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Triple prime numbers

József Bölcsföldi[1] György Birkás[2] Zsuzsanna Károlyi[3] Márta Zakar[4] Sándor Rosta[5]

1 (Eötvös Loránd University Budapest and Perczel Mór Secondary Grammar School Siófok, Hungary)
2 (Baross Gábor Secondary Technical School Siófok, Hungary)
3 VM Building Solutions Hungary Kft. Budakeszi, Hungary)
4 (Széna Square Primary School Székesfehérvár, Hungary)
5(Lukács Secondary Technical School Győr, Hungary)
Corresponding Author: József Bölcsföldi

Abstract: *After defining, triple prime numbers will be presented: Bölcsföldi-Károlyi prime numbers from 23 to 7737733, Bölcsföldi- Rosta prime numbers from 23 to 5533553, Bölcsföldi-Zakar prime numbers from 227 to 22257222577, Birkás-Bölcsföldi prime numbers from 337 to 33575737373 . How many triple 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 computers. On the other hand, the function (1) gives the approximate number of triple prime numbers in the interval (10^{p-1},10^p). Near-proof reasoning has emerged from the conformity of Mills' prime numbers with triple prime numbers. The sets of triple prime numbers are probably infinite.*

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I. 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≤x≤y), Pell-primes (P_0=0, P_1=1, $P_n=2P_{n-1}+P_{n-2}$), „All digits are 1" prime numbers (11, 1111111111111111111, 11111111111111111111111, …), 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 4 further sets of special prime numbers within the set of prime numbers. It are the sets of triple prime numbers.

2. Bölcsföldi-Károlyi prime numbers [3], [9], [10], [11], [12].

Definition: a positive integer number is a Bölcsföldi-Károlyi prime number, if
a/ the positive integer number is prime, b/ all digits are (2 or 3 or 7),
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 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 Bölcsföldi-Károlyi prime numbers (Fig.1, Fig.2).
Bölcsföldi-Károlyi prime number p has the following sum form:

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

The Bölcsföldi-Károlyi prime numbers are as follows (the last digit can only be 3 or 7):
{{23}, {223, 227, 337, 373, 733, 773}, {23327, 32233, 32237, 32323, 32327, 33223, 33377, 33773, 37223, 37337, 77377, 77773}, {2222333, 2223233, 2227727, 2232323, 2233223, 2233337, 2233373, 2237773, 2272727, 2273333, 2277733, 2323337, 2323733, 2323777, 2327737, 2332333, 2332373, 2333237, 2333323, 2337233, 2372737, 2373277, 2373323, 2377273, 2723333, 2723737, 2727733, 2733233, 2737723, 2772227, 2773237, 2773273, 2777233, 3223223, 3223333, 3223373, 3232373, 3232777, 3233323, 3233327, 3237233, 3272377, 3273233, 3273323, 3277327, 3322337, 3332233, 3333773, 3337777, 3372233, 3372727, 3377377, 3723233, 3723277, 3727723, 3732727, 3773377, 3773773, 3777223, 3777377, 7223737, 7223773, 7232377, 7232737,

7233277, 7233727, 7237723, 7272227, 7272337, 7272373, 7273237,
7273723, 7327237, 7337227, 7337333, 7337777, 7373227, 7377373,
7722373, 7727233, 7727323, 7732327, 7733377, 7737337, 7737733, etc.

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C(p) is the factual frequency of Bölcsföldi-Károlyi prime numbers in the interval (10^{p-1}, 10^{p}).
C(2)=1 , C(3)=6 , C(5)=12 , C(7)=86 , C(11)=4244 , C(13)=27600 , etc.
S(p) function gives the number of Bölcsföldi-Károlyi prime numbers in the interval (10^{p-1},10^{p}). We think that

$S(p)=0,9730x2,35^{p-1}$, where p is prime.

The factual number of Bölcsföldi-Károlyi primes and the number of Bölcsföldi-Károlyi primes calculated according to function (1) are as follows:

Number of digits p	The factual number of Bölcsföldi-Károlyi primes in the interval (10^{p-1},10^{p}) C(p)	The number of Bölcsföldi-Károlyi primes according to function $S(p)=0,9730x2,35^{p-1}$	C(p)/S(p)
2	1	2,29	0,44
3	6	5,37	1,12
5	12	29,67	0,40
7	86	163,88	0,52
11	4244	4997,94	0,85
13	27600	27601,15	1,00

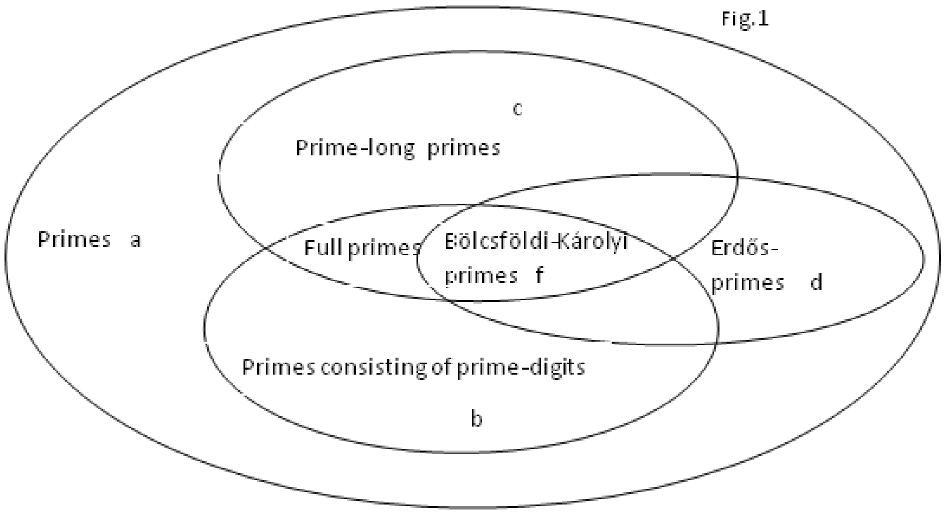
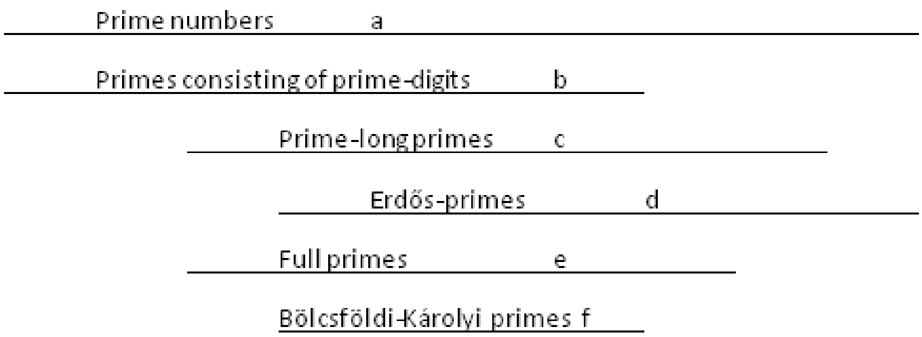


Fig.1

(1)

Fig.2



3. Bölcsföldi-Rosta prime numbers [3], [9], [10], [11], [12].
Definition: a positive integer number is a Bölcsföldi-Rosta prime number, if
a/ the positive integer number is prime, b/ all digits are (2 or 3 or 5),
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 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 Bölcsföldi-Rosta prime numbers (Fig.1).
Bölcsföldi-Rosta prime number p has the following sum form:

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

The Bölcsföldi-Rosta prime numbers are as follows (the last digit can only be 3):
{{23}, {223, 353}, {25253, 25523, 32233, 32323, 33223, 33353, 33533, 35353, 35533, 52253, 53353, 55333}, {2222333, 2222533, 2223233, 2223253, 2225233, 2225323, 2232323, 2232523, 2233223, 2235353, 2252233, 2253353, 2255333, 2322253, 2332333, 2333323, 2335253, 2335523, 2352223, 2352353, 2352533, 2355233, 2523223, 2523533, 2532223, 2535233, 2553233, 3222253, 3223223, 3223333, 3232553, 3233323, 3252533, 3253253, 3255233, 3325253, 3332233, 3353333, 3355553, 3532253, 3532523, 3552233, 3553223, 3553553, 3555353, 5222323, 5225333, 5232223, 5233523, 5235233, 5235323, 5252333, 5322353, 5322533, 5325323, 5353223, 5353553, 5533223, 5533553}}, etc.

B(p) is the factual frequency of Bölcsföldi-Rosta prime numbers in the interval (10^{p-1}, 10^p). B(2)=1 , B(3)=2, B(5)=12, B(7)=59, B(11)=2302, B(13)=20780, etc. S(p) function gives the number of Bölcsföldi-Rosta prime numbers in the interval (10^{p-1},10^p). We think that

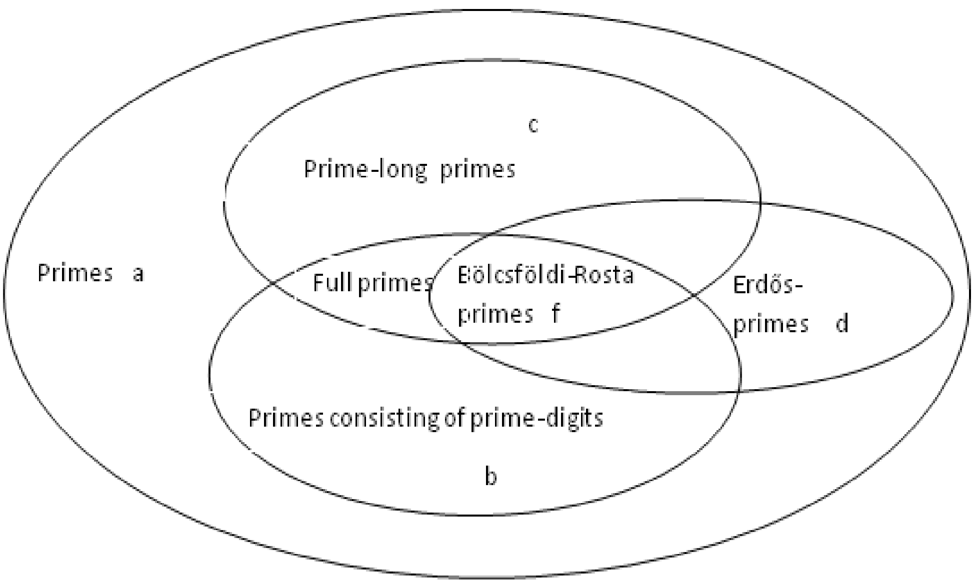
$S(p)=0,9475 \times 2,3^{p-1}$, where p is prime (1)

.

The factual number of Bölcsföldi-Rosta primes and the number of Bölcsföldi-Rosta primes calculated according to function (1) are as follows:

Number of digits p	The factual number of Bölcsföldi-Rosta primes in the interval (10^{p-1},10^p) B(p)	The number of Bölcsföldi-Rosta primes according to function $S(p)=0,9475 \times 2,3^{p-1}$	B(p)/S(p)
2	1	2,18	0.46
3	2	5,01	0,40
5	12	23,46	0,51
7	59	140,26	0,42
11	2302	3925,16	0,59
13	20780	20764,11	1,00

Fig.1



4. Bölcsföldi-Zakar prime numbers [3], [9], [10], [11], [12].

Definition: a positive integer number is a Bölcsföldi-Zakar prime number, if
a/ the positive integer number is prime, b/ all digits are (2 or 5 or 7),
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 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 Bölcsföldi-Zakar prime numbers (Fig.1).

Bölcsföldi-Zakar prime number p has the following sum form:

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

The Bölcsföldi-Zakar prime numbers are as follows (the last digit can only be 7):
. {227, 557, 577, 757}, {27527, 52727, 57557, 75227, 75557, 75577, 77557}, {2227727, 2272727, 2525557, 2572777, 2727577, 2772227, 2775277, 2777527, 5227777, 5255527, 5555777, 5557757, 5575777, 5577577, 5727277, 5755577, 5775557, 5777227, 5777557, 7272227, 7527727, 7575577, 7577777}}
{{22222272727, 22222557277, 22222575257, 22222575527, 22222577257, 22222577527, 22222727557, 22222755727, 22222775257, 22222777277, 22225225577, 22225257727, 22225275277, 22225525727, 22225575227, 22225725257, 22227222727, 22227225557, 22227225577, 22227227777, 22227277727, 22227522557, 22227525527, 22227557777, 22227722227, 22227725257, 22227772727, 22252225577, 22252225757, 22252227577, 22252557227, 22252722757, 22252725727, 22252755227, 22255222757, 22255252277, 22255275557, 22255527227, 22255527557, 22255555277, 22255575527, 22255722527, 22255752227, 22255755527, 22257222577, etc.

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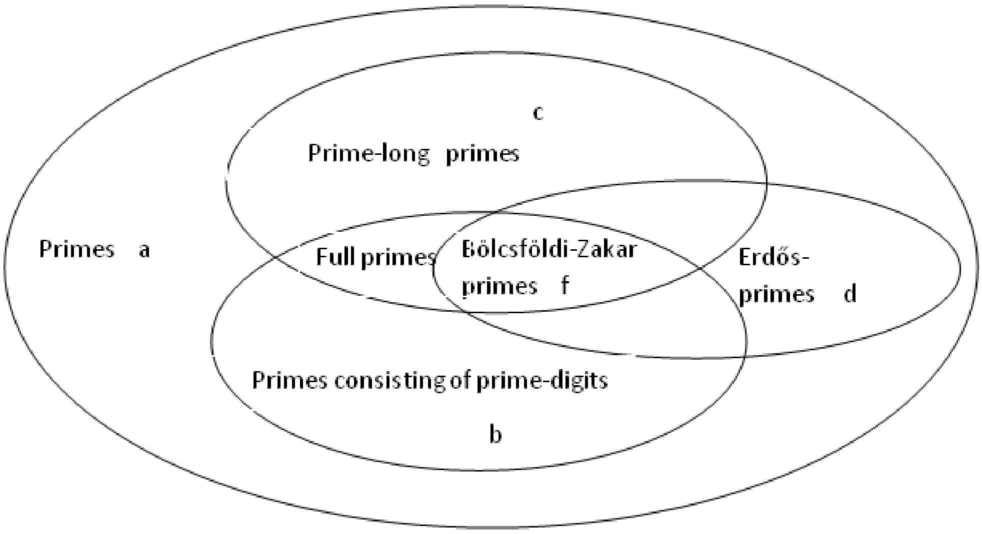
D(p) is the factual frequency of Bölcsföldi-Zakar prime numbers in the interval $(10^{p-1}, 10^p)$.
, D(2)=0 , D(3)=4 , D(5)=7, D(7)=23 , D(11)=2032 , D(13)=15527, etc.
S(p) function gives the number of Bölcsföldi-Zakar prime numbers in the interval $(10^{p-1},10^p)$. We think that

$$\mathbf{S(p)=1{,}2079x2.2^{p-1}}, \quad \text{where p is prime} \qquad (1)$$

.

The factual number of Bölcsföldi-Zakar primes and the number of Bölcsföldi-Zakar primes calculated according to function (1) are as follows:

Number of digits p	The factual number of Bölcsföldi-Zakar primes in the interval $(10^{p-1},10^p)$ D(p)	The number of Bölcsföldi-Zakar primes according to function $S(p)=1{,}2079x2{,}2^{p-1}$	D(p)/S(p)
2	0	2,66	0
3	4	5,85	0,68
5	7	28,30	0,25
7	23	136,95	0,17
11	2032	3208,17	0,63
13	15527	15527,56	1,00



5. Birkás-Bölcsföldi prime numbers [3], [9], [10], [11], [12].

Definition: a positive integer number is a Birkás-Bölcsföldi prime number, if
a/ the positive integer number is prime, b/ all digits are uneven prime (3 or 5 or 7), 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 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 Birkás-Bölcsföldi prime numbers (Fig.1).

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Birkás-Bölcsföldi prime number p has the following sum form:

2.1 $p=\sum_{j=0}^{k(p)} e_j(p).10^j$ where $e_j(p)$ € {3, 5, 7} and k(p)+1 is prime and $e_0(p)$ € {3, 7} and $\sum_{j=o}^{k(p)} e_j(p)$ is prime.

The Birkás-Bölcsföldi prime numbers are as follows (the last digit can only be 3 or 7):

337, 353, 373, 557, 577, 733, 757, 773,
33353, 33377, 33533, 33773, 35353, 35533, 35537, 35573, 35753, 37337, 53353, 53777, 55333, 55337, 55373, 55733, 57557, 57737, 57773, 73553, 73757, 75353, 75377, 75533, 75557, 75577, 75773,77377, 77557, 77573, 77773,
3333773,3335537, 3335573, 3335737, 3335753, 3337777, 3353333, 3353773, 3355337, 3355357, 3355553, 3355733, 3355777,3357337, 3357353, 3357577, 3373553, 3373753, 3375577, 3377377, 3377557, 3533357, 3533377, 3533557, 3533573, 3535373, 3535573, 3535733, 3537337, 3537733, 3553553, 3553777, 3555353, 3557377, ...
33575337353, 33575337533, 33575357537, 33575373353, 33575373737, 33575375333, 33575375777, 33575377373, 33575533373, 33575533553, 33575537537, 33575555333, 33575555357, 33575555777, 33575557553, 33575557777, 33575573333, 33575577377, 33575577533, 33575577757, 33575733353, 33575733377, 33575737337, 33575737373, etc.

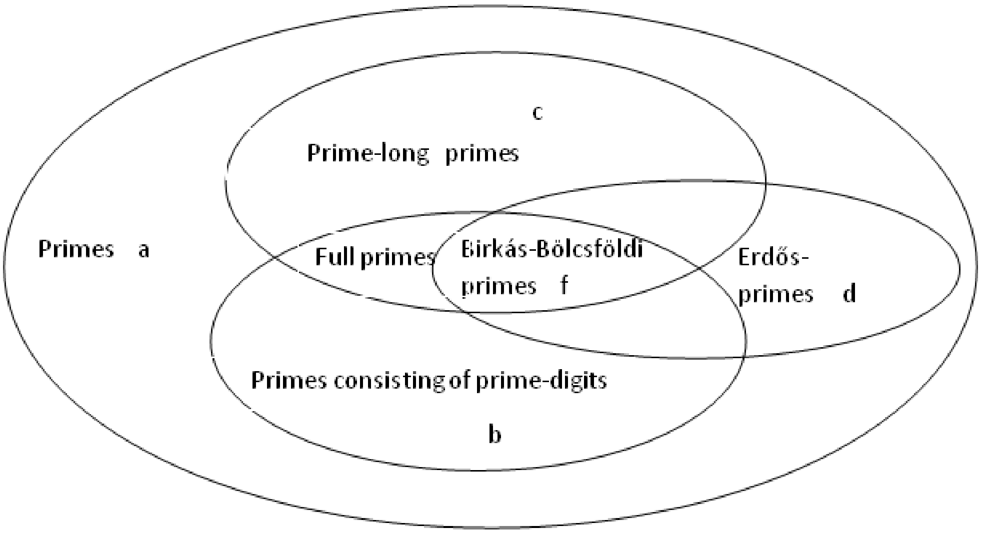
T(p) is the factual frequency of Birkás-Bölcsföldi prime numbers in the interval $(10^{p-1}, 10^p)$. ,
T(3)=8, T(5)=31, T(7)=171, T(11)=7453, T(13)=63660, etc.
S(p) function gives the number of Birkás-Bölcsföldi prime numbers in the interval $(10^{p-1},10^p)$. We think that

$S(p)=1{,}263x2{,}3^p$, where p is prime. (1)

The factual number of Birkás-Bölcsföldi primes and the number of Birkás-Bölcsföldi primes calculated according to function (1) are as follows:

Number of digits p	The factual number of Birkás-Bölcsföldi primes in the interval $(10^{p-1},10^p)$ T(p)	The number of Birkás-Bölcsföldi primes according to function $S(p)=1{,}263x2{,}3^p$	T(p)/S(p)
3	8	15,37	0,52
5	31	81,29	0,38
7	171	430,03	0,40
11	7453	12033,99	0,62
13	63660	63659,79	1,00

Fig.1



3. Number of the elements of the set for example of Bölcsföldi-Károlyi prime numbers [3],[9],[10],[11],[12].

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

Definition: The number $m=[M \text{ ad } 3^n]$ is a prime number, where M=1,3063778838630806904686144926026 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 $m=[M \text{ ad } 3^n]$ 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 Bölcsföldi-Károlyi primes in the interval $(10^{m-1},10^m)$ is $S(m)=0{,}9730x2{,}35^{m-1}$. The number of Bölcsföldi-Károlyi prime numbers is probably infinite: $\lim_{p\to\infty} C(p)=\infty$ is probably, where p is prime.

II. 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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