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Bölcsföldi-Birkás-Bíró monotone prime numbers

József Bölcsföldi[1] György Birkás[2] Tamás Bíró[3]
1 (Eötvös Loránd University Budapest and Perczel Mór Secondary Grammar School Siófok, Hungary)
2 (Baross Gábor Secondary Technical School Siófok, Hungary)
3(DRV Siófok, Hungary)

Abstract: After defining, monotone prime numbers will be presented: the monotone increasing primes from 23 to 55555555777, the monotone decreasing primes from 733 to 7777777777533. How many monotone prime numbers are there in the interval (10^{p-1}, 10^p), where p is a prime number? On the one hand, it has been counted by computer among the prime numbers with up to 43-digits. On the other hand, the function (1) gives the approximate number of monotone prime numbers in the interval (10^{p-1},10^p). Near-proof reasoning has emerged from the conformity of Mills' prime numbers with monotone prime numbers. The sets of monotone prime numbers are probably infinite.

1. Introduction

The sets of special prime numbers within the set of prime numbers are well-known. For instance, the Erdős-primes (the sum of the digits is prime) [8], Fibonacci-primes ($F_0=0$, $F_1=1$, $F_n=F_{n-1}+F_{n-2}$), Gauss-primes (in the form 4n+3), Leyland-primes (in the form x^y+y^x, where $1\leq x\leq y$), Pell-primes ($P_0=0$, $P_1=1$, $P_n=2P_{n-1}+P_{n-2}$), Bölcsföldi-Birkás-Ferenczi primes (all digits are prime and the number of digits is prime),, etc. Question: Which further sets of special prime numbers are there within the set of prime numbers? We have found 2 further sets of special prime numbers within the set of prime numbers. It are the sets of monotone prime numbers.

2. Monotone increasing prime numbers [3], [9], [10], [11], [12].

Definition: a positive integer number is a monotone increasing prime number, if a/ the positive integer number is prime, b/the digits of number are monotone increasing primes, c/ the number of digits is prime, d/ the sum of digits is prime.

The set of prime numbers meeting the conditions a/ and c/ is also well-known: it is the set of prime-long prime numbers [3], [9]. Positive integer numbers meeting all the four conditions (a/, b/, c/, d/) at the same time are monotone increasing prime numbers (Fig.1, Fig.2).

Monoton increasing prime number p has the following sum form:

$$p=\sum_{j=0}^{k(p)} e_j(p).10^j \quad \text{where } e_j(p) \in \{2, 3, 5, 7\} \text{ and } k(p)+1 \text{ is prime and } e_0(p) \in \{3, 7\} \text{ and } \sum_{j=o}^{k(p)} e_j(p) \text{ is prime.}$$

The monotone increasing prime numbers are as follows (the last digit can only be 3 or 7):

23,
223, 227, 337, 557, 577,
33377,
2222333, 2233337, 2235557, 3337777, 3355777, 5555777,
22222222223,22222222357, 22223333333, 22223335577,
22223335777, 22223357777, 22333355777, 22355555777,
22555577777, 33333333377, 33555555557, 55555555777,… etc

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M(p) is the factual frequency of monotone increasing prime numbers in the interval (10^{p-1}, 10^p).
M(2)=1, M(3)=5, M(5)=1, M(7)=6, M(11)=12, M(13)=19, M(17)=19, M(19)=32, M(23)=26, M(29)=42, M(31)=66, M(37)=80, M(41)=91, M(43)=105, … etc.
S(p) function gives the number of monotone increasing prime numbers in the interval (10^{p-1},10^p). We think that the power funktion is **S(p)=2,44p** , where p is a prime
(1)
The factual number of monotone increasing primes and the number of monotone increasing primes calculated according to function (1) is as follows:

Number of digits p	The factual number of monotone increasing primes in the interval $(10^{p-1},10^p)$ M(p)	The number of monotone increasing primes according to functions (1) S(p)=2,44p	M(p)/S(p)
2	1	4,88	0,20
3	5	4,07	1,23
5	1	12,20	0,08
7	6	17,08	0,35
11	12	26,84	0,45
13	19	31,72	0,60
17	19	41,48	0,46
19	32	46,36	0,69
23	26	56,12	0,46
29	42	70,76	0,59
31	66	75,64	0,87
37	80	102,49	0,78
41	91	100,04	0,91
43	105	104,92	1,00

Fig.1

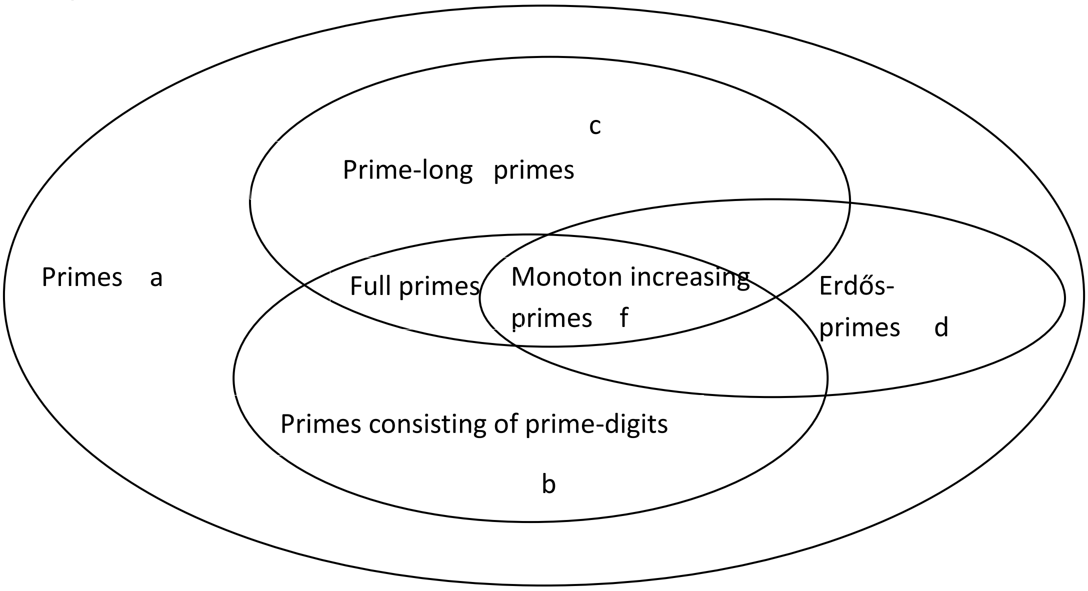

Fig.2 3

Prime numbers a

Primes consisting of prime-digits b

Prime-long primes c

Erdős-primes d

Full primes e

Monotone increasing primes f

3. Monotone decreasing prime numbers [3], [9], [10], [11], [12].

Definition:a positive integer number is a monotone decreasing prime number, if a/ the positive integer number is prime, b/the digits of number are monotone decreasing primes, c/ the number of digits is prime, d/ the sum of digits is prime.

The set of prime numbers meeting the conditions a/ and c/ is also well-known: it is the set of prime-long prime numbers [3], [9]. Positive integer numbers meeting all the four conditions (a/, b/, c/, d/) at the same time are monotone decreasing prime numbers (Fig.3).

Monotone decreasing prime number p has the following sum form:

$$p=\sum_{j=0}^{k(p)} e_j(p).10^j \quad \text{where } e_j(p) € \{2, 3, 5, 7\} \text{ and } k(p)+1 \text{ is prime and } e_0(p) € \{3\} \text{ and } \sum_{j=o}^{k(p)} e_j(p) \text{ is prime.}$$

The monotone desreasing prime numbers are es follows (the last digit can only be 3):

733, 773,
55333, 75533, 77773,
7553333, 7555333, 7775533, 7777753,
55555333333, 77777775553, 77777777533,
7775333333333, 7777777555333, 7777777777533,…etc.

M(p) is the factual frequency of monotone decreasing prime numbers in the interval $(10^{p-1}, 10^p)$.
M(2)=0, M(3)=2, M(5)=3, M(7)=4, M(11)=3, M(13)=3, M(17=10, M(19)=5, M(23)=8, M(29)=11, M(31)=10, M(37)=10, M(19)=5, M(23)=8, M(29)=11, M(31)=10, M(37)=10, M(41)=10,M(43)=9, M(47)=11, M(53)=11, M(59(=19, M(61)=13, M(67)=15, M(71)=27, M(73)=24, … etc.

Q(p) function gives the number of monotone decreasing prime numbers in the interval $(10^{p-1},10^p)$. We think that the funktion is linear:

Q(p)=0,325p+1 **,** where p is a prime. (1)

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The factual number of monotone decreasing primes and the number of monotone decreasing primes calculated according to function (1) are as follows:

Number of digits p	The factual number of monotone decreasing primes in the interval $(10^{p-1},10^p)$ M(p)	The number of monotone decreasing primes according to function (1) Q(p)	M(p)/Q(p)
2	0	1,65	0
3	2	1,98	1,01
5	3	2,63	1,14
7	4	3,28	1,22
11	3	4,58	0,66
13	3	5,23	0,58
17	10	6,53	1,53
19	5	7,18	0,70
23	8	8,48	0,94
29	11	10,43	1,05
31	10	11,08	0,90
37	10	13,03	0,77
41	10	14,33	0,70
43	9	14,98	0,60
47	11	16,28	0,68
53	11	18,23	0,60
59	19	20,18	0,94
61	13	20,83	0,62
67	15	22,78	0,66
71	27	24,08	1,12
73	24	24,73	0,97

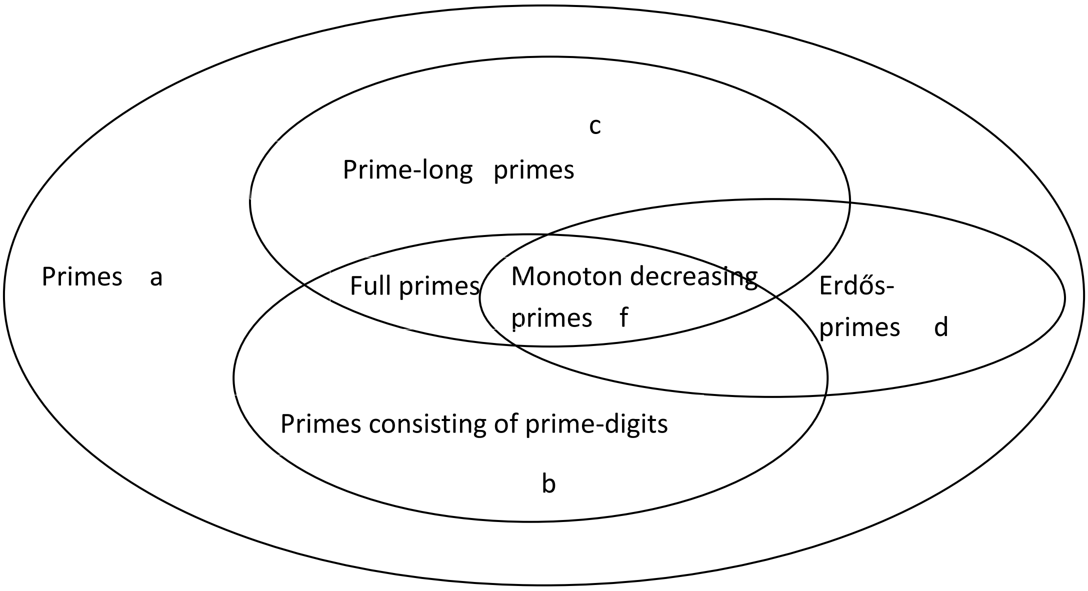
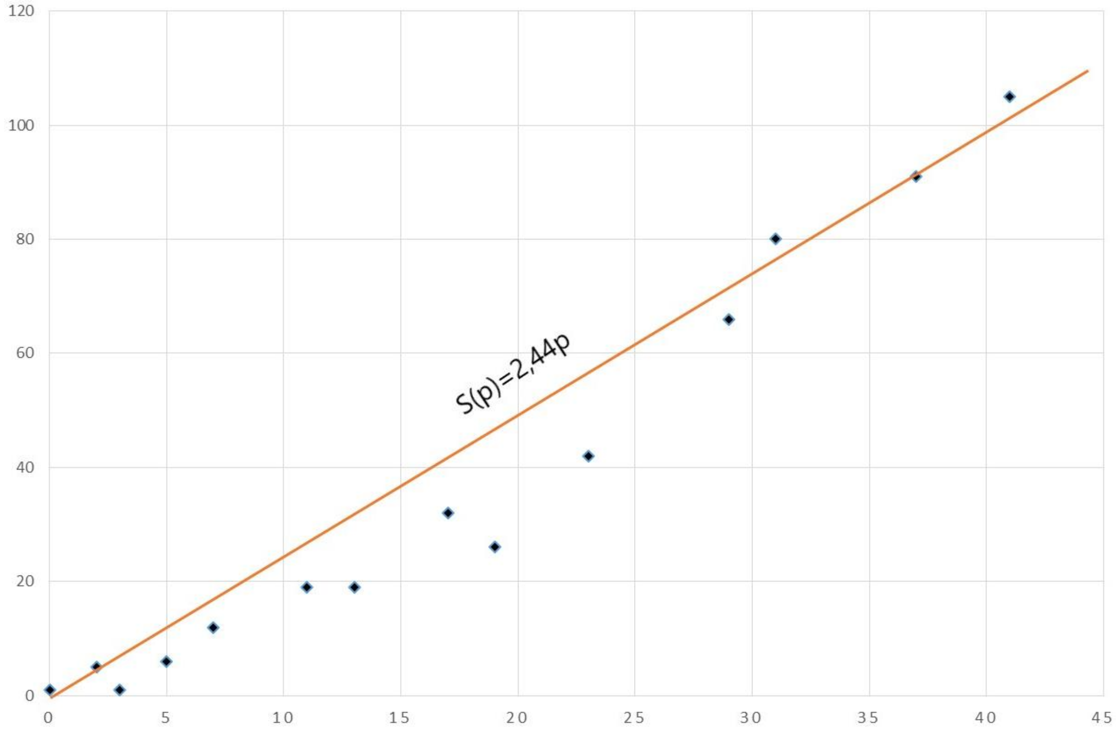
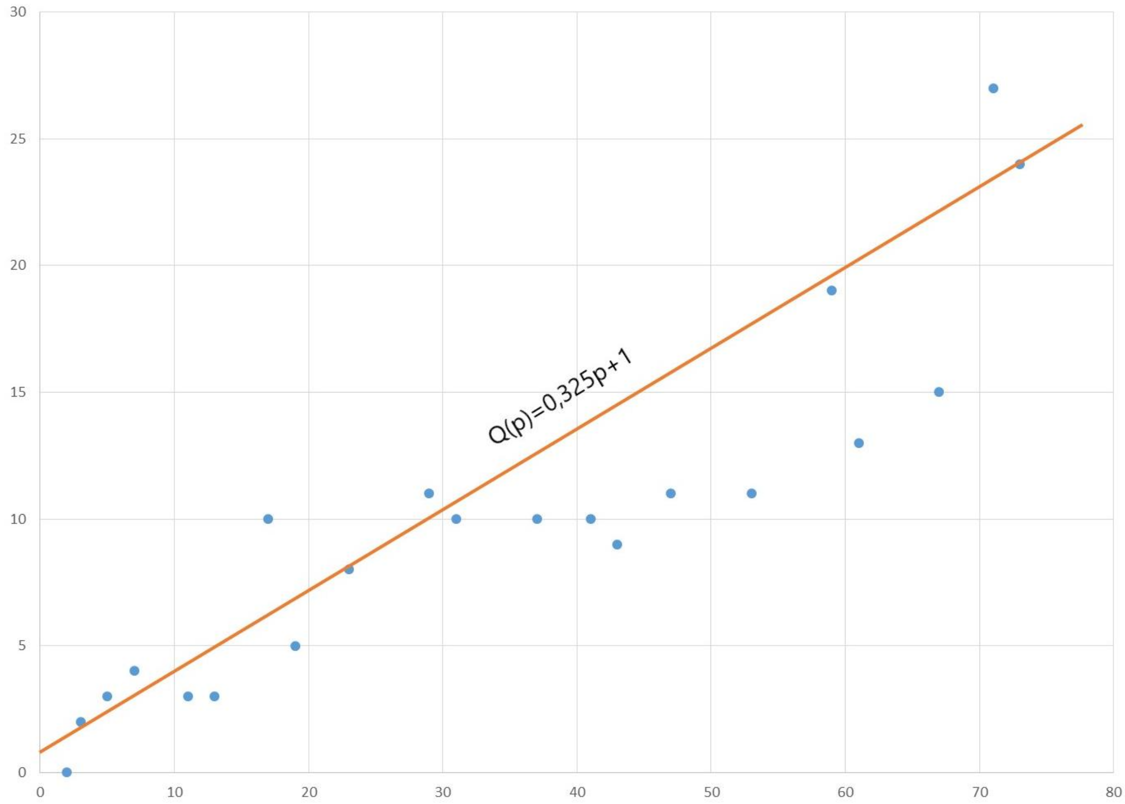


Fig.3

Approximate function of monotone increasing prime numbers
M(p) and S(p)=2,44p



Approximate function of monotone decreasing prime numbers
M(p) and Q(p)=0,325p+1



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4. Number of the elements for example of the set of monotone increasing prime numbers [3], [9], [10], [11], [12].

Let's take the set of Mills' prime numbers!

Definition: The number m=[M ad 3^n] is a prime number, where M=1,306377883863080690468614492602 is the Mills' constant, and n=1,2,3,… is an arbitrary positive integer number. It is already known that the number of the elements of the set of Mills' prime numbers is infinite. The Mills' prime numbers are the following: m=2, 11, 1361, 2521008887,…

The connection n→m is the following:1→2, 2→11, 3→1361, 4→2521008887,… The Mills' prime number m=[M ad 3^n] corresponds with the interval (10^{m-1},10^m) and vice versa. For instance:2→(10, 10^2), 11→(10^{10},10^{11}), 1361→(10^{1360},10^{1361}), etc. and vice versa. The number of the elements of the set of Mills' prime numbers is infinite. As a consequence, the number of the intervals (10^{m-1}, 10^m) that contain at least one Mills' prime number is infinite. The number of monotone growing primes in the interval (10^{m-1},10^m) is S(m)=2,44m . The number of monotone increasing prime numbers is probably infinite: $\lim M(p)=\infty$ is probably, where p is prime, if $p\to\infty$.

5. Conclusion

Countless different sets of special prime numbers have been known. We have found the following set of special prime numbers within the set of prime numbers. There may be further sets of special prime numbers that we do not know yet. Finding them will be task of researchers of the future.

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József Bölcsföldi
Perczel Mór Secondary Grammar School
H-8600 Siófok
Március 15 park 1
8624 Balatonszárszó, Rákóczi utca 53.
Hungary

György Birkás
Baross Gábor Secondary Technical School
H-8600 Siófok
Kardvirágköz 7/a
Hungary

Tamás Bíró
DRV Siófok
H-8636 Balatonszemes
Bem utca 12.
Hungary