Short-Term Scientific Mission Grant
- APPLICATION FORM[1] -

Action number: CA20111

Applicant name: Axel Ljungström

Details of the STSM

Title: Computer science applications of Cubical Agda

Start and end date: 26/04/2023 to 05/05/2023 *(including travel days)*

Goals of the STSM

Purpose and summary of the STSM.

Motivation: Cubical type theories provide a highly expressive foundation for mechanized mathematics and verified programming. They support computational univalence and higher inductive types, powerful tools for generic reasoning about data structures and mathematical structures. However, applications to computer science and programming are still quite underdeveloped and the aim of this STSM is to study these directions further using the Cubical Agda proof assistant.

Goals:

- Formalize computer science applications, for example in the area of programming language theory, in Cubical Agda.
- Introduce Agda and Cubical Agda to students and researchers in Turin, with a long term goal of using Agda in teaching and research.

Working Plan

Description of the work to be carried out by the applicant.

During the STSM there will be 3 seminars:

1. A longer introductory course on Agda by Ugo de'Liguoro,
2. an introduction to Cubical Agda by Axel Ljungström, and
3. a research seminar by Axel Ljungström on the formalization $\pi_4(\mathbb{S}^3) \simeq \mathbb{Z}/2\mathbb{Z}$ and the computation of a Brunerie number in Cubical Agda.

In addition to these we will discuss and start work on the formalization of computer science projects using Cubical Agda. For example, the mechanization of meta-theory of programming languages in Cubical Agda which is related to *Research Coordination Objective 7: Develop a modular theory of type*

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theories.

Expected outputs and contribution to the Action MoU objectives and deliverables.

Main expected results and their contribution to the progress towards the Action objectives (either research coordination and/or capacity building objectives) and deliverables.

The expected outputs of this STSM is a broader user base of Cubical Agda and new collaborations on formalization projects, in particular with an emphasis on computer science and programming applications of Cubical Agda. This will be most relevant to the objective of *Working Group 6*, which is developing theories of type theories. While our contribution does not directly do this, note that cubical type theory is important as a metalanguage which can host many mathematical developments, including the WG6 objectives. Univalence and higher inductive types make cubical type theories some of the most expressive foundational theories available today. In particular, higher inductive types are valuable tools in formalizing the general metatheory of type theories and Cubical Agda is the only major system which supports them. Furthermore, these formalizations can then serve as input to the Agda2Dedukti deliverable which will allow the results to be translated to other proof systems. Because of the expressive power and complexity of Cubical Agda this will most likely also require extensions of Agda2Dedukti to also support also cubical features.