

# The Ada Lovelace Bicentenary Lectures on Computability, December 2015 – January 2016

[Scott Aaronson](#) (MIT)

## *Explorations in Universality*

Wednesday, 23 December, 11:15-12:15

In the 1930s, Turing, Church, Post, and others discovered that every physical computing device that passes a certain "threshold of universality" is equivalent in formal power to every other one, and that a single, small machine can simulate any such device that's described to it as input. In this talk, I'll present some concrete open problems, and recent results by my students and me, aimed at better understanding these discoveries. In particular, I'll describe Dominik Janzing's 2010 challenge to create a "physically universal cellular automaton," and Luke Schaeffer's 2014 solution to that challenge. I'll also describe how Adam Yedidia constructed "small" Turing machines that encode Goldbach's Conjecture, the Riemann Hypothesis, and the consistency of set theory, and will explain the motivation for finding even smaller machines. Finally, I'll describe recent joint work with Luke Schaeffer and Daniel Grier, which completely classifies all possible sets of reversible Boolean logic gates in terms of which reversible transformations they generate, thereby supplying the reversible analogue of Post's lattice. I'll discuss the challenge of generalizing this to quantum gates acting on qubits.



[Watch the video](#)

