

# Report on the outcomes of a Short-Term Scientific Mission<sup>1</sup>

Action number: CA20111

Grantee name: Stefania Damato

## **Details of the STSM**

Title: Coinduction in Cubical Agda

Start and end date: 19/06/2024 to 29/06/2024

## **Description of the work carried out during the STSM**

Description of the activities carried out during the STSM. Any deviations from the initial working plan shall also be described in this section.

*(max. 500 words)*

The main activities carried out during the STSM are listed below.

- A suite of examples showcasing existing problems with coinduction in Cubical Agda was developed before and during my visit. Through these examples, it was determined that some of the problems are due to an issue with Agda itself, whereby the Agda termination checker does not recognise that some primitives like `hcomp` preserve guardedness. To this end, we added an improved, self-contained example to the following issue on github: <https://github.com/agda/agda/issues/4740>. We await a response from the Agda developers and will chase them up privately if required. We also determined that some non-termination errors raised by the checker are justified, since in some cases we are not guaranteed termination unless other side conditions hold. This justifies our view that the use of coinduction should be reduced to a core principle or theory to be fully usable in a proof assistant like Cubical Agda.
- We discussed whether any theoretical justifications would be needed to modify the termination checker to solve the first case of problems mentioned above. Our theory is that it is safe for the termination checker to simply view `hcomp` as guardedness-preserving, although the same is not true for e.g. `transp`.
- I reviewed a pull request with Anders that I submitted to the Cubical Agda library before my visit, related to formalisations of proofs on containers, which was then merged onto the main branch: <https://github.com/agda/cubical/pull/1129>.
- I received valuable feedback from Anders as well as PhD students in the department on other projects I have ongoing. In particular, Axel Ljungström's expertise in Cubical Agda was instrumental to improve and conclude my formalisation project on containers. Also, following

<sup>1</sup> This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

my talk at the Logic Seminar, Anders and Max Zeuner had a few suggestions on how I can make progress on finding semantics for (quotient) inductive-inductive types.

Although we did not get the chance to look in detail at more theoretical aspects of coinduction, such as our alternative definition of coinductive equality, and reducing coinduction to the use of coeliminators, I managed to get assistance and feedback on other projects in my PhD, which was not initially planned.

### **Description of the STSM main achievements and planned follow-up activities**

Description and assessment of whether the STSM achieved its planned goals and expected outcomes, including specific contribution to Action objective and deliverables, or publications resulting from the STSM. Agreed plans for future follow-up collaborations shall also be described in this section.

*(max. 500 words)*

Our efforts to pinpoint, discuss, and fix an issue to do with coinduction that we discovered in Cubical Agda contributes to Objective 3 (Make techniques for program verification more effective and more accessible to all stakeholders).

During my research visit, my code on containers was merged to the Cubical Agda library, expanding the existing codebase and enabling future mechanised proofs on containers. Axel and I have also started working on a conference paper based on this code, which we aim to submit in the coming weeks.