

**From:** Nicholas Proudfoot <njp@uoregon.edu>  
**Subject:** CAREER08 reviewer comments  
**Date:** April 29, 2011 9:37:38 AM PDT  
**To:** Nicholas Proudfoot <njp@uoregon.edu>  
▶ 5 Attachments, 0.2 KB

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### Review #1

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**Proposal Number:** 0847800  
**NSF Program:** Algebra,Number Theory,and Combinatorics  
**Principal Investigator:** Proudfoot, Nicholas J  
**Proposal Title:** CAREER: Symplectic Duality  
**Rating:** Good

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#### REVIEW:

What is the intellectual merit of the proposed activity?

The proposal centers around symplectic algebraic varieties, with a (fairly modest) stated goal of understanding their cohomology rings and categories of sheaves. Moreover, the concept of (cohomological and categorical) symplectic duality is being developed but these notions are only temporary, see Remark 4.2. Various connections to CFT's and string theory are mentioned but non of them is made precise.

What are the broader impacts of the proposed activity?

The PI proposes annual week-long workshops for advanced graduate students and post-docs, similar to the well known MIT Talbot workshops. No other educational plan is mentioned in the proposal.

Summary Statement

This proposal ranks in the middle of those I am reviewing. The topics are interesting but the problems mentioned are not very concrete. The proposal reads more like a research summary.

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### Review #2

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**Proposal Number:** 0847800  
**NSF Program:** Algebra,Number Theory,and Combinatorics  
**Principal Investigator:** Proudfoot, Nicholas J  
**Proposal Title:** CAREER: Symplectic Duality  
**Rating:** Very Good

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**REVIEW:**

What is the intellectual merit of the proposed activity?

The PI proposes to study symplectic algebraic varieties, and in particular hypertoric varieties, quiver varieties, and symplectic varieties associated with a smooth algebraic curve. These topics are deeply related to combinatorics (especially, combinatorics of polytopes, hyperplane arrangements, and, more generally, independence complexes and broken circuit complexes of matroids), representation theory, and nonabelian hodge theory.

The central theme of the proposal is defining the notion of symplectic duality. While there are constructions of large families of examples of symplectic dual pairs that have all the "expected" properties, a geometric definition of symplectic duality analogous to the definition of mirror symmetry is still elusive. Finding such a definition is one of the main goals of the proposal. Other proposed problems/directions include  
\* using the geometry and topology of hypertoric varieties to improve our understanding of combinatorics of matroids,  
\* computing mixed Hodge polynomials for a general hyperplane arrangement, and  
\* studying the intersection cohomology of singular quotients.

I believe that the PI is well qualified to undertake these projects. The PI and his collaborators already have impressive partial results. The PI is very prolific and most of his articles appear in the top tier research journals of this area.

A couple of comments to the PI:

1. papers by Ed Swartz on the f-vectors of matroids might be relevant to some of the proposed problems.
2. The language of the proposal is a bit too much technical. In the future proposals it may be worth trying to make an effort to reduce the level of technicality.

What are the broader impacts of the proposed activity?

The broader impacts component of the proposal is also very strong. The PI proposes to run annual week-long educational workshop at the University of Oregon targeted at advanced graduate students and post-docs from around the country. Each of this workshops will be oriented toward a specific set of recent papers on a single topic in areas such as algebraic geometry, representation theory, combinatorics. The lectures will be given by participants who in most cases will not be specialists on the featured topic. Such a workshop will be preceded by a preparatory weekly seminar run by graduate students. The main purpose of such workshops is to develop the ability of the participants to read papers outside their area of expertise. This initiative if funded will undoubtedly have an impact on the community of young researchers.

The PI is already very involved in various educational activities: although he started his tenure-track position only a year ago, he is already writing a paper with a graduate student, has taken on one graduate student and hopes to start advising several more graduate students this coming year.

Summary Statement

This is a strong, well conceived and organized proposal. I'd rank it as 4th or 5th out of 11 proposals I have just read. The proposer is well qualified to carry on the proposed work. He is already well established in his field and collaborates with top researchers (e.g., Braden, Hausel). In addition, he has strongest support from his chair and the whole department.

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**Review #3**

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| <b>Proposal Number:</b> | 0847800                                 |
| <b>NSF Program:</b>     | Algebra,Number Theory,and Combinatorics |

**Principal Investigator:** Proudfoot, Nicholas J  
**Proposal Title:** CAREER: Symplectic Duality  
**Rating:** Very Good

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## REVIEW:

What is the intellectual merit of the proposed activity?

The proposal centers around the notion of symplectic duality, a new concept introduced by the PI and his collaborators.

A symplectic variety is a complex algebraic  $N$  variety admitting a (semismall) resolution  $M \rightarrow N$  such that  $M$  carries an everywhere non-degenerate holomorphic 2-form. Examples of such  $N$  include the variety of nilpotent  $n$ -by- $n$  matrices, the Uhlenbeck compactification of (framed) instanton moduli spaces, moduli spaces of Higgs bundles, quiver varieties, Hilbert schemes of points on Calabi-Yau surfaces, and hypertoric varieties.

A symplectic variety with resolution  $p : M \rightarrow N$  is a cohomological symplectic dual to  $p' : M' \rightarrow N'$  if  $N$  and  $N'$  admit stratifications so that there is an order-reversing bijection between the strata and the a certain relationship holds between the intersection cohomology of the strata of  $N'$  and the cohomology of the fibers of  $p$ . For example, the variety of nilpotent  $n$ -by- $n$  matrices is dual to itself in this sense: the strata are parametrized by partitions of  $n$ , and the bijection on strata corresponds to taking the transpose of a partition.

The PI would like to explore this phenomenon and some variations or refinements of it, largely through a study of the known examples of symplectic varieties mentioned above.

A necessary tool is an ability to calculate the cohomology and/or intersection homology of the strata and fibers that appear. In this direction, the PI proposes a conjecture about the the intersection homology of certain symplectic quotients (i.e. hyper-Kahler quotients, in real terms).

A particular conjecture is that there is a cohomological symplectic duality between a moduli space of rank- $k$  instantons with Chern class  $n$ , and the Hilbert scheme of  $n$ -tuples of points on the resolution of  $A(k-1)$  singularity.

Other topics include non-abelian Hodge theory (flat bundles and Higgs bundles on curves) and the associated symplectic geometries.

What are the broader impacts of the proposed activity?

The PI proposes an annual week-long educational workshop at the University of Oregon, each focused on a topic of recent interest. Three possible topics are suggested: tropical geometry; stability conditions in triangulated categories, as developed by Bridgeland; and symplectic duality.

### Summary Statement

The research component of this proposal seems original and interesting. The educational component is less ambitious than some other proposals; but the PI is only four years from his PhD, and one might also fairly praise the proposal for being realistic in this area.

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## Review #4

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**Proposal Number:** 0847800  
**NSF Program:** Algebra, Number Theory, and Combinatorics

**Principal Investigator:** Proudfoot, Nicholas J  
**Proposal Title:** CAREER: Symplectic Duality  
**Rating:** Multiple Rating: (Excellent/Very Good)

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**REVIEW:**

What is the intellectual merit of the proposed activity?

Proudfoot proposes a collection of projects centered around the geometry and cohomology of hyperkahler manifolds. One involves the hyperkahler analog of toric varieties, with interesting connections to combinatorics, and for which Proudfoot proposes to develop an analog of the rich structure of nonabelian Hodge theory. Another involves unexpected ring structures he has found with Braden on intersection cohomology groups, which he plans to expand in applicability to settings important for geometric representation theory. Finally and most intriguingly, he is developing with collaborators a new duality, Symplectic Duality, for hyperkahler manifolds. This duality has many remarkable features which he establishes in hypertoric cases, but which appear relate to some of the deepest aspects of representation theory (Langlands duality etc). This is also paralleled by a new kind of mirror symmetry in physics, suggesting its potential importance and range.

The proposal could be significantly improved however by trying to convey more of a sense of the excitement of the symplectic duality proposal - for example by elaborating on its relations to and potential impact on representation theory and physics. The proposal reads as a fairly technical review of the author's prior and ongoing work, rather than as an ambitious and exciting proposal of a new direction that the PI is helping to spearhead and that can have a potentially transformative impact on related areas. This can prevent reviewers from fully appreciating the interest of Proudfoot's work.

The PI needs to convey an ambitious long-range program. (Such changes could significantly improve this proposal's chances in the future.)

What are the broader impacts of the proposed activity?

Proudfoot proposes intense weeklong workshops for and by grad students and postdocs, in which the participants lecture in detail through a collection of related papers. This is based on the experience of the Talbot MIT group and a group in Michigan, and is proposed as a west coast alternative.

Summary Statement

Proudfoot proposes some very exciting new directions based on his very productive recent work, interfacing geometry representation theory and physics in new ways. This is worth funding with high priority.

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**Panel Summary #1**

**Proposal Number:** 0847800

**Panel Summary:**

Panel Summary

The proposal centers around the notion of symplectic duality, a concept introduced by the PI and his collaborators. This is a very exciting area with great potential.

The main criticism of the proposal is that the PI does not explain clearly how the problems stated in the proposal would fit in a bigger picture. Also the PI does not connect well his research with CFT and string theory.

The broader impact of the proposal is strong. The PI is involved in various educational activities, has one graduate student and hopes to start advising several more this coming year.

This is a strong research proposal, but, as written, it is not as ambitious as many other CAREER proposals. The panel placed the proposal in the bottom third of the category recommended for funding if possible.