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*Implementing Algorithms to Compute Elliptic Curves Over $\mathbb{Q}$*

Let $S = \{p_1, \ldots, p_k\}$ be a set of rational primes and consider the set of all elliptic curves over $\mathbb{Q}$ having good reduction outside $S$ and bounded conductor $N$. Currently, using modular forms, all such curves have been determined for $N \leq 390000$, the bulk of this work being attributed to Cremona.

Early attempts to tabulate all such curves often relied on reducing the problem to one of solving a number of certain integral binary forms called Thue-Mahler equations. These are Diophantine equations of the form

$$F(x, y) = u,$$

where

$$F(x, y) = f_0 x^n + f_1 x^{n-1} y + \cdots + f_{n-1} x y^{n-1} + f_n y^n$$

is a given binary form of degree at least $3$ and $u$ is an $S$-unit. A theorem of Bennett-Rechnitzer show that the problem of computing all elliptic curves over $\mathbb{Q}$ of conductor $N$ reduces to solving a number of Thue-Mahler equations. To compute all such equations, there exists a practical method of Tzanakis-de Weger using bounds for linear forms in $p$-adic logarithms and various reduction techniques. In this talk, we describe our implementation of this method and discuss the key steps in used in our algorithm.