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AFDELING NUMERIEKE WISKUNDE
(DEPARTMENT OF NUMERICAL MATHEMATICS)

NW 2/78

JANUARI

H.J.J. TE RIELE

FURTHER RESULTS ON UNITARY ALIQUOT SEQUENCES

2ND EDITION

amsterdam

1978

**stichting
mathematisch
centrum**



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2e boerhaavestraat 49 amsterdam

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Preface to the second edition

The second edition of this report hardly differs from the first one, except for a few minor corrections and one major one, viz., the replacement of line 13 on page 35:

2.3E3.5E2.7a	29.41.43.59,19.131.1259	498(539)	1
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by

2.3E3.5E2.7a	29. <u>41</u> .43.59,19.131.1259	498(539)	0
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As a consequence, the total number of unitary 2-cycles given in this report is not 1186 (first edition) but 1185.

However, yet one more unitary 2-cycle was known to me at the time of the preparation of this report, viz. the (exotic) pair

$$1080150 (2.5^2 19.3.379)$$

$$1291050 (2.5^2 19.3^2 151)$$

which occurs (too) frequently in my report "Unitary aliquot sequences", MR 139/72, September 1972, but which was inadvertently left out from this report. This brings back the total number of 2-cycles to 1186.

During the preparation of this report I was not acquainted with the contents of the following two publications, which partly overlap this work: C.R. Wall, Topics related to the sum of unitary divisors of an integer, Ph.D. thesis, The University of Tennessee, March 1970, and M. Lal, G. Tillier and T. Summers, Unitary sociable numbers, Proc. Second Manitoba conference on Numerical Math., 1972, pp.211-216.

Wall reports to have found, and gives a list of, 610 unitary 2-cycles, but there are a number of errors and misprints (for example: four pairs were constructed from wrong amicable pairs given by Escott (see [5a]), one pair occurs twice). I have been able to correct and reconstruct several pairs, but not all of them: I found 592 correct unitary 2-cycles. A careful check revealed that they all occur in the list in this report. Besides the 2-cycles, Wall also gives five 1-cycles (including his well-known

24-digit one), one 3-cycle, one 5-cycle and one 14-cycle starting with 2418. As far as I know, Wall was the first to publish the 24-digit 1-cycle, the 592 2-cycles and the 3-, 5- and 14-cycle. They all are contained in this report.

Lal c.s. have computed all UAS-s of n with $1 < n \leq 10^5$. They count 88590 terminating sequences, so apparently UAS 89610, the behaviour of which was unknown to me, is terminating. They also give a list of unitary t -cycles with the following numbers:

t	1	2	3	4	5	6	14	25	39	65
number of t -cycles given by Lal c.s.	4	26	1	2	1	1	3	1	1	1

These cycles are contained in the first edition of this report, except for the 2-, 39- and 65-cycles, which are given on the next two pages.

Following the method of this report it is possible to construct from Lal's 2-cycle (next page) five other unitary 2-cycles by replacing the common factor $2.3^2.7$ by $2^2.3.7$, $2.3^2.5^2.7^2.13$, $2^2.3.5^2.7^2.13$, $2.3^3.5.7^2$ and $2^2.3^2.5.7$, respectively. This gives a total of $1186+1+5 = 1192$ unitary 2-cycles known to me at present. The updated counting list now reads:

t	1	2	3	4	5	6	14	25	39	65
#	5	1192	1	8	1	1	3	1	1	1

In this report many new unitary 2-cycles have been constructed from ordinary amicable pairs. Lal's 2-cycle (next page) allows the converse: replacing the common factor $2.3^2.7$ by $3^2.7^2.13.19$ yields the new ordinary amicable pair (in Lee's notation [5])

452A	/F	4416880923	3E2.7E2.13.19.23.41.43
.923016		4785272037	3E2.7E2.13.19.197.223

2-cycle (Lal c.s.)5109174(2.3²7.23.41.43)5535306(2.3²7.197.223)39-cycle (Lal c.s.)

2212026(2.3.317.1163)

2229798(2.3.371633)

2229810(2.3.5.11.29.233)

3835470(2.3.5.127849)

5369730(2.3.5.71.2521)

7704318(2.3.1284053)

7704330(2.3.5.67.3833)

11066934(2.3.257.7177)

11156154(2.3.19.97861)

12330726(2.3.2055121)

12330738(2.3³7.32621)9591246(2.3²7.163.467)8829234(2.3²31.15823)

6361806(2.3.11.41.2351)

7863090(2.3.5.262103)

11008398(2.3.23.241.331)

12130674(2.3.2021779)

12130686(2.3²149.4523)8227314(2.3²59.61.127)6057486(2.3²336527)4038354(2.3²157.1429)

2739846(2.3.456641)

2739858(2.3.11.41513)

3238158(2.3.7.11.43.163)

5074674(2.3.11.23.3343)

6482190(2.3.5.11.13.1511)

11806962(2.3.59.33353)

12207918(2.3.19.173.619)

13683282(2.3.2280547)

13683294(2.3²760183)

9122226(2.3.59.73.353)

9738894(2.3.11.41.59.61)

12759666(2.3.2126611)

12759678(2.3²19.37309)

9626322(2.3.59.71.383)

10280238(2.3.1713373)

10280250(2.3³5³1523)5849766(2.3³13²641)3317994(2.3²184333)

65-cycle (Lal c.s.)

473298(2.3.7.59.191)	3811530(2.3.5.127051)
632622(2.3.105437)	5336214(2.3.13.37.43 ²)
632634(2.3.97.1087)	6474186(2.3 ² 37.9721)
646854(2.3.13.8293)	4608894(2.3.31.71.349)
746538(2.3.13.17.563)	5067906(2.3.844651)
958998(2.3.159833)	5067918(2.3 ² 281551)
959010(2.3.5.13.2459)	3378642(2.3.47.11981)
1520670(2.3.5.173.293)	3522990(2.3.5.43.2731)
2162562(2.3.139.2593)	5131986(2.3.855331)
2195358(2.3.11.29.31.37)	5131998(2.3 ⁴ 79.401)
3057762(2.3.701.727)	2779362(2.3 ² 154409)
3074910(2.3.5.102497)	1852938(2.3 ² 311.331)
4304946(2.3.717491)	1254582(2.3 ³ 7.3319)
4304958(2.3.7.102499)	976458(2.3.7.67.347)
5535042(2.3.19.23.2111)	1295286(2.3.59.3659)
6630078(2.3.7.13.12143)	1339914(2.3.223319)
9691458(2.3.7.59.3911)	1339926(2.3.7.61.523)
12841662(2.3.251.8527)	1778922(2.3 ⁴ 79.139)
12947010(2.3.5.431567)	976278(2.3.162713)
18125886(2.3.19.23.31.223)	976290(2.3.5.7.4649)
23161794(2.3.3860299)	1702110(2.3.5.56737)
23161806(2.3 ² 191.6737)	2383026(2.3.17.61.383)
15649074(2.3 ² 7.124199)	2759502(2.3.619.743)
14158926(2.3 ² 17.46271)	2775858(2.3.462643)
10827954(2.3 ² 47.12799)	2775870(2.3 ⁴ 5.23.149)
7604046(2.3 ² 227.1861)	2537730(2.3 ⁴ 5.13.241)
5132034(2.3 ² 285113)	2462958(2.3 ² 293.467)
3421386(2.3 ³ 17.3727)	1664802(2.3 ² 92489)
2215350(2.3 ⁴ 5 ² 547)	1109898(2.3 ² 197.313)
1289658(2.3.214943)	755262(2.3 ² 41959)
1289670(2.3.5.42989)	503538(2.3.7.19.631)
1805610(2.3.5.139.433)	709902(2.3 ² 39439)
2569110(2.3.5.29.2953)	

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Further results on unitary aliquot sequences

by

H.J.J. te Riele

0. SUMMARY

In this report the study of the behaviour of unitary aliquot sequences, started in "Unitary aliquot sequences (MR 139/72), is extended. For reasons of comparison, several results of MR 139/72 are included. From the computations of all unitary aliquot sequences with starting values in the intervals $(0, 10^5]$ and $(10^6, 10^6 + 10^3]$ we conclude that these sequences behave in a stable manner; about 88.6% of the sequences are terminating, the others are periodic (except only one sequence with unknown behaviour).

An important part of this study is devoted to the construction of unitary 2-cycles (or unitary amicable pairs). Sections 3 and 4 contain information about 1078 new unitary 2-cycles. In section 5 we list all known other cycles (for $t \neq 2$), including several new cycles. The number of unitary t -cycles now known is 5 for $t = 1$ (discovered by Subbarao and Wall), 1185 for $t = 2$ (107 discovered by Peter Hagis, Jr), 1 for $t = 3$, 8 for $t = 4$, 1 each for $t = 5$ and $t = 6$, 3 for $t = 14$ and 1 for $t = 25$.

In the Appendix, three theorems are given, which deal with the number of different prime factors of the elements of a unitary t -cycle. This appendix is essentially due to Walter Borho.

All computations were carried out on the EL-X8 computer of the Mathematical Centre. Computer time used was about ten hours.

1. Introduction

A divisor d of a natural number n is called unitary, if $(d, n/d) = 1$.
If the prime factorization of n is given by

$$n = q_1^{\alpha_1} q_2^{\alpha_2} \dots q_r^{\alpha_r},$$

where $q_1, q_2, \dots, q_r$ are distinct primes, $q_1 < q_2 < \dots < q_r$, and α_i are natural numbers ($i = 1, 2, \dots, r$), then the unitary divisors of n are

$$1, q_1^{\alpha_1}, q_2^{\alpha_2}, \dots, q_r^{\alpha_r}, q_1^{\alpha_1} q_2^{\alpha_2}, q_1^{\alpha_1} q_3^{\alpha_3}, \dots, \\ q_1^{\alpha_1} q_2^{\alpha_2} \dots q_r^{\alpha_r}, \dots, q_1^{\alpha_1} q_2^{\alpha_2} \dots q_r^{\alpha_r},$$

and their sum $\sigma^*(n)$ can be written as

$$\sigma^*(n) = (q_1^{\alpha_1} + 1) (q_2^{\alpha_2} + 1) \dots (q_r^{\alpha_r} + 1).$$

The function $s^*(n) = \sigma^*(n) - n$ is called the sum of the unitary aliquot divisors of n . We define $s^*(1) = s^*(0) = 0$.

A unitary aliquot sequence of n (abbreviated: UAS of n) is a sequence (n_i) , defined by

$$n_0 = n, n_1 = s^*(n_0), \dots, n_i = s^*(n_{i-1}), \dots$$

Examples

- 1.1 UAS of 80: 80, 22, 14, 10, 8, 1, 0, 0, ...
- 1.2 UAS of 220: 220, 140, 100, 30, 42, 54, 30, ...
- 1.3 UAS of 3672: 3672, 864, 60, 60, ...
- 1.4 UAS of 1482: 1482, 1878, 1890, 2142, 2178, 1482, ...
- 1.5 UAS of 89610: 89610, 135010, 235914, 320502, 469770, 819318, ...

Sometimes, the $(i+1)$ th term n_i of a UAS of n_0 is denoted by $n_0 : i$, for instance $80 : 5 = 1$, $220 : 3 = 30$, $220 : 6 = 30$, $1482 : 5 = 1482$.

A t -tuple of distinct numbers $(n_0, n_1, \dots, n_{t-1})$ with

$$n_i = s^*(n_{i-1}) \quad (i = 1, 2, \dots, t-1) \text{ and } s^*(n_{t-1}) = n_0,$$

will be called a unitary t-cycle⁺; unitary 1-cycles are also called unitary perfect numbers [7], unitary 2-cycles are also unitary amicable pairs [3].

According to their behaviour, unitary aliquot sequences can be divided into three classes:

(i) Some term n_j of the sequence is a prime number, or a prime power; then the next term n_{j+1} equals 1 and $n_i = 0$ for $i > j + 1$. This UAS is called terminating. The index l such that $n_l = 1$ is called the length of the sequence; thus the length of the UAS of 80 is 5 (see 1.1).

(ii) A UAS is called periodic, if there exists an index k such that the t -tuple $(n_k, n_{k+1}, \dots, n_{k+t-1})$ is a unitary t -cycle. The least index k such that n_k is a member of a unitary t -cycle is called the preperiod l' and n_l , the endpoint of the periodic UAS. If $l' = 0$, then we have a purely periodic sequence, else ($l' > 0$) an ultimately periodic sequence.

For instance,

UAS of 220, $l' = 3$, $t = 3$, ultimately periodic (see 1.2);

UAS of 3672, $l' = 2$, $t = 1$, ultimately periodic (see 1.3);

UAS of 1482, $l' = 0$, $t = 5$, purely periodic (see 1.4).

(iii) The UAS is unbounded. It is not known, whether unbounded unitary aliquot sequences do exist. During our computations (including those in [6]) we only met one UAS, the terms of which became too large for our computational means. 11409 of the remaining 99999 sequences are periodic, the other 88590 sequences are terminating. In [6] we have proved the existence of UAS-s with m monotonically increasing terms, for any given natural number m , but this does not prove the existence of unbounded UAS-s.

⁺ In [6] we proposed the name "unitary sociable group of order t ", but this name suggests other mathematical concepts than we mean.

2. Unitary aliquot sequences with starting value less than 100000

The computations in [6] have now been extended to all UAS-s with starting values less than 100000 (was 40000). Only one sequence with unknown behaviour was left.

This sequence starts with $n_0 = 89610$; we stopped after the computation of

$$89610 : 541 = 114601234388928504726 = 2.3.c,$$

where c is a composite number.

Many results of our computations have been collected in tables 1, 2, 3, 4 and 10. We have included some results from [6], for purposes of comparison.

Table 1 shows the distribution of all UAS-s with starting values less than 100000 among classes (i) and (ii), for intervals of length 10000. Of all these sequences, those, with an odd starting value are terminating.⁺ In general, the length of these sequences is small, compared with the length of terminating sequences with an even starting value. An explanation of this phenomenon is given by the following two observations:

- We can distinguish between odd and even unitary aliquot sequences. Indeed, if n is odd, then $s^*(n)$ is odd, and if n is even, then $s^*(n)$ is even or equals 1.
- The average value of $\frac{s^*(n)}{n}$ equals .3684 (see [6]), while the contribution of the odd natural numbers to this value is .0865 and of the even natural numbers .2819.

Some information about the only UAS with unknown behaviour can be found in Table 2. The first 21 terms of this sequence, and all subsequent terms which have two prime factors greater than 10^6 have been included in this Table, together with their factorizations.

⁺In fact, there are only 34 odd unitary abundant numbers (numbers n such that $s^*(n) / n > 1$) less than 10^5 , and a unitary cycle must contain such a number.

TABLE 1 Behaviour of all unitary aliquot sequences with starting value ≤ 100000 .

	terminating	periodic						unknown
		t=1	t=2	t=3	t=4	t=5	t=14	
(0, 10000]	9025	191	149	472	0	101	62	0
(10000, 20000]	8933	184	261	466	0	136	20	0
(20000, 30000]	8943	179	277	422	0	151	28	0
(30000, 40000]	8800	174	279	520	0	180	47	0
(40000, 50000]	8800	187	304	466	0	206	37	0
(50000, 60000]	8856	141	304	463	0	182	54	0
(60000, 70000]	8783	166	373	491	0	137	50	0
(70000, 80000]	8840	133	349	460	0	178	40	0
(80000, 90000]	8828	165	343	482	1	153	27	1
(90000, 100000]	8782	177	366	480	0	162	33	0
(0 , 100000]	88590	1697	3005	4722	1	1586	398	1
	88.59%	11.41%						0.00%

TABLE 2 A unitary aliquot sequence with unknown behaviour.

k	89610:k	factorization	k	89610:k	factorization
0	89610	2.3.5.29.103	11	1234518	2.3.61.3373
1	135030	2.3.5.7.643	12	1275738	2.3.149.1427
2	235914	2.3.7.41.137	13	1294662	2.3.47.4591
3	320502	2.3.7.13.587	14	1350330	2.3.5.19.23.103
4	469770	2.3.5.7.2237	15	2243910	2.3.5.74797
5	819318	2.3.19.7187	16	3141546	2.3.293.1787
6	905802	2.3.150967	17	3166518	2.3.527753
7	905814	2.3E2.7E2.13.79	18	3166530	2.3.5.59.1789
8	774186	2.3.7.18433	19	4566270	2.3.5.19.8011
9	995478	2.3.11.15083	20	6971010	2.3.5.232367
10	1176618	2.3.41.4783			
k	89610:k	factorization			
400	8955713959776978	2.3.3270287.456418349			
417	30758774147877366	2.3E2.1097501.1557010687			
426	35871726786276138	2.3.26278393.227510911			
439	39691536251296950	2.3E2.5E2.2416123.36506177			
441	34399367297077590	2.3E2.5.23.2615779.6353003			
463	40283418787462182	2.3.2651629.2531991893			
471	51270385551153126	2.3.1126211.7587445211			
474	54859868916679290	2.3.5.113.1202107.13462073			
475	77969102204471046	2.3.1297.3000761.3338873			
498	141247679903833962	2.3.1794731.13116884917			
510	209027463954231162	2.3.109641061.317745107			
521	5221741915410821862	2.3.883.1546403.637354073			
524	6076036931507507226	2.3.31.1301.1946453.12899897			
527	13448591937574082790	2.3.5.20181463.22212780011			
541	114601234388928504726	2.3.c			

According to Table 1, the total number of periodic UAS-s is 11409. 64 of them are purely periodic, the others ultimately. It is of interest to know, into which unitary t-cycles these sequences lead, and with what frequencies. This is shown in Table 3. The only periodic sequence, which leads into a unitary 4-cycle, is the sequence 81570, 114270, 182082, 182094, 232626, 237678, 305682, 352878, 360978, 403662, 420738, 420750, 395730, 395910, 420570, 420750,

Table 4 shows more details of periodic UAS-s with endpoints which are frequently reached, viz., the distribution of the frequencies of the starting values among intervals of length 10000. The frequencies seem to be rather constant (roughly speaking), when we look at different intervals. Another remarkable fact is, that the numbers 30, 42, 54 are reached with frequencies which are in a ratio of (roughly) 3 : 2 : 1, while the numbers 114 and 126 are reached with frequencies which have a ratio of about 1 : 1. The number 1140 is 44 times an endpoint of a UAS, whereas 1260 is reached only once (by 1140).

TABLE 3 Unitary t-cycles into which lead the 11409 periodic unitary aliquot sequences with starting values ≤ 100000 , and frequencies.

t	unitary t-cycle	freq.	t	unitary t-cycle	freq.	t	unitary t-cycle	freq.
1	6	1	2	[44772	2	4	[395730	0
1	60	218		49308	2		395910	0
1	90	1477	2	[56430	1576		420570	0
1	87360	1		64530	3		420750	1
			2	[67158	1			
2	[114	579		73962	1	5	[1482	1
	126	556	2	[1080150	0		1878	35
2	[1140	44		1291050	205		1890	134
	1260	1					2142	31
2	[18018	32	3	[30	2377		2178	1385
	22302	1		42	1525			
2	[32130	1		54	820			
	40446	1						
t	unitary t-cycle	freq.	t	unitary t-cycle	freq.	t	unitary t-cycle	freq.
14	[2418	136	14	[24180	39	14	[35238	13
	2958	24		29580	3		45402	1
	3522	13		35220	1		65190	1
	3534	4		35440	1		98106	2
	4146	4		41460	2		101478	0
	4158	17		41580	1		117258	0
	3906	2		39060	1		117270	0
	3774	4		37740	1		117450	0
	4434	2		44340	3		74430	26
	4446	9		44460	2		74610	2
	3954	1		39540	1		74790	1
	3966	18		39660	2		65322	3
	3978	1		39780	2		49878	33
	[3582	1		[35820	1		[38682	20

TABLE 4 Distribution of starting values of the periodic unitary aliquot sequences which end in a member of one of the unitary t-cycles (60), (90), (114, 126), (1140, 1260), (30, 42, 54)

Unitary t-cycle	60	90	114	126	1140	1260	30	42	54
t =	1	1	2		2		3		
Interval									
(0- 10000]	30	160	56	61	8	1	219	163	90
(10000- 20000]	23	161	60	57	5	0	237	156	73
(20000- 30000]	16	163	47	39	4	0	214	136	72
(30000- 40000]	24	150	68	47	3	0	271	157	92
(40000- 50000]	29	158	57	64	4	0	245	140	81
(50000- 60000]	12	129	60	67	2	0	249	141	73
(60000- 70000]	12	154	70	55	2	0	240	169	82
(70000- 80000]	22	111	53	57	7	0	217	164	79
(80000- 90000]	26	138	53	50	2	0	247	158	77
(90000-100000]	24	153	55	59	7	0	238	141	101
(0-100000]	218	1477	579	556	44	1	2377	1525	820

The question arises whether the behaviour of UAS-s, as shown in Table 1, stays the same, when we look at all UAS-s with starting value in the interval (say) (1000000, 1001000]. We have computed these sequences, and the results are laid down in Table 5; for reasons of comparison, we have included in this Table the totals from Table 1. One very long periodic sequence was found, viz., the UAS of 1000830, preperiod $l' = 791$, endpoint $= 2178$, period $= 5$, maximum term $= 1000830 : 588 = 1623583833750$.

TABLE 5 Behaviour of all unitary aliquot sequences with starting values in the intervals $(0, 100000]$ and $(1000000, 1001000]$.

	terminating	periodic						unknown
		t=1	t=2	t=3	t=4	t=5	t=14	
$(0, 100000]$	88590	1697	3005	4722	1	1586	398	1
	88.6%	11.4%						0.0%
$(1000000, 1001000]$	883	14	35	43	0	22	3	0
	88.3%	11.7%						0.0%

In Table 10 (p.37-56) we present more information about the 7110 periodic unitary aliquot sequences with starting values in the interval $(40000, 100000]$, viz., their starting values, the preperiods and the endpoints⁺. In case of purely periodic UAS-s, only the starting value is given; this value occurs in Table 3 as a member of a unitary t-cycle. 20 sequences are purely periodic; the other 7090 sequences are ultimately periodic. [6] contains a similar Table for the interval $(0, 40000]$.

Conclusions Unitary aliquot sequences seem to behave in a stable manner. About 88.6% are terminating, about 11.4% are periodic. Whether or not unbounded unitary aliquot sequences exist, is an open question, although it is known that arbitrarily long sequences can be constructed. Very long terminating sequences, with more than 1100 terms are known [6]. The longest known periodic sequence has 791 terms before the periodic part.

⁺Table 10 also contains the starting value 89610 of the only sequence with unknown behaviour.

3. Construction of unitary amicable pairs from amicable pairs.

Two theorems from [6] deal with the construction of unitary t -cycles; application of these theorems to the construction of unitary amicable pairs ($t=2$), yields 1061 new unitary amicable pairs.

The list of nearly all known amicable pairs, recently published by Lee and Madachy [5], is our starting point. When we speak about "the LIST", we mean this list. Moreover, David [1] has recently discovered several new amicable pairs; we shall use some of them, which are suitable for our construction.

Our first tool is the following theorem from [6]; we present it in a form, suitable for our purpose here.

Theorem 3.1 Let (n_1, n_2) be an amicable pair; suppose it is possible to write n_1 and n_2 as

$$3.1 \quad n_1 = a m_1, n_2 = a m_2,$$

where $a > 1$, $(a, m_1) = (a, m_2) = 1$, and $\underline{m_1 \text{ and } m_2 \text{ are squarefree}}$; if a natural number $b > 1$ exists, such that

$$3.2 \quad \sigma(a) / a = \sigma^*(b) / b,$$

with $(b, m_1) = (b, m_2) = 1$, then the numbers $b m_1$ and $b m_2$ form a unitary amicable pair.

Examples We take amicable pair no. 6 from the LIST

$$(n_1, n_2) = (2^3 17.79, 2^3 23.59);$$

then with $a = 2^3$, $m_1 = 17.79$, $m_2 = 23.59$, condition 3.1 has been satisfied. Now we look for a natural number $b > 1$ such that

$$\sigma^*(b) / b = 15 / 8 = \sigma(a) / a.$$

This number is given by $b = 2^{10} 3.5.7.41$. Since $(b, m_1) = (b, m_2) = 1$, condition 3.2 has also been satisfied. Hence it follows from theorem 3.1 that

$$(2^{10}3.5.7.41.17.79, 2^{10}3.5.7.41.23.59)$$

is a unitary amicable pair.

Another example: start with

$$(n_1, n_2) = (3^25.13.11.19, 3^25.13.239),$$

amicable pair no. 15 from the LIST. $a = 3^25$ ($m_1 = 11.13.19$, $m_2 = 13.239$) satisfies condition 3.1 and if $b = 2^23.5^2$, then

$$\sigma^*(b) / b = 26 / 15 = \sigma(a) / a,$$

thus condition 3.2 has also been satisfied. Hence

$$(2^23.5^211.13.19, 2^23.5^213.239)$$

is a unitary amicable pair.

The difficulty in these examples is to find a number b which satisfies 3.2, for a given number a .

If a is squarefree, then $\sigma^*(a) / a = \sigma(a) / a$, so that we can take $b = a$; hence the amicable pair itself is a unitary amicable pair. In the LIST we have counted 89, and in David's discoveries, 5 squarefree pairs, a total of 94 squarefree amicable, and thus unitary amicable pairs. Hagis [3] has already mentioned 75 of these squarefree unitary amicable pairs. (Not 76, because, according to Lee and Madachy [5a], the squarefree amicable pair (177) in [4] is actually García's pair (29) on page 169 of [2]).

A computer program traced all pairs (a, b) with $a < 13000$ and $b < 13000$, such that $\sigma(a) / a = \sigma^*(b) / b$. Some other suitable pairs (a, b) were found by hand. The results are laid down in Table 6; this table extends Table 9 in [6].

TABLE 6 Numbers a and b , satisfying $\sigma(a) / a = \sigma^*(b) / b$

a	b	$\sigma(a) / a = \sigma^*(b) / b$
2^2	$2^6 3 \cdot 5 \cdot 13$	$7/4$
2^3	$2^{10} 3 \cdot 5 \cdot 7 \cdot 41$	$15/8$
3^2	$2^2 3^2 5^2$	$13/9$
$3^2 5$	$2^2 3 \cdot 5^2$	$26/15$
$3^2 13$	$2 \cdot 3^3$	$14/9$
3^3	$2^2 3^3 7$	$40/27$
$3^3 5, 3^2 7 \cdot 13$	$2 \cdot 3^3 7$	$16/9$
$3^3 5^3, 3^2 5^2 31$	$2 \cdot 3^3 5^2 7$	$416/225$
$5^2 31$	$5^2 7 \cdot 13$	$32/25$
$5^3 13$	$3 \cdot 5^3$	$168/125$
$7^2 19$	$5 \cdot 7^2$	$60/49$
$3^2 7^2 13 \cdot 19$	$2^2 3 \cdot 7$	$40/21$

Remark The pairs $a = 3^3 5$, $b = 2 \cdot 3^3 7$ and $\bar{a} = 3^3 5^3$, $\bar{b} = 2 \cdot 3^3 5^2 7$ are related by the following property: If a and b satisfy $\sigma(a) / a = \sigma^*(b) / b$, and if $p^k \parallel a$ ($k \geq 1$, p prime) and $p \nmid b$, then the numbers $\bar{a} = a p^{k+1}$ and $\bar{b} = b \cdot p^{k+1}$ also satisfy this equation. The proof of this simple property depends on the relation $\sigma(p^{2k+1}) = \sigma(p^k) \sigma^*(p^{k+1})$ ($k \geq 1$). With this property, other pairs $(\bar{a}, \bar{b})$, satisfying $\sigma(\bar{a}) / \bar{a} = \sigma^*(\bar{b}) / \bar{b}$, can be constructed from pairs (a, b) of Table 6. However, we didn't meet amicable pairs with such an $\bar{a}$ as common factor; therefore those pairs $(\bar{a}, \bar{b})$ have been omitted from Table 6.

The LIST contains 1095 amicable pairs (without those in the APPENDIX); we could construct a unitary amicable pair from 361 of them, by use of Theorem 3.1 and Table 6. Theorem 3.1 could also be applied to ten of David's amicable pairs, giving a total of 371 unitary amicable pairs, constructed with Theorem 3.1.

Our second tool for the construction of unitary amicable pairs is the following theorem, taken from [6], in a form suitable for our purpose here;

this theorem enables us to construct unitary amicable pairs from other, given, unitary amicable pairs, and will be applied to the 371 pairs, constructed with Theorem 3.1.

Theorem 3.2 Let (n_1, n_2) be a unitary amicable pair; suppose it is possible to write n_1 and n_2 as

$$3.3 \quad n_1 = a m_1, n_2 = a m_2,$$

where $a > 1$, $(a, m_1) = (a, m_2) = 1$; if a natural number $b > 1$ exists, such that

$$3.4 \quad \sigma^*(a) / a = \sigma^*(b) / b,$$

with $(b, m_1) = (b, m_2) = 1$, then the numbers $b m_1$ and $b m_2$ also form a unitary amicable pair.

Remark 1 In analogy with the so called "isotopic" or "isomeric" amicable pairs [5a], the two unitary amicable pairs, occurring in Theorem 3.2 might also be called "isotopic" or "isomeric".

Remark 2 In contrast with Theorem 3.1, Theorem 3.2 does not require m_1 and m_2 to be squarefree.

Example Let us consider the unitary amicable pair

$$(2^2 3 \cdot 5^2 \cdot 13 \cdot 11 \cdot 19, 2^2 3 \cdot 5^2 \cdot 13 \cdot 239),$$

constructed in the second example of Theorem 3.1. $a = 2^2 3 \cdot 5^2 \cdot 13$ satisfies condition 3.3 and $b = 2 \cdot 3^3 \cdot 5$ satisfies condition 3.4 $\sigma^*(b) / b = 28/15 = \sigma^*(a) / a$; hence it follows from Theorem 3.2 that

$$(2 \cdot 3^3 \cdot 5 \cdot 11 \cdot 19, 2 \cdot 3^3 \cdot 5 \cdot 239)$$

is also a unitary amicable pair.

Again, the difficulty is to find numbers b , which satisfy condition 3.4, for given a . Table 7 lists the pairs (a, b) satisfying condition 3.4; several were found by systematic computer search, some by hand. Table 7 is an extension of the second part of Table 8 in [6].

TABLE 7 Numbers a and b, satisfying $\sigma^*(a) / a = \sigma^*(b) / b$

a	b	$\sigma^*(a) / a = \sigma^*(b) / b$
2	$2^2 5, 2^3 3$	3/2
2^2	$2^3 3^2, 2^6 7 \cdot 13$	5/4
2^3	$2^4 17, 2^5 11$	9/8
2^5	$2^7 43$	33/32
2^7	$2^8 257$	129/128
2^9	$2^{11} 683$	513/512
2^{11}	$2^{13} 2731$	2049/2048
2^{15}	$2^{16} 65537, 2^{17} 43691$	32769/32768
$2 \cdot 3^3$	$2^2 3^2 5^2 13$	14/9
$2 \cdot 3^3 5$	$2^2 3 \cdot 5^2 13$	28/15
$2^2 3$	$2 \cdot 3^2$	5/3
$2^3 3^3 5$	$2^2 5^2 13$	7/5
$2^4 5 \cdot 7 \cdot 13$	$2 \cdot 5^2 13^2$	102/65
3	$3^2 5, 2^3 3^3 7$	4/3
3.5	$2^2 5^2 7 \cdot 13$	8/5
$3^2 7$	$3^3 5 \cdot 7^2$	80/63
3^3	$3^4 41$	28/27
5.7	$3 \cdot 5^3 7^2$	48/35
$5^2 13$	$3^2 5^3$	28/25
7	$5^2 7^2 13$	8/7
11	$2^5 11^2 31 \cdot 61$	12/11

Remark Several pairs (a,b), satisfying condition 3.4 can be found with one of the following three rules [6]:

- (i) If $2^{\alpha+1} + 1$ ($\alpha \geq 1$) is a prime or a prime power, then the pair $a = 2^\alpha$, $b = 2^{\alpha+1} (2^{\alpha+1} + 1)$ satisfies 3.4.
- (ii) If $(2^{\beta+2} + 1) / 3$ ($\beta \geq 1$) is a prime or a prime power, then the pair $a = 2^\beta$, $b = 2^{\beta+2} (2^{\beta+2} + 1) / 3$ satisfies 3.4.

(iii) If $(3^{\gamma+1} + 1) / 2$ ($\gamma \geq 1$) is a prime or a prime power, then the pair $a = 3^\gamma$, $b = 3^{\gamma+1} (3^{\gamma+1} + 1) / 2$ satisfies 3.4.

Rules (i) and (iii) suggest the question: do the numbers $a = p^\alpha$, $b = p^{\alpha+1} q$, where p is a prime and q is a prime or a prime power, satisfy 3.4 for other values than $p = 2$ and $p = 3$? The answer is no. Indeed, if a and b satisfy 3.4, then

$$q = (p^{\alpha+1} + 1) / (p - 1) = p^\alpha + p^{\alpha-1} + \dots + p + 1 + 2 / (p - 1);$$

hence q can only be an integer if $p = 2$ or $p = 3$.

Application of Theorem 3.2, with help of Table 7, to the 371 unitary amicable pairs constructed with Theorem 3.1, yielded 784 other pairs, making a total of 1155. 94 of these have been found by Hagis, Jr. [3], the other 1061 seem to be new.

Information about these 1155 unitary amicable pairs can be found in Tables 8 and 9 (pp. 24-35 and p. 36).

Description of Tables 8 and 9

Table 8 lists the 371 unitary amicable pairs constructed with Theorem 3.1, together with the number of isotopic pairs found with Theorem 3.2.

The greatest common divisor of the unitary amicable pair has been placed in column 1 of Table 8 (exponents are in linear form: 2^3 is written as 2E3), the remaining parts are in column 2. Column 3 gives the reference of the amicable pair, from which the unitary amicable pair has been constructed, viz., the no. in the LIST, or David [1]. In case of isotopic amicable pairs, two no.'s (one between brackets) are given in this column; both amicable pairs, of course, yield the same unitary amicable pair. Finally, column 4 tells how many unitary amicable pairs, isotopic with the pair in columns 1 and 2, have been constructed with Theorem 3.2. Pairs found by Hagis, Jr. [3] have been marked by the letter H. One letter H in column 4 means one pair from Hagis, Jr; this pair is explicitly given in [3].

The reader can find the isotopic pairs as follows. Take the part of the g.c.d. that stands to the left of the letter a. Call this number a and trace this number in column a of Table 9. The numbers b such that $\sigma^*(b) / b = \sigma^*(a) / a$ can be read from column b of Table 9. Sometimes,

not all given values of b can be used, because of one or more "disturbing" factors in the unitary amicable pair (factors such that the condition $(b, m_1) = (b, m_2) = 1$ of Theorem 3.2 cannot be satisfied). These disturbing factors have been underlined in Table 8. In a few cases, special disturbing factors always occur in unitary amicable pairs with the same a . These factors are also explicitly given in Table 9.

Table 8 has been divided into two parts. PART 1 deals with unitary amicable pairs, "constructed" from squarefree amicable pairs, PART 2 with those, constructed from non-squarefree amicable pairs. In PART 2, the g.c.d. of the original amicable pair has a place in column 1, between brackets.

Examples of Table 8.

<u>column 1</u>	<u>column 2</u>	<u>column 3</u>	<u>column 4</u>
g.c.d.	remaining parts	from no. in [5]	number of isotopic un.am. pairs, found with Th.3.2
(i) 2.5a	7.107.719, <u>17</u> .179.191 H	79	4
(ii) 2.7a19.61.853	<u>11</u> .3889679, <u>17</u> .37.68239 H	989	7 H
(iii) 2E10.3.5.7.41 (2E3)	17.79,23.59	6	0
(iv) 2.3E3.7a11 (3E3.5.11)	23.659,79.197	149(254)	6

(i) Unitary amicable pair (2.5.7.107.719, 2.5.17.179.191), found by Hagis, Jr.; the amicable pair is no. 79 in the LIST. Four "isotopic" unitary amicable pairs were found. Indeed, for $a = 2.5$, Table 9 shows five possible values of b such that $\sigma^*(b) / b = \sigma^*(a) / a$.

a	b
2.5	2E3.3.5
	2E4.3.5.17
	2E5.3.5.11
	2E7.3.5.11.43
	2E8.3.5.11.43.257,

but the second value of b is impossible, because of the disturbing factor 17.

(ii) Unitary amicable pair $(2.7.19.61.853.11.3889679, 2.7.19.61.853.17.37.68239)$, indicated by Hagis, Jr.; the amicable pair is no. 989 in the LIST. Seven isotopic unitary amicable pairs could be found with Theorem 3.2. One of them comes from Hagis, Jr. For $a = 2.7$, with disturbing factors 11 and 17, Table 9 shows 7 possible values of b .

(iii) Unitary amicable pair $(2^{10}3.5.7.41.17.79, 2^{10}3.5.7.41.23.59)$, found with Theorem 3.1; the amicable pair is no. 6 $(2^317.79, 2^323.59)$ in the LIST. No isotopic unitary amicable pairs were found.

(iv) Unitary amicable pair $(2.3^37.11.23.659, 2.3^37.11.79.197)$, found with Theorem 3.1; the amicable pair is no. 149 $(3^35.11.23.659, 3^35.11.79.197)$ in the LIST, no. 254 in the LIST is "isotopic" with this pair.

Six isotopic unitary amicable pairs were found with Theorem 3.2; indeed for $a = 2.3^37$, Table 9 gives six values of b , satisfying

$$\sigma^*(b) / b = \sigma^*(a) / a.$$

4. Other unitary amicable pairs

In section 3 we have studied unitary amicable pairs, "generated" by ordinary amicable pairs, i.e. unitary amicable pairs which are connected with amicable pairs by Theorem 3.1. Only a part (about one third) of the known amicable pairs generates unitary amicable pairs. The other two thirds of the known amicable pairs seem to be "isolated" from the collection of unitary amicable pairs. For some amicable pairs, this is clear, viz., for "exotic" amicable pairs. Lee & Madachy [5a] define exotic pairs as (we cite) "pairs which satisfy one or both of the following conditions.

a) The quotient of at least one member of the pair by the greatest common divisor of the pair is not relatively prime to the greatest common divisor;
 b) the quotient of at least one member of the pair by the greatest common divisor of the pair is not square-free". Now let $(a m_1, a m_2)$ be an exotic amicable pair (a is the g.c.d.); then theorem 3.1 cannot be applied to this pair because a) implies that $(a, m_1) \neq 1$ or $(a, m_2) \neq 1$, while b) implies that at least one of m_1 and m_2 is not squarefree. Thus the collection of exotic amicable pairs is isolated from the collection of unitary amicable pairs. Several non-exotic amicable pairs remain, from which I have not been able to construct unitary amicable pairs. I call these amicable pairs "maybe-isolated".

A close look at Theorem 3.1 reveals that it is easy to prove the converse theorem: if (n_1, n_2) is a unitary amicable pair, and if n_1 and n_2 can be written as $n_1 = a m_1$, $n_2 = a m_2$, where $a > 1$, $(a, m_1) = (a, m_2) = 1$ and m_1 and m_2 are squarefree, then the existence of a number $b > 1$ such that $(b, m_1) = (b, m_2) = 1$, and $\sigma(b) / b = \sigma^*(a) / a$, implies that the pair $(b m_1, b m_2)$ is an amicable pair.

All unitary amicable pairs, obtained in section 3 are thus connected with the collection of amicable pairs by this theorem. However, also isolated (exotic) and maybe-isolated unitary amicable pairs are known. We list them here. Those found by Hagis, Jr. are marked with the letter H.

Maybe-isolated unitary amicable pairs

$$H \ 2^2 3.7 \begin{cases} 13.41 \\ 587 \end{cases}$$

Also: $2^2 3.7$ replaced by

$$H \ 2.3^2 7, H \ 2^2 3^2 5.7, 2.3^3 5.7^2.$$

$$H \ 2^2 3.7 \begin{cases} 13.719 \\ 59.167 \end{cases}$$

Also: $2^2 3.7$ replaced by

$$H \ 2.3^2 7, 2^2 3^2 5.7, 2.3^3 5.7^2, 2.3^4 5.7^2 41$$

Isolated (exotic) unitary amicable pairs

$$H \ 2 \begin{cases} 3.19 \\ 3^2 7 \end{cases}$$

Also: 2 replaced by $H \ 2^2 5$

$$H \ 2.7 \begin{cases} 3^2 11.13 \\ 3^3 59 \end{cases}$$

Also: 2.7 replaced by $H \ 2^2 5.7$

$$H \ 2^2 3 \begin{cases} 5.11.13.23 \\ 5^3 191 \end{cases}$$

Also: $2^2 3$ replaced by $H \ 2.3^2$

$$H \ 2^2 3 \begin{cases} 5.11.467 \\ 5^2 23.53 \end{cases}$$

Also: $2^2 3$ replaced by $H \ 2.3^2$ and $2^6 3.7.13$

$$2^2 3 \begin{cases} 5.13.31.53 \\ 5^3 23.47 \end{cases}$$

Also: $2^2 3$ replaced by 2.3^2

$$2^2 3 \begin{cases} 5.13.97.107 \\ 5^3 11.587 \end{cases}$$

Also: $2^2 3$ replaced by 2.3^2

$$2^2 3 \begin{cases} 5.17.1871 \\ 5^2 11.647 \end{cases}$$

Also: $2^2 3$ replaced by 2.3^2 and $2^6 3.7.13$

$$2^2 3 \begin{cases} 5.127.701 \\ 5^2 7.2591 \end{cases}$$

Also: $2^2 3$ replaced by 2.3^2

$$2^2 3 \begin{cases} 5.127.1871 \\ 5^2 11.23.191 \end{cases}$$

Also: $2^2 3$ replaced by 2.3^2 and $2^6 3.7.13$

5. Unitary t -cycles for $t \neq 2$.

In this section we present a list of all known unitary t -cycles for $t \neq 2^+$, viz. 5 for $t = 1$, 1 for $t = 3$, 8 for $t = 4$, 1 for $t = 5$, 1 for $t = 6$, 3 for $t = 14$ and 1 for $t = 25$. Those, marked with the letter N are new.

$t = 1$ $6(2.3)$ $60(2^2 3.5)$ $90(2.3^2 5)$ $\left. \begin{array}{l} 87360(2^6 3.5.7.13) \\ 146361946186458562560000(2^{18} 3.5^4 7.11.13.19.37.79.109.157.313) \end{array} \right\} \text{ (Subbarao \& Warren)}$

$t = 3$ $30(2.3.5)$ [6]
 $42(2.3.7)$
 $54(2.3^3)$

$t = 4$ $263820(2^2 3.5.4397)N$ $395730(2.3^2 5.4397)N$
 $263940(2^2 3.5.53.83)$ $395910(2.3^2 5.53.83)$
 $280380(2^2 3.5.4673)$ $420570(2.3^2 5.4673)$
 $280500(2^2 3.5^3 11.17)$ $420750(2.3^2 5^3 11.17)$

$384121920(2^6 3.7.13.5.4397)N$
 $384296640(2^6 3.7.13.5.53.83)$
 $408233280(2^6 3.7.13.5.4673)$
 $408408000(2^6 3.7.13.5^3 11.17)$

$209524210(2.5.7.19.263.599)$ (David)
 $246667790(2.5.17.59.24593)$
 $231439570(2.5.19.23.211.251)$
 $230143790(2.5.17.499.2713)$

$2514290520(2^3 3.5.7.19.263.599)$ [6]
 $2960013480(2^3 3.5.17.59.24593)$
 $2777274840(2^3 3.5.19.23.211.251)$
 $2761725480(2^3 3.5.17.499.2713)$

$110628782880(2^5 3.5.11.7.19.263.599)$ [6]
 $130240593120(2^5 3.5.11.17.59.24593)$
 $122200092960(2^5 3.5.11.19.23.211.251)$
 $121515921120(2^5 3.5.11.17.499.2713)$

⁺A list of all unitary 2-cycles (m, n) with $\min(m, n) < 10^6$, including factorizations, can be found in [3].

19028150655360($2^7 3.5.11.43.7.19.263.599$) [6]

22401382016640($2^7 3.5.11.43.17.59.24593$)

21018415989120($2^7 3.5.11.43.19.23.211.251$)

20900738432640($2^7 3.5.11.43.17.499.2713$)

9780469436855040($2^8 3.5.11.43.257.7.19.263.599$) [6]

11514310356552960($2^8 3.5.11.43.257.17.59.24593$)

10803465818407680($2^8 3.5.11.43.257.19.23.211.251$)

10742979554376960($2^8 3.5.11.43.257.17.499.2713$)

t = 5

1482($2.3.13.19$) [6]

1878($2.3.313$)

1890($2.3^3 5.7$)

2142($2.3^2 7.17$)

2178($2.3^2 11^2$)

t = 6

698130($2.5.3^2 7757$) $\mathbb{N}$

698310($2.5.3^2 7759$)

698490($2.5.3^3 13.199$)

712710($2.5.3^2 7919$)

712890($2.5.3^2 89^2$)

713070($2.5.3^3 19.139$)

t = 14

2418($2.3.13.31$) [6]

2958($2.3.17.29$)

3522($2.3.587$)

3534($2.3.19.31$)

4146($2.3.691$)

4158($2.3^3 7.11$)

3906($2.3^2 7.31$)

3774($2.3.17.37$)

4434($2.3.739$)

4446($2.3^2 13.19$)

3954($2.3.659$)

3966($2.3.661$)

3978($2.3^2 13.17$)

3582($2.3^2 199$)

24180($2^2 5.3.13.31$) [6]

29580($2^2 5.3.17.29$)

35220($2^2 5.3.587$)

35340($2^2 5.3.19.31$)

41460($2^2 5.3.691$)

41580($2^2 5.3^3 7.11$)

39060($2^2 5.3^2 7.31$)

37740($2^2 5.3.17.37$)

44340($2^2 5.3.739$)

44460($2^2 5.3^2 13.19$)

39540($2^2 5.3.659$)

39660($2^2 5.3.661$)

39780($2^2 5.3^2 13.17$)

35820($2^2 5.3^2 199$)

35238($2.3.7.839$) [6]

45402($2.3.7.23.47$)

65190($2.3.5.41.53$)

98160($2.3.83.197$)

101478($2.3.13.1301$)

117258($2.3.19543$)

117270($2.3^2 5.1303$)

117450($2.3^4 5^2 29$)

74430($2.3^2 5.827$)

74610($2.3^2 5.829$)

74790($2.3^3 5.277$)

65322($2.3^2 19.191$)

49878($2.3^2 17.163$)

38682($2.3^2 7.307$)

$t = 25$ 763620($2^2 3.5.11.13.89$)N
 1050780($2^2 3.5.83.211$)
 1086180($2^2 3.5.43.421$)
 1141980($2^2 3.5.7.2719$)
 1469220($2^2 3.5.47.521$)
 1537500($2^2 3.5^5 41$)
 1088340($2^2 3.5.11.17.97$)
 1451820($2^2 3.5.24197$)
 1451940($2^2 3.5.7.3457$)
 1867740($2^2 3.5.7.4447$)
 2402340($2^2 3.5.40039$)
 2402460($2^2 3^4 5.1483$)
 1248180($2^2 3.5.71.293$)
 1291980($2^2 3.5.61.353$)
 1341780($2^2 3.5.11.19.107$)
 1768620($2^2 3.5.7.4211$)
 2274900($2^2 3.5^2.7583$)
 1668780($2^2 3^2 5.73.127$)
 1172820($2^2 3.5.11.1777$)
 1387500($2^2 3.5^5 37$)
 988260($2^2 3.5.7.13.181$)
 1457820($2^2 3^2 5.7.13.89$)
 1566180($2^2 3^2 5.7.11.113$)
 1717020($2^2 3^2 5.9539$)
 1144980($2^2 3^2 5.6361$)

Remark The new t -cycles in sections 4 and 5 have been found by a systematic computer search for all cycles of the form $(u v_0, u v_1, \dots, u v_{t-1})$ with $\min(u v_i) = \text{bound}_1$, $\max(u v_i) < \text{bound}_2$ and $t \leq 50$. The following cases (i) were considered:

$u = 60,$ $\text{bound}_1 \leq 6 \cdot 10^6,$ $\text{bound}_2 = 10 \cdot 10^6$
 $u = 60, 6 \cdot 10^6 <$ $\text{bound}_1 \leq 10.8 \cdot 10^6,$ $\text{bound}_2 = 15 \cdot 10^6$
 $u = 60, 10.8 \cdot 10^6 <$ $\text{bound}_1 \leq 14.4 \cdot 10^6,$ $\text{bound}_2 = 20 \cdot 10^6$

 $u = 90,$ $\text{bound}_1 \leq 6 \cdot 10^6,$ $\text{bound}_2 = 10 \cdot 10^6$
 $u = 90, 6 \cdot 10^6 <$ $\text{bound}_1 \leq 10.8 \cdot 10^6,$ $\text{bound}_2 = 15 \cdot 10^6$
 $u = 90, 10.8 \cdot 10^6 <$ $\text{bound}_1 \leq 16.2 \cdot 10^6,$ $\text{bound}_2 = 20 \cdot 10^6$

TABLE 8 Unitary amicable pairs constructed from ordinary amicable pairs

PART 1 (the ordinary amicable pairs are squarefree)			
g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2.5a	7.19.107, 47.359 H	18	5
	11.41.239, 17.29.223 H	43	1
	11.13.809, 19.6803 H	45	2
	7.21599, 19.47.179 H	54	5
	11.17.19.47, 239.863 H	55	1
	7.89.359, 23.59.179 H	58	5
	7.60659, 23.29.673 H	70	5
	7.163.449, 19.59.491 H	75	5
	7.107.719, 17.179.191 H	79	4
	7.11.11369, 757.1439 H	98	2
	11.19.41.103, 31.179.181 H	99	2
	7.19.7127, 71.79.197 H	105	5
	7.131.2339, 19.53.2287 H	146	5
	11.19.89.383, 17.359.1279 H	210	1
	17.19.149.163, 11.491.1499 H	219	1
	7.29.67.647, 47.89.2447 H	227	5
	7.863.2579, 23.29.24767 H	258	5
	13.19.179.383, 23.59.79.167	262	5
	11.19.115877, 17.61.24919 H	283	1
	7.11.929.953, 2879.29573 H	335	2
	7.11.929.1019, 2447.37199 H	340	2
	17.19.71.90149, 11.647.300499 H	537	1
	13.23.139.63737, 11.5879.42491 H	551	2
	11.23.71.1399, 29.59.83.191	David	2
2.5a11	53.1759, 59.1583 H	109	2
2.5a11.59	587.303731, 727.245321	760	2
2.5a11.61	239.161039, 38649599 H	681	2
2.5a11.83	79.3664781, 5351.54779	796	2
2.5a11.89	109.2563199, 191.1468499	800	2
2.5a11.109	59.298223, 607.29429	669	2
2.5a11.167	41.14328599, 1259.477619	870	2
2.5a11.229	43.494639, 197.109919 H	715	2
2.5a11.809	29.1708607, 1759.29123	827	2

TABLE 8 (cont.)

g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2.5a13	23.2339, 53.1039 H 17.197.2339, 1619.5147 H <u>17</u> .179.5381, 2339.7451 H <u>19</u> .89.70979, 1039.122849 H 19.83.129011, 5039.43003 H	87 360 406 523 550	5 4 4 5 5
2.5a13.59	<u>43</u> .1352987, 167.354353	705	3
2.5a <u>17</u>	13.47.2549, 359.4759 H 11.101.1889, 1427.1619 H <u>11</u> .101.3659, 719.6221 H <u>13</u> .41.23459, 3331.4139 H <u>11</u> .89.227629, 1699.144611 H	288 305 336 405 567	4 1 1 4 1
2.5a19	11.59.15199, 151.71999 H <u>11</u> .47.27739, 359.44383 H <u>11</u> .61.538649, 139.2862539 H <u>11</u> .41.34154399, 9629.1787519 H	396 419 601 804	2 2 2 2
2.5a19.37	29.73.491, 179.6067 H 29.47.1627, 2344319	478 522	5 5
2.5a29	7.67.2021183, 24683.44543	684	5
2.5a31	7.30689, 59.4091 H	204	5
2.5a47.67	7.2550689, 107.188939	720	5
2.5a67	7.59.401, 31.6029 H	243	5
2.5a79	<u>11</u> .23.7109, <u>17</u> .113759 H	383	1
2.5a107.1069.2137.25643	7.5538887, <u>17</u> .2461727 H	1077	4
2.5a929	7. <u>11</u> .5573, 535103 H	446	2
2.7a	11.13.29.47, 19.23.503 H <u>5</u> .13.17.293, 71.6173 H <u>5</u> .13.83.191, 31.71.587 H <u>5</u> .31.7853, 13.43.2447 H <u>5</u> .539783, 13.41.53.101 H <u>5</u> .11.97.26212247, 23.6803.1132627 H <u>5</u> .13.23.28687, <u>43</u> .223.5867	61 73 127 135 177 782 David	7 H 4 5 3 5 2 3
2.7a <u>11</u>	13.71.241, 23.10163 H <u>13</u> .19.10889, 83.36299 H <u>13</u> .43.13499, 29.359.769 H <u>19</u> .53.7699, 17.149.3079 H <u>13</u> .191.5939, <u>19</u> .307.2591 H	168 313 368 370 411	7 H 7 H 7 H 7 H 7 H

TABLE 8 (cont.)

g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2.7a <u>11</u> .43	<u>13</u> .131.1289, 139.17027 H	516	7 H
2.7a <u>13</u>	<u>11</u> .103.149, 17.10399 H <u>11</u> .17.1039, <u>53</u> .4159 H <u>11</u> . <u>79</u> .1637, 23.59.1091	160 172 David	5 H 5 H 7
2.7a <u>13</u> .181	<u>11</u> .499559, <u>17</u> .229.1447 H	660	5 H
2.7a <u>17</u>	<u>5</u> .101.797, 113.4283 H <u>5</u> .47.173501, 1223.40823 H <u>5</u> .47.33195287, 1181.8088191 H	234 494 777	4 4 4
2.7a <u>17</u> .101	<u>5</u> .309224831, 4283.433087	919	4
2.7a <u>19</u>	<u>11</u> . <u>13</u> .71.113, 83.107.151	David	7
2.7a <u>19</u> .61.853	<u>11</u> .3889679, <u>17</u> .37.68239 H	989	7 H
2.11a	<u>5</u> .23.43.67, <u>7</u> .197.271 H	89	2
2.17a	<u>7</u> . <u>11</u> .67.1968353, <u>5</u> .23.1223.72901 H	691	1
3.5.7	13.47.269, 23.29.251 H 11.13.37.3779, 24131519 H 13.17.19.463, 383.6089	136 403 David	0 0 0
3.5.7.11a	503.1319, 769.863 H 293.5279, 1231.1259 H 347.23099, 449.17863 H 233.1019479, 1091.218459 H	344 395 492 683	3 3 3 3
3.5.7.13.79	269.1511743, 467.872159	929	0
3.5.7.19.31	139.1081403, 167.901169	865	0
3.5.7.23	17.41.229, 107.1609 H 13.137.149, 139.2069 H	308 329	0 0
3.5.11a	7.17.439, 23. <u>43</u> .59 H	96	1

TABLE 8 (cont.)

PART 2 (the ordinary amicable pairs are <u>not</u> squarefree)			
g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2.5E2.7.13a (2.5E2.31)	19.359, 47.149	111	7
	29.41.59, 179.419	241	7
	17.109.149, 107.2749	314	6
	19.59.599, 79.8999	361	7
2.5E2.7.13a79 (2.5E2.31.79)	<u>17</u> .7109, 127979	517	6
2.5.7E2a13 (2.7E2.13.19)	47.65519, 1663.1889	607	5
	47.67157, 1511.2131	608	5
2.5.7E2a (2.7E2.19)	13. <u>17</u> .41, 97.107	134	4
2.5.7E2a23 (2.7E2.19.23)	<u>11</u> .13523, 162287	471	2
2E6.3.5.13 (2E2)	11.17.19.47, 31.71.89	36	0
2E6.3.5.11.13 (2E2.11)	17.263, 43.107	22	0
	19.197.443, 53.73.439	211	0
	17.29.16631, 263.34019	307	0
	19.1259.2969, 29.149.16631	429	0
	17.107.1038311, 37.4751.11177	614	0
2E6.3.5.11.13.23 (2E2.11.23)	131.36988691, 3041.1605031	830	0
2E6.3.5.13.19 (2E2.19)	11.113.7774829, 17.97.773.7789	739	0
	11.151.34618949, 23.37.569.121469	825	0
2E6.3.5.13.19.29.61 (2E2.19.29.61)	17.2957767, 131.403331	845	0
2E6.3.5.13.19.37 (2E2.19.37)	11.44172449, 41.1109.11369	767	0
2E6.3.5.13.23.53 (2E2.23.53)	11.18943259, 17.2437.5179	751	0

TABLE 8 (cont.)

g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2E10.3.5.7.41	17.79,23.59	6	0
(2E3)	17.29.47,59.431	21	0
	13.23.149,199.251	26	0
	13.23.251,97.863	31	0
	11.29.239,191.449	32	0
	11.31.233,127.701	34	0
	29.47.59,17.4799	35	0
	17.19.281,53.1879	37	0
	11.59.173,47.2609	40	0
	13.23.1109,71.5179	59	0
	11.163.191,31.11807	62	0
	11.23.1619,647.719	65	0
	11.23.1871,467.1151	67	0
	17.71.439,23.131.179	69	0
	11.23.2543,383.1907	76	0
	11.31.2099,79.10079	81	0
	17.53.1039,23.179.233	90	0
	17.79.769,29.43.839	95	0
	11.211.503,47.83.317	103	0
	11.71.1801,67.107.211	116	0
	17.47.2239,23.167.479	126	0
	11.71.2459,53.163.239	131	0
	17.103.1289,19.107.1117	140	0
	11.79.2879,47.149.383	143	0
	17.23.37.173,1367.2087	144	0
	19.23.29.223,1439.2239	150	0
	13.139.1979,23.349.461	159	0
	19.23.53.191,71.69119	174	0
	11.359.1223,29.271.647	180	0
	13.37.10079,47.139.797	182	0
	17.59.5641,19.433.701	186	0
	13.29.16127,59.293.383	192	0
	13.431.1511,23.107.3527	206	0
	13.23.83.347,587.16703	208	0
	11.71.11689,59.83.2003	212	0
	11.59.14489,53.137.1399	217	0
	13.31.53.457,167.65951	218	0
	13.990719,29.47.9631	239	0
	19.71.9719,23.47.12149	240	0
	13.127.10169,23.223.3389	252	0
	19.53.22679,17.719.1889	267	0
	19.53.26861,17.659.2441	277	0
	13.659.3797,19.593.2953	287	0
	19.53.36721,17.601.3659	296	0
	23.29.127.443,31.89.14207	298	0
	11.1877.2447,31.101.16901	311	0

TABLE 8 (cont.)

g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2E10.3.5.7.41 (2E3) (cont.)	13.89.55579, 29.97.23819	319	0
	13.863.6029, 23.89.33767	323	0
	13.23.61.4517, 3347.28111	331	0
	17.19.270143, 47.1259.1607	337	0
	17.19.291199, 47.1091.1999	343	0
	11.67.164429, 53.101.24359	355	0
	11.59.383.503, 47.863.3359	357	0
	19.59.138401, 17.263.34949	375	0
	11.499.29429, 29.149.39239	378	0
	17.19.591623, 47.809.5477	386	0
	19.53.214541, 17.521.24659	391	0
	11.227.114847, 31.151.64601	412	0
	17.29.37.18311, 71.5218919	418	0
	11.139.223439, 31.251.46549	420	0
	11.911.42499, 37.67.179999	434	0
	17.43.639007, 23.151.138731	442	0
	19.23.29.47189, 197.3431999	457	0
	19.23.223.8861, 31.29776319	475	0
	11.79.995651, 53.83.210719	476	0
	13.1061.102499, 19.353.215249	503	0
	11.103.1732799, 31.607.111149	525	0
	13.19.131.69191, 2239.1141667	532	0
	13.23.59.148367, 29567.101159	538	0
	11.23.257.44893, 24767.134681	546	0
	13.23.59.210143, 25343.167159	556	0
	11.29.79.182239, 48239.108799	565	0
	11.113.4113059, 29.3527.53161	572	0
	13.27.89.146383, 19.293.972407	574	0
	11.29.79.211499, 42299.143999	575	0
	13.23.59.325439, 23039.284759	577	0
	13.23.59.354551, 22751.314159	579	0
	11.29.79.264599, 37799.201599	583	0
	11.29.79.292979, 36479.231299	589	0
	13.17.449.79159, 55411.161999	592	0
	13.17.479.92177, 6803.1638719	610	0
	13.19.1993.26099, 149.97147679	624	0
	13.23.59.1117079, 20879.1078559	651	0
	13.9521.556159, 29.47.51486511	717	0
	13.23.59.4594127, 20327.4556159	728	0
	13.17.449.3387971, 28619.13424039	797	0
	13.17.443.3434129, 119447.3216779	798	0
	13.9371.7391159, 29.47.673457861	851	0
	13.11807.6742199, 19.271.204883559	861	0
	17.19.7699.1261459, 47.769.94609499	909	0
	11.59.113.349, 79.449.797	David	0
	11.23.349.1439, 2999.48383	David	0

TABLE 8 (cont.)

g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2E10.3.5.7.17.41 (2E3.17)	71.1223.1172663, 105407.980423 71.1223.5025239, 91367.4847039 71.1223.8663003, 89963.8486207	881 946 957	0 0 0
2E10.3.5.7.19.41 (2E3.19)	67.1367, 101.911 47.179.1883051, 24623.660719 89.113.191, 1367.1439	125 789 David	0 0 0
2E10.3.5.7.19.41.137 (2E3.19.137)	83.218651, 18366767	696	0
2E10.3.5.7.23.41 (2E3.23)	29.137.2887, 359.33211 29.137.599, 827.2999	404 David	0 0
2E10.3.5.7.29.41 (2E3.29)	19.2087, 173.239 17.1217.20939, 251.1821779 19.107.233159, 647.777199	101 621 630	0 0 0
2E10.3.5.7.31.41 (2E3.31)	23.61.449, 199.3347 17.107.4339, 8436959	259 397	0 0
2E10.3.5.7.37.41 (2E3.37)	23.47.73, 85247	151	0
2E10.3.5.7.41.83 (2E3.83)	11.331.383, 71.21247	352	0
2E10.3.5.7.41.467 (2E3.467)	11.532379, 37.89.1867	542	0

TABLE 8 (cont.)

g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2E2.3.5E2a (3E2.5)	7.11.29,31.89 H	14	1 H
	7.19.23.71,31.79.107	108	1
	7.19.2663,11.73.479	132	1
	7.11.59.89,31.107.149	141	1
	7.17.29.479,19.71.1439	214	1
	7.11.17.4259,53.283.479	David	1
2E2.3.5E2a7 (3E2.5.7)	53.1889,102059	162	1
	71.4339,239.1301	236	1
	71.5879,223.1889	249	1
	59.708959,421.100799	513	1
	83.149.5807,2879.25409	545	1
	59.461.9337,8819.29347	613	1
	97.113.25849,12539.23029	618	1
	83.149.42767,1889.285119	657	1
	83.139.78539,19403.47599	685	1
	83.139.93683,16879.65267	690	1
	83.139.108863,15679.81647	699	1
	59.419.147377,54449.68207	758	1
	59.419.170741,40949.105071	765	1
	59.419.182159,38639.118799	769	1
	53.2099.49633,26891.209299	775	1
	59.419.233279,33599.174959	776	1
	59.419.244199,32999.186479	778	1
	59.419.325939,30319.270899	794	1
	53.4073.42239,3779.2458367	802	1
	59.419.636473,27449.584303	832	1
	53.1931.198769,81971.252979	841	1
	53.1931.211319,77279.285281	846	1
	59.419.1274249,26249.1223279	867	1
	83.139.5742623,11807.5719279	900	1
	53.1889.886463,139967.646379	910	1
	59.419.5316959,25439.5266799	925	1
	53.1889.1411829,121013.1190699	930	1
2E2.3.5E2a7.107 (3E2.5.7.107)	3209.4493,14425739	712	1
2E2.3.5E2a7.137 (3E2.5.7.137)	307.24659,839.9041	688	1
2E2.3.5E2a7.181 (3E2.5.7.181)	149.121631,719.25339	753	1
2E2.3.5E2a7.251 (3E2.5.7.251)	89.28571831,31123.82619	974	1
	101.78010799,739.10752839	992	1

TABLE 8 (cont.)

g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2E2.3.5E2a7.379 (3E2.5.7.379)	79.6653723, 757.702239	947	1
2E2.3.5E2a11.19 (3E2.5.11.19)	139.7523, 569.1847 193.75239, 227.64019	496 642	2 2
2E2.3.5E2a11.29 (3E2.5.11.29)	43.6263, 47.5741	445	2
2E2.3.5E2.13a (3E2.5.13)	11.19, 239 H 19.47, 29.31 11.199, 29.79 19.23.43, 47.439 11.31.89, 127.269 11.47.59, 71.479 11.23.239, 179.383 23.29.97, 19.3527 17.43.149, 19.5939 11.19.1409, 449.751 11.258299, 29.59.1721 11.23.79.1051, 24238079 11.59.644999, 29.719.21499 11.19.211.14699, 747935999	15 30 48 114 137 138 173 178 203 264 389 507 677 697	3 HH 3 H 3 H 3 3 3 3 3 3 3 3 3 3 3
2E2.3.5E2.13a19 (3E2.5.13.19)	29.569, 17099 37.1583, 227.263 29.44687, 1063.1259 31.184337, 263.22343 37.113.28499, 7219.17099 37.113.255587, 4483.246923 29.569.113021, 28349.68171 29.569.117779, 27179.74099 29.569.125113, 25849.82763 29.569.152459, 23099.112859 29.569.289381, 19531.253349 37.113.1165187, 4363.1156643	268 330 515 594 764 874 898 903 906 911 939 940	3 3 3 3 3 3 3 3 3 3 3 3
2E2.3.5E2.13a29 (3E2.5.13.29)	17.1217.7039, 79.1929311	792	3
2E2.3.5E2.13a41 (3E2.5.13.41)	23.29.3361, 71.33619 11.2686319, 223.143909	585 736	2 2
2E2.3.5E2.13a79 (3E2.5.13.79)	11.72047, 37.22751	564	3
2E2.3.5E2.13a79.157 (3E2.5.13.79.157)	17.5023, 23.3767	726	3

TABLE 8 (cont.)

g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2E2.3.5E2a17.19 (3E2.5.17.19)	23.19379, 37.12239	472	2
2E2.3.5E2a19 (3E2.5.19)	<u>7</u> .227, 37.47	50	1
2E2.3.5E2a19.37 (3E2.5.19.37)	<u>7</u> .887, 7103	270	1
2E2.3.5E2a31 (3E2.5.31)	<u>7</u> .929, 11.619	100	1
2.3E3a7 (3E2.7.13)	5.17, 107 H <u>5</u> .17.1187, 131.971	12 222	1 1
2.3E3a7.37 (3E2.7.13.37)	<u>5</u> .14207, 191.443	407	1
2.3E3.7.41 (3E2.7.13.41)	<u>5</u> .4591, 163.167	346	0
2.3E3.7.41.163 (3E2.7.13.41.163)	<u>5</u> .977, 5867	552	0
2.3E3a7.131 (3E2.7.13.131)	<u>5</u> .4493.6287, 23.7064567	886	1
2.3E3a11.17.373 (3E2.11.13.17.373)	<u>5</u> .47.2237, 71.8951	824	1
2E2.3.7a (3E2.7E2.13.19)	11.10499, 89.1399 11.79.2029, 1948799 11.83.5711, 2351.2447 11.83.38821, 1061.36847 11.359.9463, 107.378559 11.83.63439, 1039.61487 11.83.83591, 1031.81647 17.23.1335949, 3079.187379	508 665 722 817 821 839 862 941	6 6 6 6 6 6 6 6
2E2.3.7a23 (3E2.7E2.13.19.23)	83.1931, 162287	700	6
2E2.3.7a29 (3E2.7E2.13.19.29)	<u>41</u> .173, 7307	544	5
2E2.3.7a83 (3E2.7E2.13.19.83)	17.149.829, 107.20749	894	6
2E2.3.7a307 (3E2.7E2.13.19.307)	17. <u>41</u> .613, 107.4297	884	5

TABLE 8 (cont.)

g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2.3E3.7a (3E3.5)	11.17.227, 23.37.53 11.13.17.107, 53.6047 17.29.31.41, 13.71.719	82(170) 171 225	6 3 1
2.3E3.7a11 (3E3.5.11)	23.659, 79.197 23.7523, 53.3343 17.241.1999, 2903.2999 17.409.2111, 439.35423 17.293.3299, 659.26459 17.211.6863, 2861.9151 23.509.2441, 59.498167 17.197.21059, 7019.10691 19.4113647, 131.419.1483 17.197.49139, 4211.41579 17.197.135089, 3761.127979 19.89.910909, 38219.42899 19.89.1205819, 26729.81199 19.89.1590467, 24097.118799 17.197.1379069, 3581.1372139	149(254) 286(388) 505(606) 541(641) 547(646) 563(670) 573(680) 625(727) 635(735) 676(770) 732(822) 786(882) 805(893) 820(908) 847(926)	6 6 6 6 6 6 6 6 6 6 6 6 6 6 6
2.3E3.7a11.43 (3E3.5.11.43)	67.874619, 1289.46103	814(905)	6
2.3E3.7a11.131 (3E3.5.11.131)	23.26723, 271.2357	637(737)	6
2.3E3.7a13 (3E3.5.13)	11.467.33569, 10529.17903 11.467.60779, 7019.48623 11.467.488239, 5743.477359	687 716 826	3 3 3
2.3E3.7a13.23 (3E3.5.13.23)	827.20071, 1103.15053	731	3
2.3E3.7a13.1013 (3E3.5.13.1013)	11.4051, 48623	611	3
2.3E3.7a17.19 (3E3.5.17.19)	79.3229, 199.1291 101.113.84811, 17707.55691 101.113.245251, 12907.220931 101.113.298343, 12647.274283 101.113.407483, 12347.383723 101.113.593291, 12107.569771 101.113.732731, 12011.709307	502(599) 927(978) 960(994) 966(998) 975(1001) 983(1007) 985(1009)	6 6 6 6 6 6 6
2.3E3.7a17.31.61 (3E3.5.17.31.61)	67.4391, 101.2927	763(857)	6

TABLE 8 (cont.)

g.c.d.	remaining parts	from no. in [5]	number of isotopic un. am. pairs, found with Theorem 3.2
2.3E3.7a19.37.73 (3E3.5.19.37.73)	23.6569, 107.1459	754(840)	6
2.3E3.7a23 (3E3.5.23)	11.19.367, 79.1103	281(384)	6
2.3E3.7a23.229.457 (3E3.5.23.229.457)	<u>13</u> .17.2741, 107.6397	973	3
2.3E3.7a113 (3E3.5.113)	<u>13</u> .17.6553, 11.137633	543	3
2.3E3.5E2.7a (3E3.5E3)	29. <u>41</u> .43.59, 19.131.1259	498(539)	0
2.3E3.5E2.7a13 (3E3.5E3.13)	149.449, 67499	423(467)	1
	191.589049, 271.415799	831(869)	1
	149.461.291857, 14699.1375901	997(1008)	1
	149.449.395039, 148139.179999	1000(1012)	1
	149.449.438899, 115499.256499	1002(1015)	1
	149.449.521399, 98999.355499	1005(1017)	1
	149.449.603899, 91499.445499	1006(1019)	1
	149.449.1076399, 77999.931499	1016(1025)	1
	149.449.1558619, 74219.1417499	1022(1030)	1
	149.449.1707947, 73547.1567499	1024(1031)	1
	149.449.2366099, 71699.2227499	1026(1033)	1
	149.449.6203411, 69011.6067499	1034(1040)	1
	139.569.6594659, 287279.1831849	1035(1042)	1

TABLE 9 Numbers a and b, satisfying $\sigma^*(a)/a = \sigma^*(b)/b$, used in TABLE 8 for the construction of unitary amicable pairs

a	dist. factors	b	a	b
2.5		2E3.3.5 2E4.3.5.17 2E5.3.5.11 2E7.3.5.11.43 2E8.3.5.11.43.257	2.5E2.7.13	2.3E2.5E3.7 2E2.3.5E3.7 2E3.3.5E2.7.13 2E4.3.5E2.7.13.17 2E5.3.5E2.7.11.13 2E7.3.5E2.7.11.13.43 2E8.3.5E2.7.11.13.43.257
2.7	5	2E3.3.7 2E4.3.7.17 2E5.3.7.11 2E7.3.7.11.43 2E8.3.7.11.43.257	2.5.7E2	2E3.3.5.7E2 2E4.3.5.7E2.17 2E5.3.5.7E2.11 2E7.3.5.7E2.11.43 2E8.3.5.7E2.11.43.257
2.7	11, 13	2.3E2.5E3.7E2 2E2.3.5E3.7E2 2E2.5.7 2E3.3.7 2E3.3E2.5.7 2E4.3.7.17 2E4.3E2.5.7.17	2E2.3.5E2	2.3E2.5E2 2E6.3.5E2.7.13
2.7	11, 17	2.3E2.5E3.7E2 2.5E2.7E2.13 2E2.3.5E3.7E2 2E2.5.7 2E3.3.5E2.7E2.13 2E3.3.7 2E3.3E2.5.7	2E2.3.5E2.13 2E2.3.7	2.3E2.5E2.13 2.3E3.5 2.3E4.5.41 2.3E2.5E2.7E2.13 2.3E2.7 2.3E3.5.7E2 2.3E4.5.7E2.41 2E2.3.5E2.7E2.13 2E2.3E2.5.7
2.11	5, 7	2E3.3.11 2E4.3.11.17	2.3E3.5E2.7	2.3E4.5E2.7.41
2.17	5, 7, 11	2E3.3.17	3.5.7.11	2E5.3.5.7.11E2.31.61 2E7.3.5.7.11E2.31.43.61 2E8.3.5.7.11E2.31.43.61.257
2.3E3	5	2.3E4.41	3.5.11	2E5.3.5.11E2.31.61 2E7.3.5.11E2.31.43.61 2E8.3.5.11E2.31.43.61.257
2.3E3.7		2.3E3.5E2.7E2.13 2.3E4.5E2.7E2.13.41 2.3E4.7.41 2E2.3E2.5E2.7.13 2E2.3E3.5.7 2E2.3E4.5.7.41		

TABLE 10 Periodic unitary aliquot sequences; starting values ($\epsilon(40000, 100000]$), preperiods and endpoints.

400002	76	56430	40524	8	54	41046	10	2178	41678	10	30	42104	3	42	42578	5	126
400004	7	42	40530	34	2178	41052	9	42	41680	4	60	42114	62	30	42596	6	126
400006	7	30	40530	17	114	41058	6	2178	41682	28	2178	42122	6	30	42600	6	114
400010	9	90	40544	3	126	41072	6	30	41688	5	1140	42126	81	56430	42606	38	56430
400014	32	56430	40546	7	30	41082	76	56430	41694	27	2178	42142	7	90	42610	5	54
400018	10	114	40550	27	56430	41100	10	30	41700	90	90	42146	10	90	42614	6	30
400022	10	30	40556	6	30	41110	6	30	41706	26	2178	42152	6	30	42624	7	42
400026	4	114	40564	24	56430	41116	6	126	41710	7	30	42170	10	30	42632	4	90
400030	12	1890	40568	6	30	41120	6	30	41716	24	56430	42172	7	114	42636	9	54
400034	186	56430	40584	8	30	41128	5	42	41720	8	30	42188	2	56430	42648	10	30
400038	8	30	40584	8	30	41136	8	42	41728	7	30	42188	2	2958	42658	11	54
400042	183	56430	40594	7	114	41140	4	126	41736	8	30	42198	15	2178	42662	7	42
400046	6	30	40604	7	30	41152	6	42	41738	5	126	42216	10	30	42664	7	42
400050	7	30	40608	6	90	41168	6	30	41744	5	90	42226	7	30	42676	5	54
400054	8	30	40628	29	56430	41194	6	90	41784	6	90	42236	4	60	42688	5	30
400058	17	2178	40654	9	90	41218	6	42	41796	7	30	42254	10	42	42692	6	30
400062	7	90	40658	5	126	41230	11	90	41800	7	30	42254	33	2178	42704	4	126
400066	9	42	40660	6	90	41232	4	60	41802	57	1291050	42266	8	54	42716	7	30
400070	8	42	40674	80	56430	41250	53	1291050	41804	27	1591050	42268	8	54	42724	6	1890
400074	12	30	40682	4	60	41252	6	60	41814	56	1591050	42270	32	2178	42726	34	2178
400078	5	126	40686	79	56430	41258	10	30	41826	5	56430	42272	7	90	42728	4	1890
400082	8	90	40698	78	56430	41260	7	54	41838	4	56430	42274	7	60	42736	8	30
400086	7	42	40704	7	30	41266	7	90	41846	6	30	42276	6	126	42738	33	2178
400090	21	2178	40710	188	56430	41280	6	30	41854	8	126	42282	26	2178	42750	33	2178
400094	5	54	40726	5	126	41290	6	54	41856	8	30	42296	5	114	42758	10	54
400098	6	42	40728	9	30	41312	4	42	41880	12	90	42298	7	30	42768	8	30
400102	8	90	40730	5	126	41316	5	2958	41884	6	30	42312	8	30	42788	7	42
400106	9	42	40734	32	56430	41322	56	90430	41886	33	56430	42318	26	56430	42792	9	30
400110	5	30	40752	11	54	41330	17	126	41914	9	30	42334	6	54	42796	3	2178
400114	5	30	40768	6	114	41334	17	56430	41920	6	114	42344	5	42	42798	17	2178
400118	5	56430	40794	36	2178	41346	16	56430	41922	203	56430	42346	11	30	42810	20	2178
400122	5	42	40806	30	56430	41356	6	30	41932	7	30	42348	9	1890	42814	5	54
400126	7	30	40818	74	56430	41360	5	42	41940	4	24180	42352	5	54	42820	7	30
400130	37	2178	40824	6	90	41370	9	36882	41946	14	2178	42358	7	42	42826	7	30
400134	6	90	40830	73	56430	41380	7	42	41948	5	42	42388	23	2178	42844	7	126
400138	5	54	40834	5	90	41382	39	2178	41958	13	2178	42392	5	114	42846	188	56430
400142	7	42	40840	7	114	41416	3	90	41960	5	90	42396	7	126	42850	5	90
400146	6	30	40852	6	30	41420	6	42	41980	8	114	42402	15	2178	42872	5	90
400150	5	90	41428	5	90	41428	23	2178	41982	38	56430	42406	11	30	42882	61	56430
400154	39	56430	40872	5	56430	41434	7	42	41986	7	30	42416	6	90	42888	13	30
400158	5	42	40878	202	90	41446	9	30	41996	37	56430	42418	7	90	42892	8	42
400162	8	90	40884	8	30	41460	9	41460	41996	4	54	42424	3	42	42896	6	30
400166	5	2178	40888	5	30	41460	9	30	41996	4	54	42424	3	42	42896	6	30
400170	23	2178	40890	24	38882	41464	7	30	42000	84	56430	42464	6	90	42918	19	2178
400174	3	90	40890	24	114	41512	11	30	42004	21	2178	42456	4	90	42900	1	44660
400178	4	42	40894	6	126	41518	9	54	42006	85	56430	42458	5	218	42906	20	2178
400182	6	42	40900	3	90	41548	9	42	42018	8	56430	42464	6	90	42912	5	42
400186	8	30	40904	4	90	41558	7	126	42018	84	56430	42464	6	90	42918	19	2178
400190	17	2178	40906	11	54	41576	8	54	42028	8	114	42468	9	42	42922	9	30
400194	8	30	40908	5	90	41580	8	41580	42034	8	114	42478	6	42	42924	7	30
400198	40446	40446	40914	25	2178	41586	24	2178	42036	7	90	42498	33	56430	42926	7	42
400202	2	54	40926	6	114	41588	4	42	42040	4	114	42508	9	90	42934	5	114
400206	39	2178	40958	7	30	41592	7	126	42044	3	3966	42510	8	56430	42936	5	54
400210	8	30	40978	9	30	41598	42	56430	42046	6	90	42512	6	42	42946	6	42
400214	9	42	40980	11	30	41616	4	60	42050	6	30	42522	36	2178	42952	7	30
400218	8	30	40982	18	30	41620	5	60	42076	6	30	42524	6	54	42954	10	2178
400222	182	56430	40956	5	54	41624	4	42	42078	75	56430	42534	9	2178	42966	9	2178
400226	23	56430	41022	33	56430	41634	23	56430	42082	6	42	42538	7	30	42984	5	42
400230	6	90	41028	6	90	41640	13	30	42084	11	126	42558	16	2178	43002	200	56430
400234	7	30	41030	10	90	41658	9	90	42088	5	60	42562	7	30	43010	10	30
400238	20	2178	41038	11	42	41658	14	2178	42090	74	56430	42570	20	2178	43012	27	56430
400242	30	56430	41044	6	90	41676	7	126	42092	6	30	42572	6	42	43014	37	2178

43018	6	43432	9	30	43334	4	114	44482	10	2178	44944	4	2418	45590	8	30
43026	38	43438	7	90	43338	33	56430	44484	206	56430	44946	10	2178	45594	16	1890
43028	5	43448	6	30	43386	24	2178	44480		44460	44954	7	42	45616	16	42
43034	8	43456	3	126	43398	23	2178	44466	205	56430	44958	32	56430	45618	187	56430
43038	38	43460	6	42	44010	22	2178	44476	4	60	44966	6	90	45626	10	42
43048	7	43462	9	54	44012	6	30	44478	204	56430	44974	7	60	45628	5	90
43048	12	43464	12	30	44020	7	42	44480	5	42	44976	6	126	45630	186	56430
43052	8	43468	18	30	44046	15	2178	44484	9	90	45002	6	30	45638	7	126
43062	13	43468	8	30	44054	4	42	44486	6	126	45018	133	18018	45642	7	54
43070	6	43472	4	1878	44054	6	42	44486	8	30	45030	5	56430	45644	5	54
43074	12	43474	7	114	44072	4	30	44492	32	56430	45032	5	42	45654	75	56430
43076	5	43476	8	126	44074	7	54	44496	3	54	45052	6	90	45656	13	30
43080	188	43500	3	24180	44078	10	90	44496	25	56430	45072	4	90	45660	19	30
43082	6	43506	28	2178	44084	6	30	44496	7	114	45090	13	56430	45670	4	30
43098	39	43508	4	54	44086	6	90	44496	82	56430	45102	37	2178	45680	4	30
43110	21	43520	7	30	44092	8	1890	44496	21	2178	45114	36	2178	45690	20	2178
43120	7	43566	33	49878	44104	5	126	44496	0	90	45120	7	114	45702	77	56430
43128	8	43572	6	42	44130	70	56430	44496	7	90	45132	12	54	45706	6	54
43146	12	43578	8	2178	44136	4	60	44496	7	90	45138	15	2178	45710	12	126
43152	9	43584	6	54	44142	32	2178	44496	5	90	45144	8	30	45732	8	42
43156	21	43590	75	56430	44144	3	90	44496	9	42	45150	14	2178	45748	24	56430
43158	85	43592	4	60	44154	31	56430	44496	36	2178	45162	76	56430	45756	10	42
43160	4	43616	2	126	44156	7	54	44496	12	30	45170	6	30	45760	12	30
43164	5	43636	23	2178	44168	8	126	44496	7	30	45176	6	30	45786	18	2178
43170	84	43638	50	1291050	44182	7	90	44496	8	30	45184	5	56430	45794	5	126
43174	6	43642	3	114	44190	196	56430	44496	39	56430	45198	79	90	45796	23	56430
43182	28	43650	14	2178	44192	6	30	44496	5	56430	45202	7	90	45796	23	56430
43188	7	43656	17	60	44200	4	114	44496	5	56430	45206	9	90	45802	31	2178
43190	7	43660	4	126	44214	28	56430	44496	5	56430	45214	11	30	45802	31	2178
43194	36	43662	29	2178	44224	4	54	44496	4	42	45240	11	30	45824	2	114
43198	11	43670	8	56430	44226	27	56430	44496	24	2178	45246	66	56430	45836	8	126
43210	6	43684	6	90	44230	9	90	44496	6	90	45258	65	56430	45840	11	30
43212	6	43686	30	56430	44232	7	60	44496	12	30	45282	30	56430	45848	4	30
43218	39	43714	7	30	44236	7	90	44496	8	30	45284	30	2178	45848	32	49878
43224	6	43720	5	126	44244	5	90	44496	4	42	45294	29	2178	45858	6	42
43230	35	43722	13	2178	44250	202	56430	44496	5	42	45306	28	2178	45870	31	49878
43232	5	43726	7	90	44258	11	30	44496	4	30	45312	10	30	45888	6	30
43234	7	43730	9	114	44266	4	56430	44496	11	44722	45334	9	90	45892	6	42
43236	4	43750	11	54	44292	7	114	44496	7	90	45336	7	60	45894	82	56430
43242	27	43752	11	30	44304	10	30	44496	69	56430	45342	22	2178	45898	9	30
43248	5	43758	35	2178	44308	5	126	44496	6	56430	45356	8	2418	45906	81	56430
43254	26	43764	8	54	44310	15	2178	44496	29	38682	45372	6	42	45918	11	2178
43266	22	43766	10	42	44316	4	90	44496	29	56430	45402	8	45402	45942	23	2178
43274	11	43772	3	2178	44326	5	44340	44496	45	56430	45414	14	30	45944	10	2178
43278	21	43778	8	30	44330	27	56430	44496	9	30	45414	8	56430	45956	10	54
43284	10	43784	6	30	44346	27	56430	44496	12	2178	45440	6	42	45966	29	2178
43290	20	43818	24	2178	44348	5	90	44496	46	56430	45456	7	30	45972	8	42
43298	32	43830	23	2178	44358	196	56430	44496	20	2178	45468	7	42	45976	7	30
43314	16	43852	6	30	44362	9	54	44496	6	126	45472	6	42	45978	12	2178
43316	8	43860	7	90	44370	195	56430	44496	4	54	45480	10	30	45982	5	90
43326	15	43862	10	90	44372	6	90	44496	4	2178	45484	5	126	45984	9	30
43332	6	43878	13	2178	44376	7	30	44496	3	90	45508	5	42	45994	9	90
43342	10	43890	22	2178	44382	83	56430	44496	6	30	45514	9	42	46004	7	30
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94242	6	42	95580	8	30	95336	9	54	96434	8	126	96986	12	42	97426	7	54
94248	9	30	95586	9	56430	95346	6	54	96436	6	114	96996	8	90	97436	10	30
94254	42	42	95592	9	30	95356	10	30	96438	9	30	97006	9	56430	97446	9	30
94260	9	60	95598	9	2178	95366	10	42	96440	19	2178	97016	14	56430	97456	8	30
94266	10	60	95604	3	2178	95376	11	42	96442	18	2178	97026	10	2178	97466	16	30
94272	5	60	95610	4	2178	95386	3	42	96444	18	2178	97036	7	126	97476	131	2178
94278	2	114	95616	21	60	95396	10	54	96446	7	90	97046	7	126	97486	128	56430
94284	8	30	95622	9	90	95406	9	30	96448	24	2178	97056	9	56430	97496	188	96430
94290	180	56430	95628	73	56430	95416	9	54	96450	8	30	97066	12	56430	97506	30	2178
94296	7	180	95634	5	42	95426	9	30	96452	23	2178	97076	6	56430	97516	7	30
94302	86	56430	95640	6	90	95436	7	30	96454	6	54	97086	9	42	97526	7	60
94308	13	90	95646	7	1140	95446	70	90	96456	7	90	97096	6	126	97536	7	30
94314	7	54	95652	7	126	95456	11	30	96458	6	126	97106	17	90	97546	11	2178
94320	41	2178	95658	6	114	95466	7	1890	96460	8	30	97116	10	114	97556	33	2178
94326	8	30	95664	6	114	95476	7	114	96462	5	30	97126	8	56430	97566	11	90430
94332	4	90	95670	39	2178	95486	10	42	96464	45	1891050	97136	3	126	97576	39	56430
94338	8	54	95676	12	90	95496	10	42	96466	24	2178	97146	12	56430	97586	80	56430
94344	16	42	95682	9	30	95506	10	1878	96468	10	30	97156	60	56430	97596	14	56430
94350	8	30	95688	16	30	95516	5	30	96470	12	30	97166	9	42	97606	11	30
94356	8	2418	95694	81	56430	95526	8	30	96472	12	90	97176	6	126	97616	11	26
94362	9	126	95700	16	30	95536	11	90	96474	12	90	97186	5	56430	97626	5	126
94368	12	54	95706	23	2178	95546	11	30	96476	46	1291050	97196	29	2178	97636	3	126
94374	16	30	95712	9	30	95556	11	90	96478	46	1291050	97206	5	42	97646	1	126
94380	16	30	95718	23	2178	95566	11	30	96480	46	1291050	97216	29	2178	97656	1	126
94386	16	30	95724	9	30	95576	11	90	96482	46	1291050	97226	29	2178	97666	1	126
94392	204	56430	95730	9	30	95586	19	2178	96484	46	1291050	97236	29	2178	97676	1	126
94398	7	60	95736	7	126	95596	4	126	96486	12	90	97246	29	2178	97686	1	126
94404	5	114	95742	6	126	95606	3	126	96488	12	90	97256	29	2178	97696	1	126
94410	8	30	95748	8	30	95616	5	126	96490	12	90	97266	29	2178	97706	1	126
94416	8	30	95754	8	30	95626	5	126	96492	12	90	97276	29	2178	97716	1	126
94422	7	30	95760	8	30	95636	5	126	96494	12	90	97286	29	2178	97726	1	126
94428	7	30	95766	8	30	95646	5	126	96496	12	90	97296	29	2178	97736	1	126
94434	7	30	95772	8	30	95656	5	126	96498	12	90	97306	29	2178	97746	1	126
94440	7	30	95778	8	30	95666	5	126	96500	12	90	97316	29	2178	97756	1	126
94446	7	30	95784	8	30	95676	5	126	96502	12	90	97326	29	2178	97766	1	126
94452	61	56430	95790	8	30	95686	5	126	96504	12	90	97336	29	2178	97776	1	126
94458	8	42	95796	8	30	95696	40	2178	96506	45	56430	97346	11	30	97786	39	56430
94464	4	30	95802	7	114	95706	1	4308	96508	45	56430	97356	68	56430	97796	80	56430
94470	4	30	95808	7	42	95712	1	4308	96510	45	56430	97366	13	54	97806	14	56430
94476	5	42	95814	7	42	95718	1	4308	96512	45	56430	97376	13	54	97816	14	56430
94482	76	56430	95820	4	2178	95724	4	42	96514	45	56430	97386	47	56430	97826	11	30
94488	9	90	95826	4	2178	95730	4	42	96516	45	56430	97396	47	56430	97836	11	30
94494	9	90	95832	4	2178	95736	4	42	96518	45	56430	97406	47	56430	97846	11	30
94500	36	56430	95838	4	2178	95742	4	42	96520	45	56430	97416	47	56430	97856	11	30
94506	36	56430	95844	4	2178	95748	4	42	96522	45	56430	97426	47	56430	97866	11	30
94512	36	56430	95850	4	2178	95754	4	42	96524	45	56430	97436	47	56430	97876	11	30
94518	36	56430	95856	4	2178	95760	4	42	96526	45	56430	97446	47	56430	97886	11	30
94524	36	56430	95862	4	2178	95766	4	42	96528	45	56430	97456	47	56430	97896	11	30
94530	36	56430	95868	4	2178	95772	4	42	96530	45	56430	97466	47	56430	97906	11	30
94536	36	56430	95874	4	2178	95778	4	42	96532	45	56430	97476	47	56430	97916	11	30
94542	36	56430	95880	4	2178	95784	4	42	96534	45	56430	97486	47	56430	97926	11	30
94548	36	56430	95886	4	2178	95790	4	42	9								

97658	9	54	98124	6	42	98628	11	30	99212	9	30	99720	6	126
97668	4	218	98136	32	2178	98646	22	2178	99216	7	2178	99724	6	54
97672	7	114	98130	17	90	98652	5	90	99240	11	30	99728	29	2178
97688	15	2178	98136	17	90	98662	8	42	99246	32	56430	99736	57	1291050
97700	6	30	98148	11	30	98674	9	30	99248	4	90	99744	9	42
97718	10	54	98160	15	30	98678	9	126	99252	7	114	99750	64	1291050
97722	17	2178	98166	29	2178	98680	5	30	99258	85	56430	99756	10	42
97738	15	90	98178	28	2178	98682	41	56430	99262	16	90	99764	6	30
97748	8	30	98188	4	114	98688	40	56430	99266	23	2178	99768	12	54
97758	31	2178	98190	27	2178	98694	3	90	99270	69	56430	99788	28	56430
97766	16	30	98202	57	1291050	98704	50	56430	99278	9	42	99792	5	90
97770	160	1291050	98204	5	30	98754	9	90	99280	8	1890	99802	13	30
97794	25	56430	98208	10	42	98758	9	30	99282	186	56430	99806	11	90
97804	5	90	98210	9	42	98760	9	30	99284	189	56430	99810	8	114
97806	104	1291050	98222	11	30	98766	35	56430	99302	10	42	99844	6	54
97812	10	42	98230	6	30	98774	5	54	99326	13	42	99846	135	2178
97818	103	1291050	98240	6	30	98778	6	114	99334	11	90	99864	6	42
97822	13	54	98256	9	30	98780	6	42	99336	22	2178	99878	12	30
97824	8	30	98260	9	30	98782	8	114	99342	22	2178	99886	6	1140
97830	81	56430	98262	23	2178	98800	7	42	99352	38	2178	99894	46	1291050
97836	4	60	98274	61	1291050	98808	11	30	99402	37	2178	99906	45	1291050
97848	11	90	98276	7	54	98812	24	2178	99414	37	2178	99918	44	1291050
97850	11	30	98278	7	90	98814	61	56430	99424	5	2178	99936	8	30
97854	78	56430	98288	6	30	98824	7	30	99426	22	2178	99942	12	2178
97856	131	2178	98294	10	30	98832	7	30	99428	6	114	99944	9	30
97876	19	2178	98306	9	54	98838	69	2178	99430	11	56430	99954	11	2178
97890	32	2178	98308	8	114	98846	8	30	99438	69	56430	99964	5	90
97892	8	54	98310	191	56430	98846	8	30	99444	7	126	99972	7	30
97896	11	30	98314	9	42	98868	12	30	99446	68	56430	99984	8	30
97898	9	42	98316	6	126	98870	11	90	99450	11	30	99988	9	42
97908	6	54	98324	8	30	98880	8	1140	99454	11	218			
97924	18	2178	98334	15	2178	98886	36	56430	99472	7	218			
97928	10	30	98332	8	42	98892	7	60	99474	22	2178			
97934	8	114	98354	8	30	98898	35	56430	99486	49	56430			
97938	1	65322	98358	60	1291050	98916	11	54	99508	79	56430			
97942	10	90	98370	26	2178	98928	7	30	99510	214	56430			
97950	4	56430	98382	60	1291050	98976	4	1140	99522	202	56430			
97954	11	42	98388	6	30	98992	5	30	99526	9	30			
97966	8	54	98404	6	54	98996	6	90	99528	10	30			
97968	7	30	98412	11	30	99002	13	42	99534	61	56430			
97972	9	114	98416	4	114	99006	59	1291050	99544	7	30			
97982	10	90	98428	7	30	99008	6	42	99552	8	42			
97986	20	2178	98430	40	2178	99062	12	54	99558	69	56430			
97988	8	114	98444	6	42	99066	28	2178	99572	7	90			
97996	9	90	98456	6	30	99072	6	30	99576	7	30			
97998	81	56430	98466	207	56430	99076	7	54	99596	7	1890			
98002	9	114	98472	10	30	99080	9	42	99604	8	54			
98008	7	90	98478	206	56430	99092	7	90	99618	33	56430			
98010	80	56430	98480	6	126	99102	19	2178	99620	1	54			
98016	10	30	98512	5	30	99106	9	90	99626	11	42			
98028	4	4158	98522	4	60	99120	10	42	99630	32	56430			
98032	7	30	98544	6	42	99124	9	2178	99638	12	90			
98040	13	30	98554	25	2178	99128	3	126	99646	9	90			
98044	5	2178	98554	5	30	99142	6	90	99660	23	30			
98088	7	54	98576	7	42	99146	11	42	99664	6	218			
98092	6	126	98578	15	126	99150	76	56430	99686	9	114			
98094	1	98106	98580	24	30	99162	89	1291050	99690	186	56430			
98102	7	42	98600	5	90	99168	14	30	99694	8	42			
98106	58106	98608	98608	8	90	99176	8	90	99696	7	30			
98116	7	54	98620	8	42	99188	5	90	99714	30	2178			
98118	8	56430	98622	42	56430	99190	13	90	99716	5	1890			

APPENDIX. On the number of different prime factors of unitary t-cycles.

Here we present three theorems about the number of different prime factors of unitary t-cycles. The theorems essentially come from, and are included with the kind permission of, Walter Borho.

If n is a natural number, then $\omega(n)$ means the number of different prime factors of n .

Theorem 1 Let (n, m) be a unitary 2-cycle, $n < m$. Then

$$\text{a) } \omega(m) \geq 2. \quad \text{b) } \omega(n) \geq 3. \quad \text{c) } \text{If } \omega(m) = 2, \text{ then } \omega(n) \geq 6.$$

Proof a) is clear. A prime power cannot belong to a unitary cycle, because $s^*(\text{prime power}) = 1$.

b) We have $s^*(n)/n = m/n > 1$, i.e. n is unitary abundant. But a unitary abundant number has at least three different prime factors because

$$s^*(n) / n \leq s^*(2.3) / (2.3) = 1, \text{ in case of } \omega(n) = 2.$$

c) For abbreviation we write $s^*(k) / k = \alpha(k)$, for any natural number k .

Assume, contrariwise, $\omega(m) = 2$ and $\omega(n) \leq 5$. Then

$$\alpha(n) \leq \alpha(2.3.5.7.11) = 1152/385 - 1 = 767/385.$$

Because $\alpha(n)\alpha(m) = 1$, it follows that

$$(*) \quad \alpha(m) = \alpha(n)^{-1} \geq 385/767 = \frac{1}{2}(1+3/767) > \frac{1}{2}.$$

Let $m = PQ$, $P < Q$, be the decomposition of m into two prime powers. If $P \geq 4$, then $\alpha(m) \leq \alpha(4.5) = \frac{5}{4} \cdot \frac{6}{5} - 1 = \frac{1}{2}$, contradictory to (*).

Hence $P = 2$ or $P = 3$.

If $P = 3$ and $Q \geq 11$, then $\alpha(m) \leq \alpha(3.11) = 5/11 < \frac{1}{2}$. Hence $Q < 11$ and $m = PQ \leq 3.7 = 21$. This is impossible ([3]).

If $P = 2$ then from (*) it follows that $Q \leq 767 < 1000$. Thus $m = PQ < 2000$.

But again, according to [3], no 2-cycles exist with $\omega(m) = 2$ and $m < 2000$.

Q.e.d.

Theorem 2 There is only one unitary 2-cycle (n, m) with $\omega(n) + \omega(m) < 7$, viz. $(n, m) = (114, 126) = (2.3.19, 2.3^2.7)$.

Proof According to Theorem 1, we only need to investigate the case $\omega(n) = \omega(m) = 3$. Assume $n < m$, then n is unitary abundant.

Lemma If n is unitary abundant and $\omega(n) = 3$, then $n = 70 = 2.5.7$ or $n = 2.3.R$, $(6, R) = 1$.

Indeed, let $n = PQR$, $P < Q < R$, be the decomposition of n into three prime factors. If $P \geq 3$, then $\alpha(n) \leq \alpha(3.4.5) = 1$. Hence $P = 2$. If $Q \neq 3$, then $Q \geq 5$ and $\alpha(n) \leq \alpha(2.5.9) = 1$, unless $n = 2.5.7 = 70$. This proves the lemma.

Because $n = 70$ is not a member of a 2-cycle, we can assume $n = 2.3.R$, with R a power of a prime ≥ 5 . We have $\sigma^*(n) = 3.4(R+1)$, hence $6 \nmid m = \sigma^*(n) - n$. Because $4 \mid \sigma^*(n)$, but $4 \nmid n$, we have $2 \parallel m$. Hence m has the form $m = 2.3^\mu S$, where S is a prime power such that $(6, S) = 1$, and $\mu > 1$.

(n, m) form a 2-cycle, hence

$$m+n = 6(R+3^{\mu-1}S) = \sigma^*(n) = 12(R+1) = \sigma^*(m) = 3(3^\mu+1)(S+1).$$

Elimination of R gives for S the equation

$$S = (3^\mu + 5) / (3^{\mu-1} - 1),$$

a monotonically decreasing function of μ . For $\mu = 2$, $S = 7$, hence $R = 19$, as indicated in the Theorem. For $\mu \geq 3$, we have $4 \geq S > 3$, which is impossible. Q.e.d.

Without proof, we finally quote

Theorem 3 Let X be an arbitrary positive number. The number of unitary t -cycles $(n, m, \dots)$ (t arbitrary, but fixed) with $\omega(n) \leq X$, $\omega(m) \leq X$, ... is finite.

Remark. Theorem 2 can be extended to:

There is only one unitary 2-cycle (n, m) with $\omega(n) + \omega(m) < 8$. The proof is somewhat longer than the proof of Theorem 2, but the same ideas are used.

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