SYRACUSE UNIVERSITY

DEPARTMENT OF PHYSICS
College of Arts and Sciences

To whom it may concern,

I am responding to apply to the postdoctoral position as advertised on Inspirehep.net. I am currently a graduate student studying at Syracuse University working under Dr. Jay Hubisz. I have completed all necessary degree requirements and I anticipate to have defended and graduate by this coming April, 2013. I believe my research experience as I outline below, and as elaborated in my research statement, makes me an strong candidate for the position as it is described.

My research is in Beyond-the-Standard Model (BSM) phenomenology. In the past I have primarily studied models with large extra dimensions, particularly light degrees of freedom and composite Higgs models in extra dimensions. The study of light degrees of freedom, which also provides an axion candidate, was published in Physical Review D. Currently, with the discovery of the Higgs at the LHC, my interests have turned to the BSM effects on Higgs decays, the hierarchy problem, and electroweak precision. In particular I am concentrating efforts on better understanding the $h \to \gamma Z$ decay in various BSM scenarios. This decay, although rare in the SM, is a clean signal, and offers an excellent chance to constrain, and hopefully discover, BSM physics at the LHC. There are numerous avenues to explore and I look forward to continuing this work in the future. In general, I have broad experience in many aspects of Quantum Field Theory such as renormalization, non perturbative effects, Supersymmetry, and effective field theories.

I am deeply passionate about physics both as a personal challenge and sharing it with others- whether it's a debate about research with a colleague, a discussion with a student, or speaking to people outside of the field. I am excited by the prospect that this position offers to continue my involvement in the physics community. I am happy to provide you with any additional materials at your request. I appreciate you taking the time to review my materials and consider me for this position.

Sincerely,

Don Bunk

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Cell: (845) 453-8064

Curriculum Vitae

Don Bunk

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Syracuse NY, 13244
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Research

- "A Top Seesaw on a 5D Playground"

  [arXiv:1111.3951 [hep-ph]].

  Research investigating composite Higgs models in compact extra dimensions with Jay Hubisz, Jing Shao and Philip Tanedo.

  Presented at SUSY '11.
- "Revealing Randall-Sundrum Hidden Valleys"

  Phys. Rev. D 81, 125209 (2010). [arXiv:1002.3160 [hep-ph]].

  Research with Dr.Jay Hubisz investigating resolving the strong CP problem in the context of extra dimensional quantum field theories.

  Presented at Pheno -'10.
- "A Computational Study of Cadmium Sulfide Clusters with Organic Capping Agents"

  Modeling of amino acids as organic ligands to isolate Cadmium Sulfide nano-clusters.

  Sponsored by Stacie Nunes of the SUNY New Paltz Physics department.

  Presented at the 231st ACS National Meeting.
- "Nested Derivatives and Inverse Functions"

  Study of involutory functions and power series expansion for inverse functions.

  Sponsored by Diego Dominici of the Mathematics department at SUNY New Paltz.

  Presented at 12th annual Hudson River Undergraduate Mathematics Conference.

Schools, workshops and conferences attended

- Supersymmetry and pre-SUSY *August 2011*
- Phenomenology Symposium *May 2010*
- TASI- Theoretical Advanced Study Institute in Elementary Particle Physics *June 2009*

Talks and seminars

- SUNY New Paltz- 'The Higgs Particle: Past motivations, current status and future prospects' *November 1st 2012*
- 2011 SUSY & pre-SUSY- 'Composite Scalar with a Compact Extra Dimension' *August 28th 2011*

- 2010 Pheno- ‘A Warped Solution to the Strong CP problem’

  May 5th 2010
- High Energy Seminar-Syracuse University Physics Department- ‘A Warped Solution to the Strong CP problem’

  November 10th 2009

Awards and honors

- Outstanding Teaching Assistant Award *2009*

  Presented by the Syracuse University Graduate School.
- Henry Levinstein Fellowship *2008*

  Syracuse Physics Department summer fellowship.
- Outstanding graduate physics department SUNY New Paltz *2006*
- Outstanding graduate philosophy department SUNY New Paltz *2006*

Professional service

- Physics Graduate Student Organization President *2007-2009*

  Physics graduate student event coordinator, representative to graduate student organization and graduate student liaison to physics faculty.
- Board of Directors, Inn Complete *2007-2009*

  Graduate student liaison to on-campus bar subsidized by the Graduate Student Organization.
- Physics Graduate Student Senator *2006-2007*

  Representative to graduate student organization.

Academic service

- Invited talk on experience in graduate school - SUNY New Paltz. *Nov 2012*

  “Grad School: Because the real world will still be there in six years”
- Doctoral student panelist-Syracuse Career Services *Sept 2011*

  “Strategies for success in your Doctoral Program”
- Tenure review committee for Dr.Cristian Armendariz- Grad student representative *Fall 2010*

  Polled/ compiled students and advisees surveys.
- Physics graduate student panelist-Syracuse Physics Department *Fall 2008, 2009, 2010*

  “Features of good TA work”
- Syracuse graduate student training panelist-Syracuse Graduate School *Summer 2009*

  “Leading a Discussion/Recitation”

University service

- Mountain Biking Chair, Syracuse University Outing Club *2009-2012*

  Coordinated group rides and bike maintenance clinics, maintained bikes and bike storage, allocated budget.

Professional development

- Syracuse Future Professoriate Program *Fall 2009-2011*

  Program to prepare future faculty for responsibilities and culture of academic life.

Education

- Syracuse University *2006-2013 (ABD)*

  Pursuing a PhD in Theoretical Physics. Advisor: Dr. Jay Hubsiz

  3.89 current GPA

- State University of New York at New Paltz *2006*

  B.S. Physics

  B.A. Philosophy

  3.89 GPA

- Dutchess Community College *2002*

  Associates Degree in Liberal Arts

  3.71 GPA

Teaching experience

- Syracuse University

  Grader:

  Physics 312- Introduction to General Relativity *S 2009*

  Physics 641- Graduate electricity and magnetism *S 2010*

  Teaching assistant/ Recitation instructor:

  Physics 211- Calculus based introductory mechanics *F 2007,F 2008*†

  Physics 212- Calculus based introductory electricity and magnetism *F 2006, S 2007, S 2009, S 2011*

  Physics 215- Honors calculus based introductory mechanics *F 2012*

  Physics 216- Honors calculus based electricity and magnetism *S 2012*

  Teaching assistant/ Lab instructor:

  Physics 102- Introductory physics for non-science majors *S 2010*

  Physics 222- Introductory electricity and magnetism lab *S 2008, F 2011*†

- State University of New York at New Paltz

  Workshop leader:

  Physics 201- Calculus based introductory mechanics *F 2005, S 2006*

† Head teaching assistant.

Don Bunk - Research Statement

As the LHC is currently collecting data it is an exciting time to be in the high energy community as the LHC pushes the bounds on our current understanding of nature through exploration of the TeV scale. There are many exciting prospects to explore at this point, with the recent discovery of the 126 GeV resonance at the the LHC at the forefront.

There are a handful of indications that the Standard Model (SM) is not a complete description of nature (i.e. the evidence for dark matter, the Strong CP problem, and the presence of neutrino masses). However, there is one issue looming above all else in the SM, and that is the fine tuning of the Higgs mass. Unlike fermions whose masses are protected by a chiral symmetry, the Higgs naively has no symmetries to protect it from getting quantum corrections to its bare mass that are many orders of magnitude times its physical mass. If the SM holds up to the Plank scale, this means the Higgs mass is unbelievably fine-tuned in order to get a 126 GeV Higgs.

There are two main model building paths that potentially resolve the fine tuning problem. The first path assumes that the Higgs remains a degree of freedom up to much higher energies. This means we have to confront the fine tuning problem head-on and introduce new symmetries to keep the Higgs light. This class of models include supersymmetry (SUSY), which potentially resolves the fine tuning problem by adding a super partner to each SM particle to cancel its corrections to the Higgs mass. The LHC is putting severe constraints on minimal SUSY models, making it less likely that minimal SUSY is realized at the TeV scale. The second path assumes the Higgs results from new confining dynamics. Much a pion, it's only an effective description that will break down at some energy, rendering the worst part of the fine tuning problem a moot point since quantum corrections are cut-off at the strong coupling scale (a few TeV). There is typically a moderate amount of fine-tuning that remains in models like these, so there has been a great deal of interest in a subclass of strong coupling models known as Little Higgs models that address the remaining 'little hierarchy problem'.

With the fine tuning problem in mind, and the current data coming in from the LHC, my recent attention has turned to LHC predictions for models that ameliorate fine tuning. In particular, the processes $h \to \gamma\gamma$ and $h \to \gamma Z$ are important observables for testing the SM because they vanish at tree level thus any observed rate is a probe of loop effects. This means that beyond the SM (BSM) physics may give contributions of the same order as SM physics in these channels, giving the best chance to see indirect effects of exotica. This is in contrast to processes like $h \to WW^*$ that are dominated by tree level contributions in the SM. Also, while both these channels predict small rates, the cleanliness of the final states allows for a significant signal to background ratio.

Data coming from the LHC indicates that BSM physics may be present in the Higgs sector. In particular the $h \to \gamma\gamma$ rate is almost twice the SM value. Naively, both $h \to \gamma\gamma$ and $h \to \gamma Z$ will be sensitive to the same BSM physics, so we should be anticipating similar discrepancies in $h \to \gamma Z$ as that comes online. Because $h \to \gamma Z(\to \gamma l^+ l^-)$ is so small in the SM this was not an early priority, but now with the observation of the suspected Higgs at 126 GeV, and moreover the observed deviation in the $h \to \gamma\gamma$, it is then well motivated to explore whether models that are candidates to solve the fine tuning problem simultaneously predict modifications in Higgs rates. In one implementation we study a minimal Little Higgs model which is essentially the top sector from the Littlest Higgs Model. We are also considering a general model where the Higgs is part of a larger, strongly coupled sector that unitarizes WW scattering, and in which vector resonances contribute.

There are other motivations for BSM Higgs physics. In particular if we run the SM with a 126

GeV Higgs to the Plank scale the Higgs potential becomes metastable. While technically ok, a metastable vacuum requires at the very least some anthropic support in order to explain why we landed in our vacuum in the first place. Alternatively, BSM physics could keep the Higgs potential stable, or better yet radiatively generate a Higgs vacuum expectation value. Taken as a whole, between the fine tuning problem, the Higgs decay rates, and vacuum stability we have plenty of motivation for BSM physics in the Higgs sector, and plenty of models to consider and refine as the data gets better. In particular, either of the models we have considered for the $h \to \gamma Z$ rate are relatively minimal, and could be part of much larger sectors that will alter Higgs physics.

Most of my research prior to the Higgs research has centered around TeV scale extra dimensions and their effect on weak scale physics. The most exciting aspect of extra dimensions is the long-standing promise that warped extra dimensions allow us to map the energy scale of a strongly coupled model into the geometric picture of an extra dimensional model via the AdS/CFT correspondence. Thus with perturbation theory in the extra dimensional model we are able to probe theories that are otherwise beyond perturbative control. Specific implementations of this include the Randall-Sundrum (RS) model, which recasts the hierarchy problem as the Higgs localized to an IR brane in a slice of AdS space with little overlap of UV localized physics. The RS model is the starting point for many more refined models that attempt to address BSM physics.

As an example of trying to look at basic questions within the context of extra dimensions we have explored the presence of light fields in minimal extra dimensional models. Light particles of this form can arise from being protected by a 4d gauge symmetry or shift symmetry both of which are a manifestation of a 5d gauge symmetry with a particular choice of boundary conditionss. In our model we considered a generic 5-dimensional gauge field which is weakly coupled to SM fields in a RS background. Here the 5th component of the gauge field with particular boundary conditions is a scalar field with a shift symmetry from the perspective of 4d. These sorts of Goldstone bosons when coupled to a chiral fermion field can provide an axion candidate. While the light fields are naively hidden from colliders, taking gravitational fluctuations of the RS geometry into account, the moduli field creates a bridge to a sector that is otherwise weakly coupled to SM fields. Thus these sorts of models exemplify a class of 'Hidden Valley Models'.

We have also looked at dynamical symmetry breaking in extra dimensions. In our model based on the Nambu-Jona-Lasinio model, we begin with a 4-fermion operator, introduce a 5D scalar auxiliary field, and calculate the effective potential to see if there is a fermion condensate. In order to approach this question correctly we took the 4d loop momentum to be the same cutoff as the cutoff for the sum over KK masses, instead of approximating loops with the first couple of KK modes. This has led to a more general investigation of renormalization in extra dimensions and the consequences for model building. We discovered some counterintuitive features in that brane localized divergences do not follow from naive power counting, and moreover a vacuum expectation value can be obtained purely by instability created by loop induced brane localized terms. This is significant since many people simply assume the brane localized terms take on the naive form of the terms obtained in a theory with one less spatial dimension. The current work in the flat extra dimension amounted to a toy model, and we hope to extend this work on a warped RS background in order to make full use of the AdS/CFT correspondence.

I am very interested in continuing to explore the boundaries of the Standard Model. The Higgs sector in particular is deserving of attention in order to understand BSM models in light of current constraints. Although I have primarily focused on extra dimensions, and I am interested in continuing research in this direction, I am always open to new possibilities, exposure to new areas in the high energy research community, and new questions to answer.

PUBLICATIONS LIST-DON BUNK

[1] D. Bunk, J. Hubisz, Phys. Rev. **D81**, 125009 (2010). [arXiv:1002.3160 [hep-ph]].
[2] D. Bunk, J. Hubisz, J. Shao, P. Tanedo, [arXiv:1111.3951 [hep-ph]].
[3] D. Bunk, J. Hubisz, B. Jain, ‘Higgs to Z-γ and Dynamical Electroweak Symmetry Breaking’ -forthcoming-.