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## Proposal All Reviews: 2246877

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Agency Name: National Science Foundation

Agency Tracking Number: 2246877

Organization:

NSF Program: Combinatorics

PI/PD: Williams, Nathan

Application Title: Combinatorics and Braid Varieties

### Review 1

**Rating:**

**Multiple Rating: (Excellent/Very Good)**

**Review:**

**Summary**

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

The proposal presents various important problems in the area of algebraic combinatorics, specifically concerning Richardson varieties, Hecke algebras, rational Cherednik algebras, and noncrossing Coxeter-combinatorics. This is an established, strong researcher who has just produced surprising, important results (the first uniform enumeration of noncrossing objects in Coxeter-Catalan combinatorics and a vast generalization to the "rational" setting). The PI's success in these results lends a lot of plausibility to his proposal, which in part uses the same new tools. Beyond these two big results, the PI has done a lot of other solid research, and similarly he proposes a large number of additional problems and describes reasonable plans and tools to approach them.

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

Broader impacts, beyond the usual, include REU involvement, honors UG reading courses, a technologically innovative UG discrete math textbook, undergraduate outreach programs within the university and public outreach outside of academia.

Please evaluate the strengths and weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if applicable

Summary Statement

The PI will build on previous exciting results to break new ground in algebraic combinatorics. The proposal is Excellent in Intellectual Merit and Good/Very Good in Broader impacts, and is one of the top two proposals that I read, possibly the very best.

### Review 2

**Rating:**

**Good**

**Review:**

**Summary**

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

The PI's research is in algebraic combinatorics. He has a strong track record of solving long-standing problems using original ideas. He describes several problems he wants to look at, related to Braid varieties, finite Coxeter groups, affine Weyl groups, Kac-Moody groups, cohomology theory linked to Hodge structures, ...

Based on his track record, it is likely that he will be able to advance in several of these problems.

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

The PI will mentor and teach to undergraduate students.

He will also organise a yearly online workshop to bring together undergraduates and early graduate students. He has graduated one PhD student so far.

Please evaluate the strengths and weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if applicable

The PI has a good track record of research outputs (35 papers at PhD + 9). He is editor of Annals of Combinatorics. He has organised several conferences.

The amount requested is for him but also for 2 graduate students hence the large amount.

Summary Statement

This is a good proposal from a very good PI.

### Review 3

**Rating:**

**Very Good**

**Review:**

**Summary**

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

This is an exciting proposal which involves connections between Coxeter-Catalan combinatorics, counting  $F_q$ -points of braid Richardson varieties, Hecke algebra traces, and diagonal harmonics.

Theorem 1.8 and its application to counting Coxeter-Catalan numbers in Theorem 2.5 seems impressive. This is a good example of applying powerful machinery coming from geometry and Hecke algebras to solve difficult combinatorial problems.

Theorem 3.4 gives an exciting connection between counting  $F_q$  points of braid Richardson varieties and the  $t=q^{-1}$  specialization of the diagonal harmonics Hilbert series. The idea to use mixed Hodge structures to get the full  $q,t$  series is great.

The recent results of [GLTW22] have opened many doors and the PI poses many exciting directions to capitalize on the new machinery.

In the context of the five review elements, please evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

The broader impacts are excellent. The PI has supervised two graduate students, five undergraduate honors theses, and several independent study projects. The PI has organized over ten conferences, and has developed interactive JavaScript posters to teach topics such as algorithms, permutations, and inclusion-exclusion.

Please evaluate the strengths and weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if applicable

Summary Statement

This proposal is in the top third of those I read.