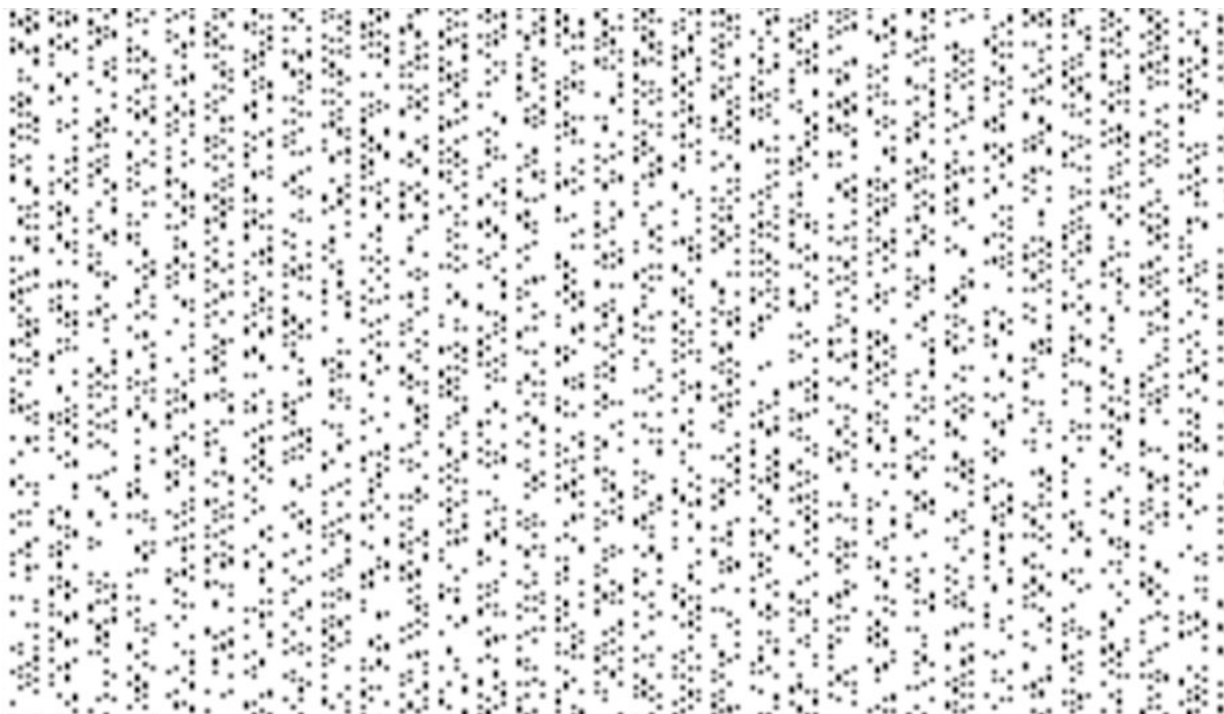


A newly discovered prime number makes its debut

January 31 2018, by Avner Bar-Hen



The distribution of prime numbers from 1 to 76,800, from left to right and top to bottom. A black pixel means that the number is first, while a white pixel means that it is not. Credit: Wikipedia, CC BY

On December 26, 2017, J. Pace, G. Woltman, S. Kurowski, A. Blosser, and their co-authors announced the discovery of a [new prime number](#): $2^{77232917}-1$. It's an excellent opportunity to take a small tour through the wonderful world of prime numbers to see how this result was achieved

and why it is so interesting.

A [prime number](#) is one that is divisible only by itself and the number 1, that is, essentially a number that has no divisor. Some speak of [prime numbers](#) as the atoms of the mathematical universe, others as precious stones.

It is to [Euclid](#) that we owe the first two definitions of a prime number:

- They are infinitely many: the number $(1 * 2 * 3 * \dots * n) + 1$ is not divisible by any number other than 1 and itself. It is not divisible by any of the numbers less than n , so there exists a (new) prime number greater than n . This is considered the first reduction to absurdity.
- Any number is the unique product of prime factors.

[Eratosthenes](#), who lived from -276 to -194, proposed a process that allows us to find all prime numbers less than a given [natural number](#) N . The process consists of eliminating from a table integers from 2 to N that are multiples of those numbers. By deleting all the multiples, there remain only integers that are not multiples of any integer, and so are prime numbers. The search for efficient algorithms is an active research topic – for example for the [Lucas-Lehmer test](#)).



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After the Greek era, there was a long dark period that lasted until the end of the 16th century and the arrival of French theologian and mathematician [Marin Mersenne](#) (1588-1648). He was an advocate of Catholic orthodoxy, yet also believed that religion must welcome any updated truth. He was a [Cartesian](#) and translator of Galileo.

Mersenne was looking for a formula that would generate all the prime numbers. In particular, he studied the numbers $M_p = 2^p - 1$, where p is prime. These numbers are now called Mersenne numbers or [Mersenne primes](#). In 1644 he wrote that M_p is prime for $p = 2, 3, 5, 7, 13, 17, 19, 31, 67, 127, 257$, and compound – in other words, non-prime – for the other 44 lower p values at 257. This definition actually commits five errors: M_{61} , M_{89} and M_{107} are prime, while M_{67} and M_{257} are not.

The new prime number discovered at the very end of 2017 corresponds to $M_{77232917}$. It has 23,249,425 digits – almost a million digits more than the previous record-holding prime. If the number were contained by a document written in the font Times New Roman with a point size of 10 and standard page margins, it would fill 3,845 pages.

The official date of discovery of a prime number is the day that someone declares the result. This is in keeping with tradition: M_{4253} is reputed not to have one because in 1961 the American mathematician Alexander Hurwitz read a printer output from the end forward, and found M_{4423} a few seconds before seeing M_{4253} . The previous Mersenne number also had a complicated history: the computer reported the result to the server on September 17, 2015, but a bug blocked the email. The prime number

remained unnoticed until January 7, 2016.

Quantum cryptography

We often refer to the use of prime numbers in cryptography, but they're too big to be really useful. (There is hope that [quantum cryptography](#) will change things.) Historically, Mersenne's search for prime numbers has been used as a test for computer hardware. In 2016, the premium95 community discovered a flaw in Intel's [Skylake CPU](#) as well as many PCs. This prime [number](#) was found as part of the [Great Internet Mersenne Prime Search Project](#) (GIMPS).

$2^{77232917}-1$ is the 50th Mersenne prime and if the challenge to discover the 51st tempts you, the verification program [is available to all](#) – and there's even a [\\$3,000 prize](#).

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