Internship proposal at the University of Copenhagen

Title	Geometric Complexity Theory
Topics	Computational Complexity Theory Algebraic Geometry
Location	Copenhagen, Denmark
Lab	Department of Computer Science University of Copenhagen
Advisor(s)	Thomas Seiller, seiller@di.ku.dk
Head of Team	Jakob Grue Simonsen, simonsen@di.ku.dk
Head of Department	Mads Nielsen, madsn@di.ku.dk

Context. Computational Complexity aims at classifying problems – e.g. decision problems – according to the resources (e.g. time, space) required to compute their solution, i.e. according to the (asymptotic behaviour of the function computing the) amount of resources needed by the most efficient program computing its solution. The question of obtaining separation results, i.e. lower bounds on the amount of resources needed to solve specific problems, is intuitively hard because of this universal quantification over the set of all programs. More to the point, it is factually hard to obtain separation results, as some problems are still open over 60 years after the first attempt to solve them. Even more than that, they were *shown* hard to obtain as a series of several negative results – or *barriers* – showing that proof techniques previously used to obtain separation results are inefficient against the remaining open problems [5, 1, 2]. The *Geometric Complexity Theory* (GCT) currently is the only research program widely acknowledged by the community as able to bypass these barriers was initiated by Ketan Mulmuley [4].

Aim of the internship. The Geometric Complexity Theory program was introduced by Mulmuley after he proved some lower bound for a PRAM model without bit operations [3] using techniques from algebraic geometry, providing some evidence for the PTIME $\neq$ NC conjecture. The purpose of the internship is to read and understand Mulmuley's proof of a lower bound, and (if time permits) his subsequent discussion of the possible use of similar techniques against the PTIME $\neq$ NC conjecture.

Workplace. This internship will be supervised by Thomas Seiller, Marie Curie fellow at the University of Copenhagen (KU). The intern will be working at the Department of Computer Science of the University of Copenhagen (DIKU), as part of an international team working on different aspects of computability theory, rewriting, and complexity theory, lead by Prof. Jakob Grue Simonsen.

References

[1] Scott Aaronson and Avi Wigderson. Algebrization: A new barrier in complexity theory. *ACM Trans. Comput. Theory*, 1(1), 2009.

[2] Theodore Baker, John Gill, and Robert Solovay. Relativizations of the P $\stackrel{?}{=}$ NP question. *SIAM Journal on Computing*, 4(4):431–442, 1975.

[3] Ketan Mulmuley. Lower bounds in a parallel model without bit operations. *SIAM Journal of Compution*, 28(4):1460–1509, 1999.

[4] Ketan Mulmuley and Milind Sohoni. Geometric complexity theory I: An approach to the P vs. NP and related problems. *SIAM Journal of Computation*, 31(2):496–526, 2001.

[5] A. A. Razborov and S. Rudich. Natural proofs. *Journal of Computer and System Sciences*, 55, 1997.