

Covering Letter

for Nikolai Kraus, Nottingham

Tim Lichtnau

December 2, 2024

My name is Tim Lichtnau, I am 23 years old, and I am a master's student at the University of Bonn. Even in kindergarten, it was clear to me that I would become a mathematician. Problem-solving is my passion. Luckily, I grew up in a highly inspiring environment. On one hand, I participated in nation-wide training for math olympiads, which brought me many prizes at the national level and other competitions in Germany. This experience taught me to discuss mathematical ideas with people across the country. On the other hand, from the age of 12, I received individual mentoring from Professor Ines Kath once a week. Together, we explored topics like induction (over the naturals), analysis, Galois theory, and later, topology.

This strong foundation enabled a smooth start to my studies in mathematics at Bonn, where I focused early on algebraic topology and algebra. In my second term, I began reading about category theory—unfortunately, there were no lectures on this topic in Bonn! From that point, category theory became my constant companion. In my fourth term, I co-authored a paper with Professor Peter Koepke for the Computational Intelligence of Computer Mathematics conference on the Naproche system (Natural Proof Checking), which processes input texts approximating the natural language of mathematics. Even then, my niche in mathematics was emerging: somewhere between topology and the formalization of mathematics. Meanwhile, I became a teaching assistant and continued in that role for the remainder of my time in Bonn.

For my bachelor's thesis, I began studying higher category theory, which

opened an entirely new world for me. During my master's, I focused mainly on algebraic geometry and algebraic topology, while also participating in reading groups on higher category theory. I co-founded an informal seminar with a colleague to compensate for the lack of a category theory lecture in Bonn. Teaching was incredibly rewarding, and the positive feedback we received confirmed its success.

I felt that some areas of mathematics were taught using unnecessarily complicated language—like working with one hand tied behind your back. For me, the set-theoretic framework was not a satisfying foundation for the fields I was most interested in. Two key events shifted my perspective further. First, I learned about HoTT and Agda at the HoTTTest Summer School. It was the most beautiful intellectual experience of my life. From that moment, I knew what I wanted to do: make the lives of mathematicians easier with HoTT. I read most of the HoTT book and Egbert Rijke's book on the subject.

Second, building on this foundation, I attended workshops where I discovered Synthetic Algebraic Geometry, which allows one to work internally in the Zariski ∞ -topos rather than introducing a complicated theoretical framework to discuss structure sheaves or generic points. Grothendieck might have appreciated this synthetic approach, as the proofs are clearer and more elementary than those in conventional theory. I even organized a one-week holiday course on HoTT and Synthetic Algebraic Geometry, contrasting it with the often-painful process of learning algebraic geometry at university.

In addition to my academic pursuits, I developed software in Haskell for the startup Digitally Induced and studied Lean under Floris van Doorn. I formalized the fibered Yoneda lemma and, as part of a collaborative project, formalized distribution theory. I also participated in the Trimester Program on Formal Mathematics in Bonn and attended the “From Analysis to Homotopy Theory” conference in Greifswald.

When Hugo Moeneclay invited me to write my master's thesis with him on synthetic algebraic geometry, I realized it was my chance to do actual research mathematics—in a new foundational framework. My work focuses on synthetic algebraic geometry and what is classically known as algebraic stacks. Classically, algebraic stacks and the geometry required to define them are documented in the Stacks Project, a massive body of thousands of pages. Through my work I am able to add lex modalities to my toolbox. Also, as a

guest student of the University of Gothenburg, I am enjoying the academic environment of the Type Theory research group. For example, I participate in a reading group under Christian Sattler, where we work on constructivizing Cisinski's higher categories and homotopical algebra.

In my free time, I love thinking about category theory. Currently, I am developing a calculus for canonical morphisms, aiming to answer the question: is there a canonical morphism $A \rightarrow B$ in a certain context, and if so, how does it look like? This work is grounded in the framework of fibered categories, and I have received valuable feedback from Paul Melliès and Denis-Charles Cisinski.

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