Figure 1: Figure caption.

1 Summary

SpaghettiLens is a tool developed by Rafael Kueng [1] that makes it possible for SpaceWarps volunteers to easily model Gravitational Lenses (GL). It is a simple web user interface that requires very little training to use. With the release of SpaghettiLens v1.4.1 it became possible for volunteers to work together, refining each other models, in order to come up with the most successful model for a single GL candidate.

2 Why is it Necessary to Model Lens Candidates?

When a SpaceWarps volunteer flags an object as being a possible GL candidate, it is necessary to do follow up work to determine if it is, in fact, a worthy candidate. If we can successfully create a simple model that has the physical characteristics of the object concerned, it suggests that the object could indeed be a lens.

3 How did we go about collaborative modelling?

The SpaceWarps Science Team [2] selected candidate *ASW0004dv8* [Fig.1] as being the initial subject for collaborative modelling. A basic model (*4516*) [Fig.2] was generated and it was expected the volunteers would continue to refine this model.

As nothing like this had been done before, we had expected there to be initial problems. User apathy / lack of collaboration were a concern. Once a manual system, using SpaceWarps Talk, had been put into place to report the changes a volunteer had made, the outcome of those changes, and improvements the volunteer would like to see to the model - things went smoother. With the
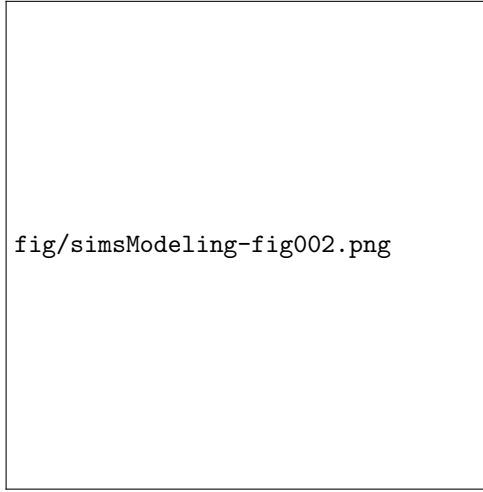
fig/simsModeling-fig002.png

Figure 2: Figure caption.

addition of Google+ spread sheet [3] to track our changes, managing the project became easier.

In total, 47 models were posted - this does not include the countless models that were rejected by the volunteers concerned. The vast majority of the models posted were descendants [4] of the initial model, the geneology [Fig.3] of the initial model makes interesting viewing. It is important to note, only models posted by their owners in the thread [5] on SpaceWarps were included.

4   What determines a successful model from a failure?

When analysing the output of a model there are several things we look for; are the lines of the contour plot smooth and uncomplicated [Fig.4]? Is the Mass Distribution clean or does it resemble a chessboard [Fig.5]? Finally, does the Synthetic image resemble the lensed object [Fig.6]? If we can say yes for all of the above, we can deem the model a success. For the purposes of this letter we will ignore other output from SpaghettiLens. Each of the images represented below are from different models that were generated within this project, and are used to represent the criteria we were looking for.

5   Where we able to reach consensus on a single successful model?

In a word, No.

fig/simsModeling-fig003.jpg

Figure 3: This should be the caption for `fig/simsModeling-fig003.jpg`.

fig/simsModeling-fig004.png

fig/simsModeling-fig005.png

Figure 4: Contour Plot: *Success Failure*

fig/simsModeling-fig006.png

fig/simsModeling-fig007.png

Figure 5: Mass Distribution: *Success* Mass Distribution: *Failure*

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fig/simsModeling-fig008.png
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fig/simsModeling-fig009.png
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Figure 6: Synthetic Image: *Success* Synthetic Image: *Failure*

Do we consider this a failure? Not necessarily.

By the end of the project we have narrowed down the list to 12 convincing models. We have refined techniques that can be used to move collaborative modelling forward, and in the process, the skills of the existing modellers have been improved. I was recently asked what I hoped to achieve by writing this letter - the answer is easy; if we can attract more Zooniverse volunteers to lens modelling, and dispel the myth that it is the preserve of Astrophysicists', it is a job well done.

Clicking on an image below will navigate you to the corresponding model result page.

6 Feedback and moving collaborative modelling forward.

With all previous Zooniverse projects [6] volunteers would independently classify images and at the end of the project, mass consensus would determine the result. The Science Team would interpret the results and present a paper.

When we started this project it was not clear whether the volunteers would prefer to work in a team or independent of each other - It appears we have a happy medium. On the positive front, we enjoy learning from each other and find viewing / working on each other's models an educational experience. Some of us are also not afraid of going against the grain and trying something different - but this is only possible without fear of censure.

On the downside, we expect others to manage the project, and anticipate progression in the project without having to make a large contribution.

Trust is also necessary between collaborative modellers, and this can only be built up between small groups of people - instead of having a 'free for all' approach should we think of setting up small teams of modellers? With more experience modellers taking on an apprentice? Or does this go against the ethos of citizen science?

Moving forward, it is apparent that clear guidelines and a proper framework, along with a form of project management is required. One of the downfalls of on-line citizen science is that responsibility ends with a click of a mouse.

Another concern is that we are not leaving the door open for new modellers to take part - that we are creating a clique within SpaceWarps. This was never the intention, but we need to look at new ways of introducing people to Lens modelling, and supporting them.

7 Acknowledgements

fig/simsModeling-fig010.png fig/simsModeling-fig011.png fig/simsModeling-fig012.png

fig/simsModeling-fig013.png fig/simsModeling-fig014.png fig/simsModeling-fig015.png

fig/simsModeling-fig016.png fig/simsModeling-fig017.png fig/simsModeling-fig018.png

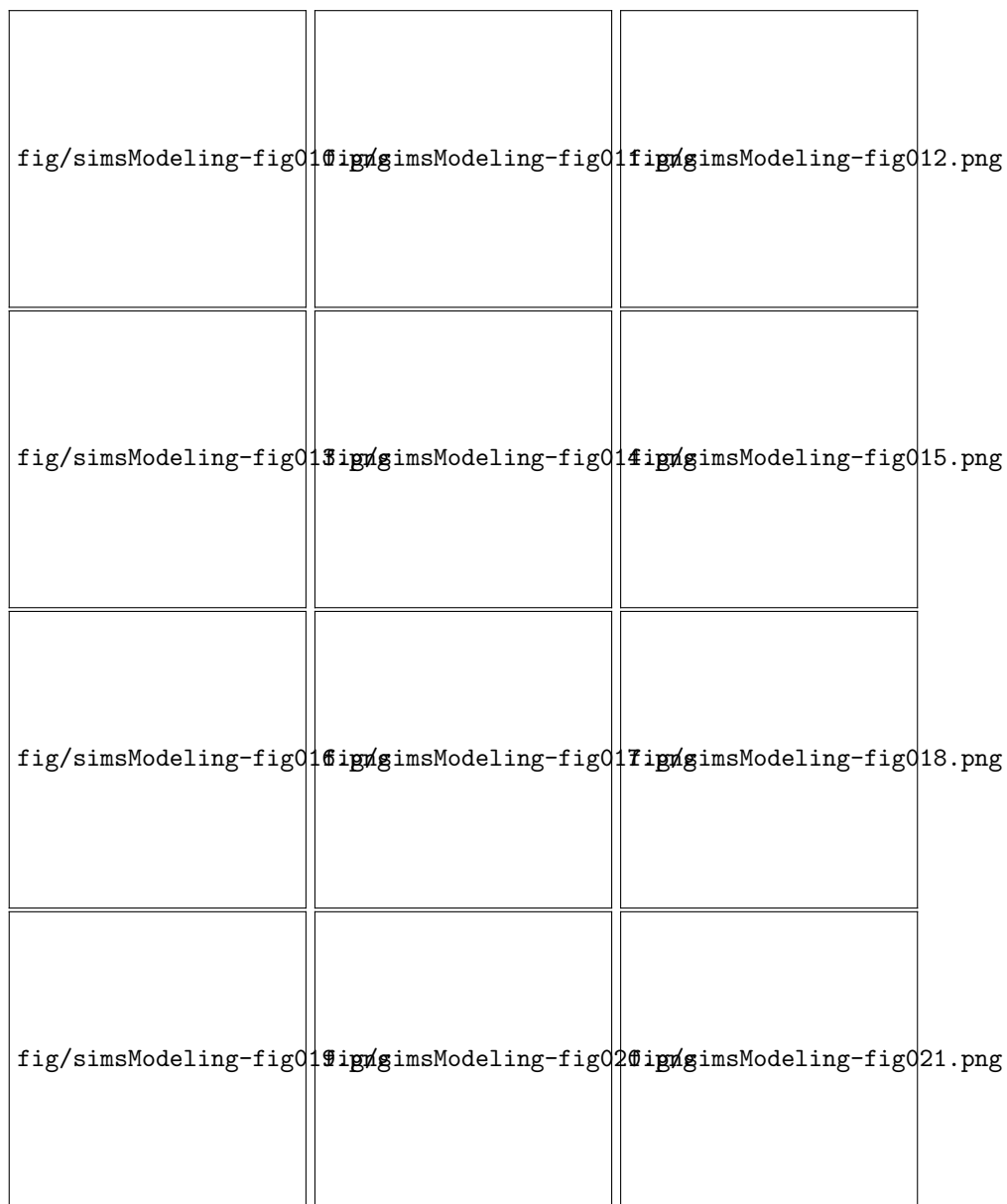fig/simsModeling-fig019.png fig/simsModeling-fig020.png fig/simsModeling-fig021.png

Figure 7: Figure caption.

beta test SpaghettiLens. Finally, to Dr Phil Marshall for being the PI for this letter, and one of the forces behind Spacewarps.

8 References

[1] Ask Rafi who he wants' credited.

[2] Phil Marshall, Aprajita Verma, Anupreeta More, Elisabeth Baeten, Claude Cornen, Ccile Faure, Janine Fohlmeister, Mandeep Gill, Rafael Kueng, Christine Macmillan, Surhud More, Prasenjit Saha, Matthias Tecza, Julianne Wilcox and Layne Wright.

[3] *Model Results*

[4] *Model Hierarchy*

[5] *http://talk.spacewarps.org/#/boards/BSW0000006/discussions/DSW00008fr*

[6] With the recent exception of GZ Quench.