifa, Israel
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Military service

1996-1999, Combat soldier (Infantry).

Education

Current:	PhD in Physics, Center For Theoretical Physics, RUG, April 2012.
	Supervisor: Prof. Elisabetta Pallante.
Graduate:	M.Sc. in Physics, Department of Physics, Technion, Israel, March 2006.
	Grade Average: 94
	Thesis Grade: 87
	Supervisor: Prof. Paul Singer(deceased) , Prof. Michael Gronau.
Undergrad:	2003 B.A. in Physics.
	Department of Physics, Technion, Israel. Grade Average: 83.6

Research interests

Quantum Field theory, Particle physics, Gravity, Cosmology, Extra Dimensions, Quantum Gravity.

Research thesis for M.Sc. degree: *"The Two-Photon Exclusive Decays $D^0 \to \eta(\eta', \bar{K}_0^*)\gamma\gamma$ ".*

Research thesis for PhD degree (Defended on April 23, 2012): *"The Flavor of Symmetries in a Warped Extra Dimension and a "Slinkyvolving" View of Creation".*

Current Research: Thick Brane Scenarios and cosmology, Non-Abelian Discrete Flavor Symmetries, Particle Phenomenology in Warped Extra Dimensions.

Languages

Hebrew (mother tongue), English (fluent), Dutch (good).

Computer Skills

Environment: Windows (fluent), Unix/Linux (good).
Languages and softwares: Wolfram Mathematica (fluent), Matlab (good), C/C++ programming (fair), MADGRAPH, ALPGEN, Pythia, Delphes (beginner). Excellent knowledge of sound design, sound manipulation and music composition softwares: Cubase, WaveLab, SoundForge, Reaktor, Waves Diamond Bundle, TC Native Plugins and many others.

Teaching

2002-2005- Teaching Assistant , Physics Department, Technion.
Statistical Physics (second year) and Physics 3 (modern physics, second year)
2002-2005- Physics Lab Instructor (first second and third year), Physics Department, Technion
2008-2012- Teaching Assistant, QFT Master course, Physics Department, Univ. of Groningen.

Conferences, Talks, Schools and Travels

- Symposium: "Trends in Theory–7th biennial symposium of the Dutch Research School of Theoretical Physics (DRSTP)" , Dalfsen, The Netherlands, 31 May – 1 June 2007. Poster: "Non perturbative aspects of domain wall branes and brane cosmology".

- School: "DRSTP Theoretical High Energy Physics (THEP)" school, Driebergen, The Netherlands, February 28 January – 8 February 2008. Presentation/Talk:"Thick FRW branes-The quest for a dynamical model of our universe".

- School: "Parma international school for theoretical physics", Parma, Italy, 8 September – 13 September, 2008.

- School: The 26th winter school on theoretical physics "Particle physics at the age of LHC" Hebrew University, Jerusalem, Israel, 28 December 2008 – 9 January 2009.

- School: "DRSTP THEP school", Driebergen, The Netherlands, 16–27 February 2009: Talk: "An A4 flavor model for quarks and leptons in warped geometry".

- Symposium: "Trends in Theory–7th biennial symposium of the Dutch Research School of Theoretical Physics (DRSTP)", Dalfsen, The Netherlands, 14 May – 15 May 2009. Poster: "An A4 flavor model for quarks and leptons in warped geometry".

- Conference: "Planck 2010", CERN, Geneva, Switzerland, 31/5/2010-4/6/2010. Talk(cancelled): "CP violation and FCNC in a warped A4 flavor model".

- Symposium: "Discrete 2010 – The Symposium on Prospects in the Physics of Discrete Symmetries", Sapienza Universita di Roma, Rome, Italy, 6–11 December 2010. Talk(accepted): "Suppression of flavor violation in an A4 warped flavor model"

- Workshop: "FLASY 2011 – Workshop on flavor symmetries and consequences in accelerators and cosmology", University of Valencia, Valencia, Spain, 11–14 July 2011. Talk(invited): "Warped Extra Dimensions and Models of Discrete Flavor Symmetries".

- Symposium: "SSP 2012– 5th International Symposium on Symmetries in Subatomic Physics", KVI, Groningen, The Netherlands, 18–22 June 2012. Talk: " Flavor and CP violation in a warped extra dimension".

- Workshop: "FLASY 2012 – 2nd Workshop on flavor symmetries and consequences in accelerators and cosmology", Dortmund University, Dortmund, Germany, 30 June–4 July 2012. Talk(invited): "RS-A_4, θ_{13} and LFV".

- Group Seminar: "Slinky evolution of domain wall (DW) brane cosmology", 12 July 2012, Center for theoretical physics, University of Groningen.

- Invited Seminars: *"Slinky evolution of DW brane cosmology"* – EPFL Lausanne (10/9/2012). *"Flavor violation and θ_{13} in the A_4 Randall-Sundrum model"* – Cornell Univ. (5/10/2012), Stoney Brook (10/10), Brookhaven (12/10/2012)), University of Virginia (17/10/2012), UC Riverside (22/10/2012), UC Irvine (24/10/2012).

Awards, honors and scholarships

- Dean's honor list at the Technion, Israel

  –Faculty of physics Dean's honors list in 2000, 2001 and 2002.

- Scholarship: "The Irwin and Joan Jacobs Graduate school" full master student scholarship (tuition+allowance) for the years 2003–2005.

- Scholarship: The "Ubbo Emmius" doctoral scholarship for four years of full time study from the end of 2006 to February 2011 inclusive.

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December 30, 2012

List of Publications

1. A.kadosh , *"The Two-Photon Exclusive Decays $D^0 \to \bar{K}^0(\eta, \eta')\gamma\gamma$"* , (Master Thesis)
2. A.Kadosh and E.pallante, *"An A4 flavor model for quarks and leptons in warped geometry"*, JHEP **1008**, 115 (2010) [arXiv:1004.0321 [hep-ph]]
3. A.Kadosh and E.Pallante, *"CP violation and FCNC in a warped A4 flavor model"*, JHEP **1106**, 121 (2011) [arXiv:1101.5420[hep-ph]]
4. A.Kadosh, *"Suppression of flavor violation in an A_4 warped extra dimensional model"*, J. Phys. Conf. Ser. **335**, 012019 (2011), [arXiv:1102.4105[hep-ph]]
5. A.Kadosh *"An RS-A4 flavor model in light of T2K and MEG"*, (Appearing in the proceedings of FLASY 2011), [arXiv:1201.5525[hep-th/gr-qc]]
6. A.Kadosh, A.Davidson, E.Pallante ,*"Slinky evolution of domain wall brane cosmology"*, Physical Review **D** 86, 124015(2012), [arXiv:1202.5255[hep-th/gr-qc]]
7. A.Kadosh, *"RS-A4, θ_{13} and LFV"*, [arXiv:1210.6239[hep-ph]], (Appearing in the proceedings of FLASY 2012).
8. A.Kadosh, *"The flavor of symmetries in a warped extra dimension and a 'Slinkyvolving' view of creation"*, (PHD thesis, ISBN:978-90-367-5500-9)
9. A.Kadosh *"RS-A_4 relaxation of Flavor and CP violation"*, (Proceedings of SSP 2012), Journal of Hyperfine Interactions, 0304-3843(2013) .

Work in Progress

10. A.Kadosh, G.Perez, P.Paradisi *"Revisiting $D^0 - \bar{D}^0$ mixing in Quark-Squark alignment models"'*, [arXiv:1302.xxxx[hep-ph]]
11. A.Kadosh, *"RS-A4 θ_{13} and LFV"*, [arXiv:1302.xxxx[hep-ph]].
12. A.kadosh, *"Flavor structure of non anarchic warped penguins and $\mu \to e\gamma$ in RS-A_4"*, [arXiv:1303.xxxx[hep-ph]].
13. A.Kadosh, A.Davidson, E.Pallante, *"Non factorizable extra dimensional geometries, covariance and cosmology"*, [arXiv:1303.xxxx[hep-th/gr-qc]]

Avihay Kadosh (a.kadosh@rug.nl, avihaykadosh@gmail.com), December 2012

Research statement

As a musician and a scientist I was always puzzled by the way abstract ideas and patterns inspired by beauty and intuition, that are born in one's mind, turn out to be in correspondence with yet unknown "natural laws" and manifest themselves in various aspects of nature and human existence.

The idea that we might live inside a domain wall in an extra dimensional space time goes back to Rubakov and Shaposhnikov. However, the interest in phenomenological models with extra dimensions has significantly raised after the famous works of Arkani-Hamed, Dimopolous and Dvali (ADD) on large compactified extra dimensions and the works of Randall-Sundrum (RS) based on warped compactifications and inspired by the Horava-Witten solution of Supergravity. In particular, the RS models have drew a lot of attention in the last decade and were studied, implemented, modified and extended in various areas of research such as Gravity, cosmology and particle phenomenology. Currently, brane world cosmology, which is usually studied in the context of the (1-brane) RS2 or Dvali-Gabadadze-Porrati (DGP) scenarios, still fails to provide us with concrete predictions, which can be confronted with WMAP and Type 1a supernova data. Consequently, the most promising experimental constraints, which can be currently imposed on RS phenomenological models, come from particle physics, or more explicitly from model independent bounds on flavor violation.

My current research focuses on two distinct aspects of brane world scenarios, the first is the construction of RS flavor models with additional discrete non abelian flavor symmetry, in which flavor violations are relaxed compared to the flavor anarchic and other RS flavor frameworks. The second is the attempt to find a domain wall configuration admitting a cosmologically plausible "thin" brane limit, which can serve as a setup for numerous cosmological and phenomenological constructions.

The ultimate goal of this double line of research is the establishment of warped extra dimensional setups, which are relevant for the study of both particle phenomenology and cosmology and confronting them with the wealth of experimental data expected to come from LHC, PLANCK and more.

Previous and Current Work

RS-A_4 flavor model

The task at hand was to construct a flavor model based on the non abelian discrete flavor symmetry, A_4 and implemented in the RS1 setup, which yields realistic masses and mixing patterns in the quark and lepton sectors, with the minimal number of assumptions and parameter assignments. Me and my supervisor Elisabetta Pallante published our results in Ref.[2]. Once the flavor structure of the model is established, it was shown that in oppose to flavor anarchic frame works, the dangerous tree level Kaluze-Klein (KK) gluon exchange contribution to ϵ_K vanishes due to the degeneracy of left handed (LH) bulk mass parameters. For the same reasons, the down type contribution to the neutron EDM is also vanishing, evading us from the little CP problem associated with RS-anarchic setups. The choice of the degenerate LH bulk mass parameter was shown to be significantly constrained by electroweak precision measurements and perturbativity bounds of the top quark Yukawa coupling. The model was shown to be in good agreement with recent indications of $\theta_{13} > 0$ in Ref. [4].

Relaxation of flavor and CP violation in the RS-A_4 scheme

The estimations of the NP contributions in the RS-A_4 model neglected the effect of overlaps associated with the fact that all fields in our model propagate in the bulk. In our subsequent work (Ref. [3] in the list of publications) we first developed a scheme in which overlap correction factors are translated to matrices in flavor space, which are then combined with the spurion analysis of the IR localized Higgs case. The resulting contribution to the neutron EDM still

turned out to be very suppressed in this scheme and to be more precise, it was necessary to go beyond the mass insertion approximation and explicitly obtain the full flavor structure of the fermionic zero modes and first KK modes, considering the overlap effects associated with the bulk Yukawa interactions. Unlike the flavor anarchic case a one generation approximation failed to provide us with a clear insight on possible cancellation mechanisms, associated with the remnant A_4 structure in the leading order (LO) and next to leading order (NLO) mass and Yukawa matrices. Consequently, the 3-generation (zero+KK) mass matrices (12×12) were diagonalized to obtain explicitly the physical coupling of fermionic zero and KK modes.

Interestingly, the remnant A_4 flavor structure allowed for an approximate analytical diagonalization of the full mass matrices and still significantly relaxes the corresponding bounds on KK masses arising from the nEDM, ϵ'/ϵ_K, $b \to s\gamma$ and Higgs mediated FCNC. The methods we developed can be used in other RS-flavor schemes, based on alternative/additional symmetries. Our results were published in JHEP (Ref. [3]) and presented in the "Discrete 2010" symposium and FLASY (2011 and 2012) workshops. The proceedings of my contributions, containing additional results for custodial anarchic models and θ_{13} can be found in Ref. [4] and [5] of my publication list. A thorough analysis of the RS-A_4 predictions for θ_{13} (fitting well RENO & Daya Bay), $B_{s,d} \to \mu^+\mu^-$ (LHCb, weak constraints) and $\mu \to e, 3e$ (future experiments, strong constraints) will be published shortly (Ref.[11]) and the most important results appear in Ref.[7].

Revisiting $D^0 - \bar{D}^0$ mixing in quark-squark alignment models

In the MSSM the dominant new physics contributions to $D^0 - \bar{D}^0$ mixing come from one-loop box diagrams with intermediate squarks and gluinos/charginos/neutralinos. These contributions were studied extensively in the literature using the mass insertion approximation (MIA) for the squark masses. In particular, it was shown that in the context of quark-squark alignment models the constraints coming from neutral D mixing imply a bound $\delta = (\tilde{m}_1 - \tilde{m}_2)/(\tilde{m}_1 + \tilde{m}_2) < 0.3$ on the degeneracy of the masses of the first two generations squarks. This bound seemed to become signifcantly stronger for the CP violating effect in D meson mixing ($\delta < 0.035$). In this work we study in detail the non-trivial interplay between gluino, chargino and neutralino contributions to $D^0 - \bar{D}^0$ mixing, considering the most recent upper bounds on gaugino masses from direct searches by CMS and ATLAS and up to date measurments of the $D^0 - \bar{D}^0$ parameters by LHCb. The goal is to study the viability of a spectrum with two light 1st and 2nd generation squarks ($\tilde{m}_{1,2} \sim 0.5$TeV). By pefroming the full calculation (no MIA), we demonstrate that the constraint from CP violation in neutral D mixing is weaker than expected and can actually increase with degeneracy. We also show that it is exactly in the small $\tilde{m}_{1,2}$ region, in which the interplays between the (usually dominant) gluino contribution and the (usually subdominant) chargino, neutralino and gluino/neutralino contributions are most important. In total, it seems that a spectrum with two light squarks around 0.5TeV will require a degeneracy of order 10%. The full results, including many additional insights will be published shortly in Ref.[10] of the list of publications.

Domain-Wall Brane Cosmology

The most simple dynamical realization of a 4D brane is the thin limit of a domain wall configuration of a scalar field in 5D. Models of this sort, admitting the RS2 scenario as a limit, have already been constructed in the literature and were later generalized to account for AdS_4 and dS_4 branes. The thin dS case introduces a problem in the form of curvature singularity in the center of the domain wall configuration which can be overcome by shifting the position of the singularity and compactify the extra dimension to be a circle of the same radius of the shift. This, in turn enables one to localize gravity on the brane. The construction of of a thick brane (domain wall) configuration which admits a dS_4 thin limit is problematic because the scalar potential must have a cusp at the compactification point. This problem can be overcome by compensating divergences of the scalar field in the compactification point, yet no concrete thick brane realization of such a scenario was obtained so far.

All the above cases considered maximally 4-symmetric spaces as the thin brane limit. Obviously, when we want to address brane cosmology we should generalize our ansatz to account for maximally 3-symmetric Friedmann-Robertson-Walker (FRW) branes. The problem of the localization of gravity on such branes already arises in the infinitely thin brane case, when one attempts to embed a 4D FRW brane inside an AdS_5 space. In addition, no actual time dependent gravitational solitonic configurations, that admit a cosmologically plausible thin limit were obtained so far. A small step in this direction was taken by symmetrizing the maximally 4-symmetric solutions with respect to time in conformal coordinates and obtaining a solution with a non trivial time dependence.

Once I have studied the above subjects, almost two years of my PhD were dedicated to the problem of obtaining a more reliable thick brane cosmological scenario using similar methods. After an intensive thinking on the subject by myself and Prof. Aharon Davidson, we came up with a new approach to the problem of "thick" 5D cosmology. The main idea lies in the "indistinguishability" of the y and t directions before a domain wall brane is generated dynamically within such a space time. Considering the most general 5D metric ansatz, we look for a curve (watershed) in the $y-t$ plane on which the yet undetermined scalar potential should be peaked and where the dynamically generated domain wall (DW) brane configuration should be centered. On this curve the real time evolution of the DW scalar can be intuitively described by a "falling slinky" configuration as follows: *At $t=0$ all the links of a slinky spring, which represents the DW scalar, are sitting on the maxima of the scalar potential between two degenerate minima. As time goes by the links starts falling towards the minima on the right and on the left, such that at very late times, only one link of the slinky is interpolating between the two piles of links sitting at the two minima.* The early time accumulation of links in the maxima correspond to a huge initial dark energy density, which decreases with time in a yet unspecified pace. This energy density drives an inflationary period on the DW brane, which terminates when most of the links of the slinky hit the minima, or equivalently when the DW kink configuration becomes very thin. The late time interpolating link(s) will thus correspond to a small remnant dark energy density, which can drive the observed late time acceleration of our (DW) universe. As a first step we published the derivation and analysis of preliminary "slinkyvolving" DW configurations (see Ref. [6] in the list of publications). Subsequently, many questions arise, such as the nature of the scalar potential, the localization and effect of matter and radiation fields within such setups, the definition and validity of the thin brane limit and eventually possible experimental signatures. I wish to pursue various aspects of this subject in the next few years since I truly believe it can open a new era in extra-dimensional cosmology and might give some clues on candidate string theory cosmological constructions (D-branes) in higher dimensions.

Future Work

In the near future I would like to continue working along the interface between theory and experiment, with emphasis on LHC phenomenology. Simultaneously, I want to pursue the more theoretical direction of establishing extra dimensional setups, which can be used for the construction and study of realistic models of both particle physics and cosmology and their experimental signatures.

- *Bulk flavons and Higgs-Radion phenomenology* The presence of bulk flavons in the RS flavor models described above has an additional interesting phenomenological feature. The Radion field, corresponding to fluctuations in the inter brane distance, should develop a VEV that sets the size of the extra dimension. To stabilize the size of the extra dimension requires an additional scalar with a non trivial 5D profile and small bulk mass, referred to as a Goldberger-Wise (GW) field. On the other hand, in the two brane setups we use, the SSB pattern from UV peaked flavons is mediated (shined) to the IR brane and *vice versa*, such that the bulk flavor symmetry is completely broken. Therefore, it is interesting to unify the shining of flavor violation with stabilization of the extra dimension, by considering all flavons as GW fields. This will allow for a cross check on the stability

and viability of the setups we use. In such a situation, the Radion is likely to be the lightest new particle and as such it may be the first signal for these WED setups. We wish to study the Radion collider phenomenology which mimics the one of the Higgs. In particular, we want to see if we can obtain a Radion of mass around 125 GeV , which is able to account for the apparent enhancement of the $H \to \gamma\gamma$ channel (ATLAS,CMS), without modifying the other common Higgs discovery channels ($H \to ZZ^*, WW^*, (V)b\bar{b}$). In addition, we want to verify that Tree-level Radion mediated FCNC's do not introduce any new phenomenological problems and that the inter brane distance can be stabilized at a realistic scale for such a constrained Radion field. It will than be interesting to study the modifications of the above phenomenological subjects in the composite Higgs (gauge Higgs unification) realizations of the RS-A_4 model and analogous realizations based on alternative (continuous or discrete) flavor symmetries and/or field content.

- *Implications of KK oscillations on collider phenomenology*

  In addition to the mixing arising from bulk Yukawa interactions, I wish to study the effect of mixing from boundary conditions, brane localized kinetic terms and other sources, in the context of various RS-flavor schemes. It is interesting to see whether the patterns of KK mixing can be probed experimentally at the LHC by KK fermion decays, CP asymmetries and rare flavor violating processes.

- *Generalizations of the model in light of new experimental data.*
  The information which will be obtained by the first two research objectives, will shed more light on the phenomenological viability of the RS-A_4 schemes, depending on the results of the various experiments. In general we expect the new experimental data to strongly constrain our constructions and thus necessitate their extension and generalization. To this end, we shall start with the implementation of the RS-A_4 models in a full fledged (4D) composite Higgs model with an A_4 symmetry, dual to 5D models of gauge Higgs unification and perform analogous phenomenological studies in both the 4D and 5D pictures. Subsequent generalizations will involve models based on larger bulk flavor symmetries (S_4, T',...) in WED. The inevitable presence of additional bulk flavons, will undoubtedly introduce new difficulties in the model building part, specifically in achieving the desired flavon vacuum alignment. Once these generalizations are established, we wish to thoroughly test them against experimental data.

- *"Soft Wall" phenomenology*

  I would like to pursue the construction of realistic models of fermion masses and mixing based on in the context of "Soft Wall" setups. These constructions are more tractable on the conformal field theory (CFT) side, since they allow for a regularization of the IR brane and give rise to linear Regge trajectories for meson masses.

- *Domain Wall "Slinky" Solutions*

  After establishing the first plausible "Slinky" like configuration I wish to study various aspects of this kind of solutions such as localization, the scalar potential and finally cosmological signatures. The goal is a phenomenological extra dimensional setup which satisfies the constraints from both particle physics and cosmology. Hopefully this kind of setup might shed light on the search and study of cosmologically tractable string theory or Supergravity solutions and perhaps have some interesting dual description on the CFT side.

- *The problem of "Planck Mass" in a domain wall brane universe*

  It has been pointed out that in the context of a domain wall brane universe the 4D Planck mass is an ill defined concept. Studying the 4D effective action reveals a species and momentum dependent Planck Mass. I wish to study the theoretical aspects and cosmological implications of such a scenario and hopefully confront it with experimental data.