

DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE
UNIVERSITY OF SOUTHERN DENMARK, ODENSE

COMPUTER SCIENCE COLLOQUIUM

**PhD colloquium: Finding hay in a haystack - or proving superlinear
circuit lower bounds for linear circuits**

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Abstract:

We continue to study the notion of cancellation-free linear circuits. We show that every matrix can be computed by a cancellation-free circuit, and almost all of these are at most a constant factor larger than the optimum linear circuit that computes the matrix. It appears to be easier to prove statements about the structure of cancellation-free linear circuits than for linear circuits in general. We prove two nontrivial superlinear lower bounds. We show that a cancellation-free linear circuit computing the $n \times n$ Sierpinski gasket matrix must use at least $\frac{1}{2}n \log n$ gates, and that this is tight. This supports a conjecture by Aaronson. The proof is based on gate elimination. This makes it the first, to the authors' knowledge, superlinear lower bound using gate elimination. If time permits we will show how a proof strategy due to Mehlhorn for proving lower bounds on monotone circuits can be almost directly converted to prove lower bounds on cancellation-free linear circuits. We use this together with a result from extremal graph theory due to Andreev to prove a lower bound of $\Omega(n^{2-\epsilon})$ for infinitely many $n \times n$ matrices for every $\epsilon > 0$. These lower bounds for concrete matrices are almost optimal since all matrices can be computed with $O(n^2/\log n)$ gates.