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# Proposal All Reviews: 2302074

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Agency Name:                                          National Science Foundation

Agency Tracking Number:                              **2302074**

Organization:

NSF Program:                                         ALGEBRA,NUMBER THEORY,AND COM

PI/PD:                                               Bruce, Juliette

Application Title:                                   Multigraded Homological Algebra and Geometry

## Review 1

**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.

IM: G

This proposal presents two projects regarding multigraded algebra and algebraic geometry.

The first project concerns a series of problems related to stacky curves, and in particular seeks to extend Green's conjecture to this setting. It is a natural question, with a lot of room for exploration. In my view, the questions / problems presented here vary extensively in terms of difficulty. The PI has substantial previous work related to the questions being asked, and is we positioned to make progress on some of the questions being presented.

On approach to this project presented is through making certain arguments in the existing literature explicit and then following up with extensive computer calculations. There is a lot of wo here, and the PI has begun some of the calculations (in genus zero). A further analysis of the preliminary computations that have been done would strengthen this part of the proposal. An approach presented goes through generalizing the notion of varieties of minimal degree to toric varieties -- particularly investigating the case of weighted projective spaces. Some partial p by the PI and coauthors is presented in a simpler case. While I found this second approach to be somewhat interesting in its own right, it too would benefit from additional preliminary computations and further refinement.

The second project concerns the study of multigraded Hilbert schemes. The PI proposes to study nonemptyness (which Hilbert functions can appear) combinatorially, when they are conne (it's known they need not be), and which ones are smooth. Again, I found the questions here to be natural questions of interest, and some indication of approaches are given. Bolstered by previous work of the PI, and also given the heavy computational and combinatorial components of the project, it is reasonable to expect that progress will be made. However, in my view, t

project seemed to be less developed than the first one, and in particular would benefit from the inclusion of some additional supporting computations and examples.

The PI also describes the outcomes from two prior sources of NSF support (only the one most closely related to the proposal need be included according to the guidelines) in great detail. the PI has a strong track record, the excessive detail given in this portion of the proposal -- totaling over five pages -- detracts from the depth that the PI was able to go into for proposed p This, in particular, likely affected the second proposed project.

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

BI: VG

The PI has an exceptionally strong record or organizing and supporting activities which promote certain underrepresented groups in mathematics. There is no question that the PI has had tremendously positive impact on the community. The PI proposes to continue similar organizational activities, and lists additional mentoring activities as well.

While I have some reservations about the activities proposed well, overall I found the proposed broader impacts to be the strongest among those proposals that I reviewed from researche similar career stage.

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

Summary Statement

I found this to be a quality proposal, worthy of support. However, in comparison with other proposals being reviewed by this panel, the intellectual merit would benefit from additional development.

## Review 2

**Rating:**

**Multiple Rating: (Very Good/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 proposal focuses on multi-graded commutative algebra and algebraic geometry. There are two primary objectives: (1) extend Green's conjectures which describes the syzygies of car curves to the canonical rings of "stacky curves" and (2) study the geometry of multi-graded Hilbert schemes with respect to properties such as non-emptyness, connectedness, smoothnes

I very much appreciate the exposition of the ideas presented in the proposal. It is very clear that the PI has thought deeply about the problems presented therein. I especially like the probl related to establishing the correct notion of varieties of minimal degree in multi-projective spaces and their homological properties. I also like the proposed problems on multi-graded analo Macaulay's theorem (a theorem that characterizes the possible Hilbert functions of graded ideals). I did not see enough details regarding the PI's approach to this problem (and the propos problems related to Hilbert schemes in general) to be able to judge the potential success. Extending techniques from standard graded to multigraded algebra is often quite subtle, sometim can yield to unexpected obstructions and other times to stronger results.

One weakness of the proposal is the lack of detail on the techniques that would allow the PI to achieve their goals; this is mostly in regard to the second listed objective. Another potential weakness is the extent to which stacky curves would be of relevance to the community at large. Since these have relatively newly started to be explored only time can tell regarding this.

The PI is well qualified to carry out the proposed activities. Their previous work on multi-graded syzygies and multi-graded regularity demonstrates both high quality and outstanding produ believe there are adequate resources available to the PI at their current institution, namely expertise available in topics highly relevant to the proposal, which will makes it favorable to carr the proposed activities.

This is a strong proposal, but among many other strong proposals I have read I would place it in the last third. The intellectual merit is good.

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

This proposal had the best broader impacts among all proposals I have read. The PI has an outstanding record of mentorship and organization in the field, including work benefitting tradit under-represented gender minorities in mathematics which is transforming the community. The PI is uniquely qualified to undertake some of this work and is doing more at an early career

than other mathematicians do at a much later stage in their career.

The broader impacts of the proposal consist of research mentorship of undergraduate and graduate students, organization of professional conferences and of conferences dedicated to ur represented populations in STEM, and efforts towards creating a more welcoming community for LGBTQ+ mathematicians. I have every reason to believe these efforts will be carried out superb level just like the PI's prior endeavors.

The broader impacts are excellent.

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

Summary Statement

This is a very well written proposal. I appreciate the geometric grounding of the research projects and the PI's prior experience with related topics. I would have liked to see more detail on aspects of how the proposed research will be brought to fruition. I encourage the PI to persist in investigating these topics as this will naturally fill in some missing details. I also encourage to persist in their broader activities as these are the lifeblood of the community.

## Review 3

**Rating:**

**Multiple Rating: (Very Good/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 proposal presents projects on syzygies for canonical rings of stacky curves, varieties of minimal degree in toric varieties, and multigraded Hilbert schemes.

IM Rating: G

The proposal does an excellent job of presenting the historical background and motivation for each problem. The PI demonstrates strong knowledge of the literature. These problems are and interesting, and their solutions would be a big advance in multigraded commutative algebra.

The PI's prior support with GRFP and Postdoc fellowships resulted in 12 papers, 4 software packages, 1 public-facing database, and 2 articles in the Notices of the AMS, along with exten broader impacts work.

Problems in this proposal, especially in Section 3, are still at a preliminary stage and would benefit from a more detailed explanation of approaches and hurdles to the problems, as well as supporting evidence as the projects develop.

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

BI Rating: E

The PI will continue their very strong track record in organizing meetings for and mentoring students from underrepresented groups, particularly gender minorities and LGBTQ+ mathemati This work is extensive and very valuable to the community.

The broader impacts in this proposal are by far the strongest in my batch; this work will have a great impact on the mathematical community.

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

Summary Statement

This proposal presents a number of interesting projects with potential to truly advance the field of multigraded algebra. As other proposals made a more compelling case for the approache

planned in their proposed problems, this proposal ranked in the bottom half of those I reviewed.

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