Contemporary Mathematics

Upper Bounds for Equilateral Stick Numbers

Eric J. Rawdon and Robert G. Scharein

Abstract. We use algorithms in the software KnotPlot to compute upper bounds for the equilateral stick numbers of all prime knots through 10 crossings, i.e. the least number of equal length line segments it takes to construct a conformation of each knot type. We find seven knots for which we cannot construct an equilateral conformation with the same number of edges as a minimal non-equilateral conformation, notably the 8_{19} knot.

1. Introduction

Knotting and tangling appear in many physical systems in the natural sciences, e.g. in the replication of DNA. The structures in which such entanglement occurs are typically modeled by polygons, that is finitely many vertices connected by straight line segments. Topologically, the theory of knots using polygons is the same as the theory using smooth curves. However, recent research suggests that a degree of rigidity due to geometric constraints can affect the theory substantially. One could model DNA as a polygon with constraints on the edge lengths, the vertex angles, etc.. It is important to determine the degree to which geometric rigidity affects the knotting of polygons. In this paper, we explore some differences in knotting between non-equilateral and equilateral polygons with few edges.

One elementary knot invariant, the *stick number*, denoted here by *stick*(K), is the minimal number of edges it takes to construct a knot equivalent to K. Richard Randell first explored the stick number in [**Ran88b, Ran88a, Ran94a, Ran94b**]. He showed that any knot consisting of 5 or fewer sticks must be unknotted and that *stick*(trefoil) = 6 and *stick*(figure-8) = 7. Negami [**Neg91**] used graph theory to provide the first lower bounds for the stick number in terms of the crossing number, $stick(K) \geq \frac{5+\sqrt{9+8cr(K)}}{2}$.

Several other researchers have provided bounds for the minimal stick number in terms of various knot invariants and have determined the exact stick number for some classes of knots. Using the superbridge index, Jin and Kim [**JK93**] determined bounds for the stick number of (p, q) torus knots. Jin [**Jin97**] later extended

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this work, proving that the stick number of a (p, q) torus knot with $2 \leq p < q < 2p$ is exactly $2q$. Working independently, Adams, Brennan, Greilsheimer, and Woo [**ABGW97**] showed that the stick number of a $(p-1, p)$ torus knot is exactly $2p$. Jin [**Jin97**] and Adams et al. [**ABGW97**], independently showed that when one composes two knots, $\mathit{stick}(K_1 \# K_2) \leq \mathit{stick}(K_1) + \mathit{stick}(K_2) - 3$. Citing the limitations in using the superbridge index in bounding the stick number, Furstenberg, Li, and Schneider [**FLS98**] introduced the radial maximum function and showed that the stick number is bounded below by it. They also determined an upper bound for the stick number of 1, 2, and 3-integer Conway knots. Meissen [**Mei97, Mei98**] constructed conformations of several knots realizing the stick number by using the knot visualization program KED [**Hun**]. Concentrating on 2-bridge knots, McCabe [**McC98**] showed that $\mathit{stick}(K) \leq \mathit{cr}(K) + 3$.

In computing the stick number, one explores the knot space $\mathit{Geo}(n)$ consisting of all polygonal knots with n edges. By choosing a base vertex and an orientation, a polygonal knot can be viewed as a point in $\mathbb{R}^{3n}$: One simply lists the x, y, and z-coordinates of each vertex beginning at the base vertex and proceeding in the direction determined by the orientation. Thus, $\mathit{Geo}(n)$ can be thought of as a subspace of $\mathbb{R}^{3n}$. There are no restrictions on the edge lengths of knots in $\mathit{Geo}(n)$ and the edge lengths are free to change in deformations within the space.

Calvo has determined the number of different knot component in $\mathit{Geo}(n)$ for small n. He [**Cal98, Cal01a, Cal01b**] has shown that there exist five components in $\mathit{Geo}(6)$ consisting of two components each of right and left-handed trefoils and one unknot component. The space $\mathit{Geo}(7)$ has five components, one each for the unknot, left-handed trefoil, and right-handed trefoil and two components of the figure-8 knot. Topologically, the figure-8 knot is reversible, but in $\mathit{Geo}(7)$, it is not. Calvo [**Cal01b**] also increased the lower bound provided by Negami to $\mathit{stick}(K) \geq \frac{7+\sqrt{8\mathit{cr}(K)+1}}{2}$.

The study of other knot spaces has provided interesting results related to the stick number. Cantarella and Johnston [**CJ98**] studied spaces of knots in which the length of the edges are fixed (and not equal) throughout deformations. They proved that there exist spaces of knots for which the unknot has more than one connected component. Furthermore, knot spaces can be defined for which any knot type has an arbitrary large number of connected components. Thus, the study of polygonal knot spaces has revealed a degree of geometric rigidity not present in the topological knot theory.

Millett and Calvo [**Mil94a, Mil94b, Mil01, CM98**] have used Monte Carlo explorations of $\mathit{Geo}(n)$ to find conformations of knot with few edges. They provide tables in [**CM98**] and [**Mil01**] charting the progress of finding low edge knot conformations of knot types through 9 crossings. Although Monte Carlo searches are interesting in their own right, they have not been effective at finding upper bounds for the stick number of large sets of knots. The data presented in [**CM98**] showed no improvement over the earlier results in Scharein's thesis [**Sch98**]. In that work, Scharein found minimal stick candidates for all prime proper knots through 10-crossings (as well as all prime links to 9-crossings) using KnotPlot. Random and deterministic "forces" were applied to the knot to achieve conformations with few edges. We use this large database as a starting point for our exploration of the equilateral stick number.

For some of the knots found in [**Sch98**], we know that the conformations are truly minimal because of lower bounds determined by other researchers. Other knot conformations are merely *minimal stick candidates*, i.e. no proof is known to show that they are minimal. In these cases, the data provides the *provisional stick number*, denoted by $stick_p(K)$, which is an upper bound on $stick(K)$.

In this paper, we are interested in understanding the minimum number of sticks required to create an *equilateral polygon* of a given type, which we call the *equilateral stick number*, $eqstick(K)$. We use the software KnotPlot [**Sch02**] to find equilateral conformations for all knots through 10-crossings with a minimal number of edges. Little is known about the equilateral stick number. Certainly, $eqstick(K) \geq stick(K)$, but are there knot types for which $eqstick(K) > stick(K)$ or $eqstick(K) > stick(K) + 1$?

One can also define $Equ(n)$, the subspace of $Geo(n)$ consisting of all equilateral knots with n edges. Here, one need only study the set of polygons based at the origin with total length one to understand the whole space. Any other knot in $Equ(n)$ is related to such a knot by a homethety. Monte Carlo searches in [**CM98**] suggest that the growth rate of knot types in $Equ(n)$ is slower than the growth rate of knot types $Geo(n)$ as n tends to infinity. If that is the case, then many knots have $eqstick(K) > stick(K)$. However, the different growth rates could simply be an artifact of the Monte Carlo search. Suppose we have a knot type K whose stick number is n. The path component associated with K in $Geo(n)$ is likely to be very small relative to the whole space. The subcomponent associated with equilateral knots of the same type (if it exists) will likely be a tiny portion of the component. Thus, it may be much more difficult to find these small pockets of equilateral conformations of K. Just as for the non-equilateral case, we introduce the *provisional equilateral stick number*, $eqstick_p(K)$, which is an upper bound on $eqstick(K)$. Our computer simulations suggest that the equilateral stick number may in fact be larger than the stick number for some knots, the first such occurrence being the 8_{19} knot. However, we provide no proofs that any of these conformations are minimal.

A topic related to the stick number is the lattice number, that is the minimal number of edges required create a knot on a lattice. This quantity is lattice dependent, but most of the results have assumed the lattice $\mathbb{Z}^3$. Diao [**Dia93**] was the first to find the lattice number for a non-trivial knot. He showed that a non-trivial lattice knot must have at least 24 edges, and that the trefoil is the only knot that can be made of 24 edges. In a subsequent article, [**Dia94**] Diao exhibited the 3496 unrooted trefoils with 24 edges. Janse van Rensburg and Promislow [**JvRP95**] used simulated annealing to find low edge lattice conformations through 60 edges. They found 46 different knot types that could be represented with 60 edges or fewer and explored the growth rate in the lattice number for the composition of n copies of a given knot type.

2. Almost Equilateral Knots

Of course, calculating equilateral stick numbers on a computer is problematic: The finite precision of computers takes us from the realm of equilateral knots to “almost equilateral” knots. Working with arbitrary precision can strengthen the case for existence, but a mathematical proof is more attractive. In [**Jin97**] and [**FLS98**], conformations of torus knots were constructed using sticks lying on

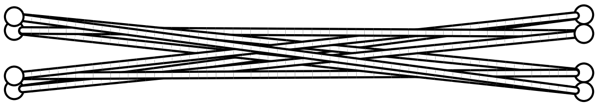

FIGURE 1. Collapse of the 8_{19} knot as it approaches an equilateral state.

hyperbloids (these conformations were not equilateral). One could attempt to construct each of the knots presented here on a surface for which we could explicitly compute the edge lengths. Such constructions, however, are not in the spirit of this paper. We wish to compute equilateral stick numbers quickly without restricting ourselves to certain classes of knots.

Instead, we use a theorem due to Millett and Rawdon [**MR01**] to insure that equilateral conformations exist near our "almost equilateral" knots. Given a polygonal knot K with an average edge length of exactly 1, let $MD(K)$ be the minimum distance between any two non-consecutive edges of K and let L_i denote the length of the i^{th} edge. If

$$|L_i - 1| < \min\{MD(K)/n\, ,\, MD(K)^2/4\}, \tag{2.1}$$

then an equilateral knot exists with the same knot type as K. The theorem illuminates the delicate balance between the knot being close to equilateral and non-adjacent edges of the knot becoming arbitrarily close. For knots in which it appears that *stick*$(K) <$ *eqstick*(K), letting non-consecutive edges become arbitrarily close improves how close we can get to an equilateral knot. During the generation of the data in [**MR01**], the 8_{19} was identified as the first case for which one had no equilateral knot with the same number of edges as the polygonal knot. Using perturbations to construct an arbitrarily close approximation to an equilateral knot, Millet and Rawdon observed that the closer to equilateral the configuration became, the closer the vertices came to all lying in a plane. This phenomenon is exactly that observed by Calvo in his proof that there is no polygonal 8_{18} with eight edges [**?**]. As a consequence, this 8_{19} example was proposed as a candidate distinguishing between *eqstick*(K) and *stick*(K). Our experiments also suggest that the 8_{19} knot can be made arbitrarily close to an equilateral 8-gon. However, we never obtain a conformation for which the theorem guarantees the existence of an actual equilateral knot. Figure 1 shows what happens with the 8-stick 8_{19} knot as it approaches an equilibrium configuration. The knot appears to "collapse" into 8 nearly colinear line segments. The configuration shown fails the condition in Equation 2.1 by more than a factor of 15.

3. Experimental technique and results

The method used to compute minimal stick candidates in [**Sch98**] is exceedingly simple. It involves alternating phases of random agitation of the knot and "opportunistic" vertex deletion. Both the random agitation and vertex deletion are done by KnotPlot in a manner that preserves knot type. The initial configuration for the knot is essentially arbitrary; the configurations in KnotPlot's standard catalogue were used in most cases. For a few knots, a direct construction from the Conway notation for the knot was used instead. Despite this algorithm's apparent naïvety, the method works very well, usually finding a minimal stick candidate in a few minutes of computer time. Some knots, however, can require much more time (sometimes many hours) on typical workstations. Examples of “difficult knots” are the knot 7_1 and the torus knots $K_{p,p+1}$ for $p > 5$. For more detail on these techniques, we refer the reader to [**Sch98**], which also contains many pictures of the minimal stick candidates and representatives.

In this paper, we found equilateral conformations for all prime knots to 10 crossings by starting with the non-equilateral data of [**Sch98**]. KnotPlot was used to simulate a dynamical system where the vertices of the knot are connected by springs that have a unit rest length. All other of KnotPlot’s usual forces were turned off. Using these dynamics, knots would often move immediately to a nearly equilateral state, but in many cases a phase of random agitation was required before the knot would relax in this way.

Perhaps surprisingly, for 242 of the 249 prime knots[1] to 10 crossings, this method succeeds in finding equilateral versions with the same stick numbers as their non-equilateral counterparts. That is, for these knots $\mathit{eqstick}_p(K) = \mathit{stick}_p(K)$. The seven “problem knots” are 8_{19}, 9_{29}, 10_{16}, 10_{79}, 10_{107}, 10_{119}, and 10_{147}. For each of these knots, we find that $\mathit{eqstick}_p(K) = \mathit{stick}_p(K) + 1$.

Figure 2 shows orthographic projections for three of the equilateral knots found. These knots are shown in a minimal energy conformation for the minimum distance energy E_{MD} [**Sim96**]. After being brought into an equilateral conformation, all of the knots presented in this paper were relaxed in this manner. For the energy minimization, we used “crankshaft rotations”, popularized by Millett [**Mil94b**], which preserve edge length. As Simon has shown, energy minimized knots often reveal interesting symmetries when viewed in an orthographic projection along one of the principal axes of inertia. The knots in Figure 2 exhibit this property, but most knots do not reveal their symmetries so easily, as the examples in Figure 3 show (with the exception of the one view of the 9_{47} knot).

Table 1 in the Appendix lists $\mathit{eqstick}_p(K)$ for all prime knots to 10 crossings, as well as the vertex locations for each knot. The numbering is consistent with the Rolfsen table [**Rol76**], with the exception that the Perko pair has been eliminated. For these knot conformations we find that

$$|L_i - 1| < 10^{-2.90} \min\{MD(K)/n\,,\, MD(K)^2/4\}, \tag{3.1}$$

so the theorem of [**MR01**] is satisfied easily, meaning that a true equilateral knot exists for each of these knots. The exponent of -2.90 in Equation 3.1 is for the actual integer data shown in Table 1. This data was rounded to seven significant places in order to reduce the amount of printing space required. If the full 64-bit double precision data is used instead, the exponent is < -11. The integer data in Table 1 as well as the full precision data is available at the WWW site www.cecm.sfu.ca/∼scharein. Also included in Table 2 of the Appendix are the non-equilateral conformations for the seven problem knots.

4. Conclusions

Determining the stick number and equilateral stick number of knots is a difficult problem. If we have found the exact stick numbers and equilateral stick numbers for those in our table, then the results are quite surprising and counterintuitive that $\mathit{eqstick}(K) = \mathit{stick}(K)$ for most K. New theoretical techniques and ideas are needed before we can hope to prove this, however. Unfortunately, most knots (as

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[1] Not including the unknot and removing one of the Perko pair knots.

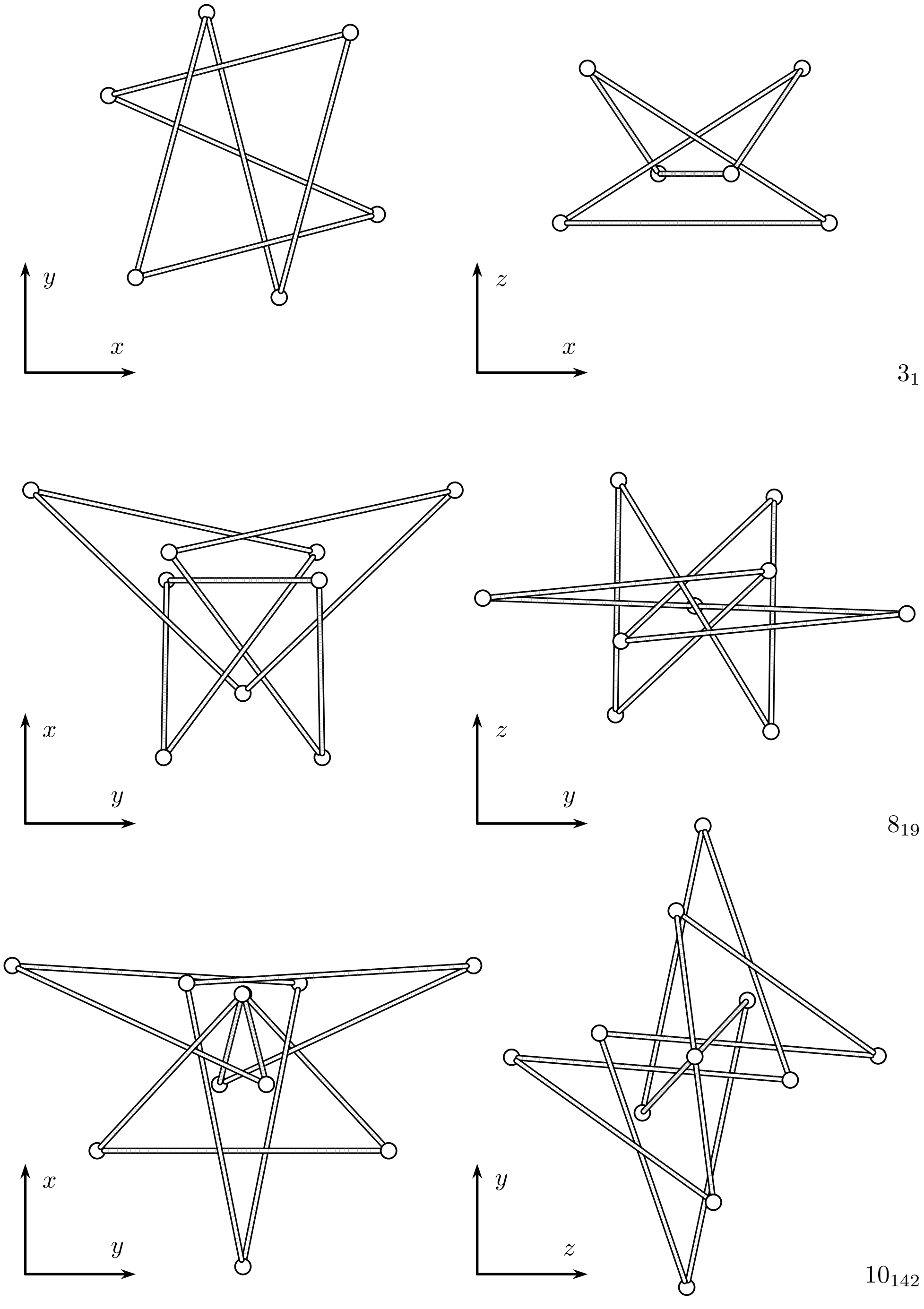

Figure 2. Orthographic projections of three equilateral knots along principal axes. All knots have the same edge lengths.

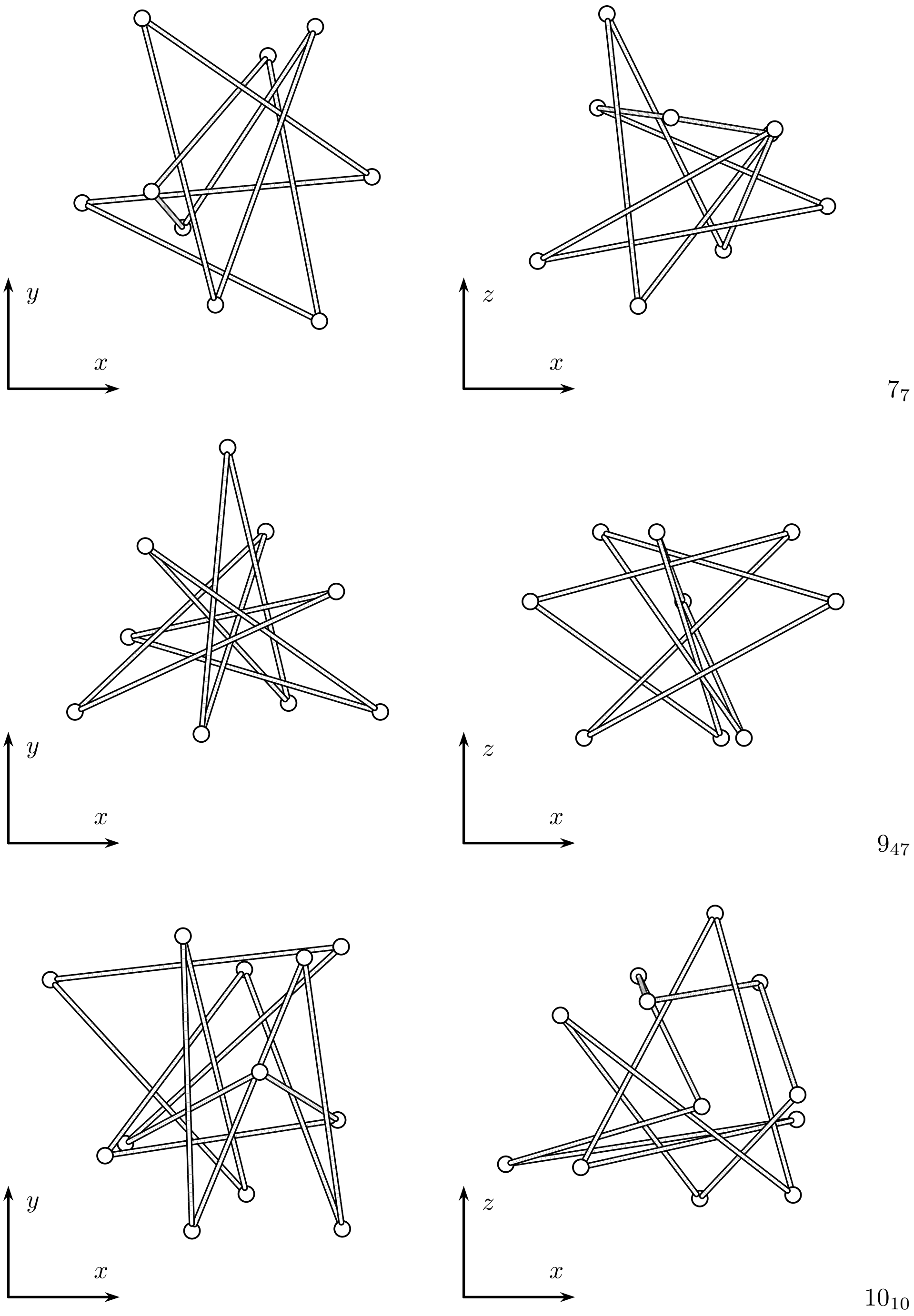

FIGURE 3. Orthographic projections of three more equilateral knots along principal axes. All knots have the same edge lengths.

the crossing number increases) do not appear to have any special characteristics that allow the analysis to be managable. Successful theoretical studies, e.g. [**Jin97, ABGW97, FLS98**], have focused on special classes of knots, such as torus knots or connected sums. These knots are exceptional in many ways; the stick number and equilateral stick number of the "average" knot is a more difficult theoretical problem.

The method presented here appears to be quite successful in finding good candidate models for equilateral stick nimber conformations and identifying candidates for which there may, in fact, be a difference between the stick number and equilateral stick number. The 8-stick version of the 8_{19} knot seems to collapse to 8 nearly colinear line segments as it approaches a nearly equilateral state. However, it seems to never quite reach that state. This provides additional evidence, beyond that in [**MR01**], that the 8_{19} knot is a very likely candidate for the first knot for which $\mathit{stick}(K) \neq \mathit{eqstick}(K)$. We have developed a tool that can be used in exploring the equilateral stick number for large classes of knots. Some other candidates, one of which might prove to be a more attractive target than the 8_{19}, are also provided in this paper.

Given our results, it is tempting to further conjecture that, in the general case, $\mathit{eqstick}(K) \leq \mathit{stick}(K) + 1$. We feel that this conclusion would be premature. Our results may suffer from the fact that we are considering only the most simple knots and that more complex structures only appear for knots with greater numbers of crossings. As a consequence, it might be that for most knots $\mathit{stick}(K)$ is extremely hard to find, and that the results found in [**Sch98**] are not the actual values (at least for most of the 9 and 10 crossing knots).

In conclusion, while we know that the equilateral stick number is difficult to determine, this project provides explicit equilateral stick number candidates for prime knots through 10 crossings against which one can test methods for determining the equilateral stick number.

5. Acknowledgments

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Appendix

Table 1. Equilateral minimal stick representatives and candidates. The first line of each entry indicates the knot type and the provisional equilateral stick number, *eqstick*$_p(K)$, for that knot. A $\star$ indicates that the value shown is known from theoretical studies to be the actual equilateral stick number *eqstick*(K).

3_1		$6\star$
1228524	697186	7716595
9718277	2911275	2283329
281723	7088584	2283534
8771546	9302722	7716671
6274418	3	4012316
3725183	9999997	4012154

4_1		$7\star$
6768180	1969142	1648297
3513308	9999997	6428238
1436260	517233	8351703
4881397	7922832	2763789
9255669	3	6767684
744331	4443496	4369945
8507162	9580692	7729161

5_1		$8\star$
3099634	2243356	8577916
9093861	3335828	2174670
906139	6665496	2192661
6929095	7756620	8569123
6646111	3	4340575
8014739	8230135	1422084
1981556	1770541	1434258
3363877	9999997	4348199

5_2		$8\star$
9469337	3088734	2481786
531233	6911704	2481996
6229952	3	6257945
6333696	9638766	7518214
526668	3098815	3274129
9473332	6901707	3274336
3666696	361200	7518100
3770313	9999997	6258077

6_1		$8\star$
1559033	172965	3967116
5782105	7760718	8008284
7977219	3	2841839
8570648	9373023	4721659
2733394	2261773	7385483
4396684	9999997	1991716
8394961	3197811	7421579
1429352	9571267	5809526

6_2		$8\star$
9733086	7120748	4806681
233857	6908993	6397009
7898156	1358473	8202444
3887337	6408356	1045534
9766143	9999997	7779707
5793157	2287887	3590664
2042194	9356779	8954466
4215236	3	8221010

6_3		$8\star$
9916645	2428244	6805572
1158601	7610103	6913536
5233176	698477	653031
83355	1907376	9346969
4634439	8881522	3497562
5788911	3	8330000
6994424	9999997	6876210
715945	3267266	2538276

7_1		$9\star$
1881019	3	1483399
1964792	7076672	7323993
8275517	1032114	4524552
5821254	9513898	7021496
4179062	486052	7021597
1724483	8967825	4524925
8035524	2923260	7323635
8118614	9999997	1483115
5000242	4999935	8516885

7_2		$9\star$
3	5039425	7556384
9187451	3634633	7053760
3780524	8733632	1450134
9999997	2026495	3172847
6414962	9774439	6881237
5024063	667646	8210520
9411451	8158532	4853033
5134943	225561	2526079
9200251	6041276	8549866

7_3		$9\star$
9137685	7095816	2350471
3997514	3624162	8299852
3633972	9999997	2547858
1961992	1806556	4533025
7039880	8499288	6347211
7619195	3	5209044
3448813	7325547	6886299
2790538	503570	1700148
862315	8497206	4200671

7_4		$9\star$
6992096	3741963	1149787
308547	9999997	4974264
8954169	5130481	4996292
365823	161393	4907359
9691453	1368651	8075101
4804565	9464843	5070199
5794139	462505	1015807
8196792	7722990	7338153
2188010	3	8984193

7_5		$9\star$
1270218	9030689	4655618
1665554	1223692	2225255
4347913	7149270	7195629
7102508	3	4312518
8099032	7801982	2043553
5095611	3003098	7956447
3491629	9999997	4021629
1363142	2106596	4441047
8729782	5661196	4772065

7_6		$9\star$
4235990	1903136	537695
3	9787347	3818669
534285	295063	3125667
6321668	7511710	824500
3117895	5063582	9462305
9999997	6339302	2990954
642646	6120393	1185070
5927636	212653	6480033
4563976	9639386	6097553

7_7		$9\star$
7914496	9719972	5863375
3536879	3088082	178472
2511291	4281083	9821528
6348137	8756439	2029646
8046462	3	6017646
218145	3903708	1665387
9781855	4762650	3471293
2201849	9999997	6723573
4616829	538239	6397029

8_1		10
8348546	9305846	2530772
7722393	2172658	5309650
3575660	8276475	7441465
4194618	2850059	2040770
6790826	7000739	7959230
6613655	3	4804089
7492601	7599586	5489947
1651454	2612214	5428869
2757504	9999997	3641713
5707451	3987839	7403145

8_2		10
3814960	8748877	3297211
8588713	3134961	5570408
1411287	4180172	8190388
5732372	4790372	1832080
2313243	9999997	6375379
1664857	4264001	1261659
8053133	6554584	4924355
4420988	3	6745667
5276547	7400642	8738341
1980969	1471223	5070461

8_3		10
2165850	2339212	4805699
2098916	9753899	2091356
4080890	4260737	7406116
7926886	9999997	3582643
8423232	2557755	6174246
2469510	7688200	5411719
3712521	3	4109308
1576768	6587303	7903483
5667752	2639769	2423469
6340951	8279750	7908644

8_4		10
1366480	5652125	6312617
6750295	250848	1285347
6257406	5541894	8714653
1708332	3	3055495
8015369	6492979	1832692
3084761	51870	6031968
677460	8366867	3116763
4828812	1582358	7607801
7185502	9999997	4957882
9322540	1177782	5974883

8_5		10
6060535	9843098	5498536
1351250	3437826	6274090
8084442	3	3694973
8442612	6286724	8609768
5081852	6911291	1390241
3939569	156774	5498532
8648750	6562105	6274224
1915719	9999997	3694779
1557312	3713251	8609525
4918546	3088540	1390232

8_6		10
7185719	7847135	3813849
8640051	3	8161494
1653728	5313873	5805935
9837805	7958820	8741871
3354474	1599909	9095774
5723227	9999997	6561586
5025739	2921694	904226
4367394	7848367	8512712
8351822	65327	6034162
162195	3618803	7736337

8_7		10
5149856	7689242	3231121
9388734	1310587	4262249
2491271	3024678	7296299
4843722	9999997	4944818
611266	3581368	5723331
7787003	6449391	5680930
3835771	3	4096088
3218481	6308896	8515973
1548027	3573958	1484027
5932151	1229836	7400370

8_8		10
4225311	542405	1620477
9298881	6462332	7531501
3	3481702	6920306
5537944	9811973	1921733
5945548	47265	2381300
2054738	6726320	8379523
9040642	257377	6126354
9999997	9952735	5228283
5476200	1753720	8063469
1965083	9815268	3772740

8_9		10
9154979	5657116	4672995
2842745	9999997	3116518
7559362	3934554	4562706
845021	3	5314011
2899862	6828101	8520604
5224417	2814897	2226307
8500505	6391171	8358603
4859152	7129139	1479396
5798884	423674	5388509
1653523	6968065	6444183

8_{10}		10
4757646	9999997	6200478
457690	3136666	5801080
6888657	8071292	6016925
6426146	3	5388561
7962599	7032805	9121317
3912723	6679598	2105035
9542310	2606282	6284785
2784792	6864638	7683644
7052177	5752706	878683
3622566	2035536	7217049

8_{11}		10
8523475	9487575	6298880
7947032	2150850	3903290
2326983	7405495	3065185
4534199	1900015	8036760
4954237	6902292	2146134
7462404	3	4588711
7455068	7703388	3842732
1476525	3032176	5370959
4630071	9999997	6555561
5504402	3831950	1963240

8_{12}		10
9017874	35075	5624147
8929148	9091098	2649515
5490762	2312241	8402119
3154176	8985475	2008672
4854932	681434	6369655
3028878	9999997	7204973
982126	1021627	4741736
8399841	6528191	7091868
4149344	3	1597881
2841049	6868754	8076807

8_{13}		10
6843184	965674	6878913
2834196	7100264	3442302
9999997	7251973	7203120
4599820	1367018	8514937
7779281	6645169	3266354
3	6486104	5496378
5945925	1131826	4274416
5396587	9034326	5937004
8344848	2951279	1485063
8284854	8930173	6940768

8_{14}		10
4499361	9999997	5400053
7914152	3501881	8339319
6766343	7576673	1660681
6888773	250304	4633039
1165154	5673565	5228033
8834846	5159502	7081992
4818591	3	2635098
4551860	7531013	5030579
2314623	5044	5968740
8041267	3781960	2036052

8_{15}		10
2538729	9557938	5338930
2472900	1123249	9076561
4283677	5043182	923439
2675056	9999997	8536619
406013	1561979	5575288
5553110	9027621	3875352
7149207	3	4911105
8138088	8983747	6763844
1637150	5902265	987992
9593987	3619526	5061816

8_{16}		$9\star$
3084204	9450446	5623054
3136449	942336	4160456
9735067	5972823	6544214
1776038	6595297	3258451
3624312	3	8513529
4823979	4869409	1486471
2936020	9999997	8167979
264933	1979544	6416554
8758344	2956624	5217745

8_{17}		$9\star$
6508388	9999997	986129
8307067	3668331	7953621
902602	3025155	1901232
6598083	8910620	6880589
8142006	3	3704364
414395	5666135	3480378
9585605	8328985	2662255
3276797	4904500	9013871
8208433	621571	1999124

8_{18}		9
920930	3480597	4079402
9666753	1040636	4756402
8482403	9898645	6498285
2018494	5448868	1881086
5030854	3	8524633
6726767	5507533	1475367
333247	8208121	7368659
5075347	1201310	4004397
7216652	9999997	4952600

8_{19}		9
8151949	9999997	4815870
3359612	4999999	5000000
8151950	3	5184131
6688324	6741014	5829836
1848051	3128619	2435322
6026747	3202117	7961032
6026748	6797884	2038968
1848050	6871378	7564677
6688326	3258985	4170164

8_{20}		$8\star$
2734522	3	4562419
8088989	7520455	9267067
1124029	7168917	1603714
9157345	2604779	6293672
842655	8651850	7582114
7153195	4110151	732933
1185220	1519965	8797389
5446618	9999997	4639170

8_{21}		$9\star$
4283525	9926691	7971289
5892255	2814340	1313374
9999997	8018751	8630609
760983	6597432	5449124
8164450	73309	5094337
5478263	9561126	4577514
3	1808440	7295214
6022480	6818211	1284113
6506219	334685	8715887

9_1		10
5181466	6703901	1601740
5023921	118023	5510682
8536699	6467803	3057290
1461434	3532026	3074285
4985868	9881913	5510624
4809017	3295910	1602717
6115911	3	8392966
8829989	5026594	3289476
1170011	4973182	3307822
3908079	9999997	8398260

9_2		11
4347321	2656085	8899706
2535068	3	2144062
3379955	7208148	3962460
9502540	2915825	3702331
7553027	9999997	5113594
4905098	3667762	2135502
497460	6918421	7232923
4656287	1518118	4147695
4977170	8343668	1100294
8644000	3747441	5727043
2218761	5463001	2299084

9_3		11
5369581	1441253	2163258
5326374	9784940	1946516
1179963	2885548	4153690
3721353	9999997	7702197
936897	2156997	7069647
8534365	2543410	3635244
1195327	6339914	2455821
3052895	3	7556893
1375886	7870537	5341424
4541173	242773	4131406
9063103	6059595	8053484

9_4		10
4296552	8091312	2636525
7135661	1440819	6469869
9026512	9038501	4085751
6082242	2280857	7642383
4376858	9999997	5523266
9090971	3311043	5661647
909029	3152292	5783067
7668522	60421	2357617
7873520	7124974	6484866
5068249	3	3595340

9_5		10
5510074	3	4595999
5410942	8192784	2275783
4764770	1680341	7724217
682849	8562299	4810206
5246458	1558454	6433326
6353573	9999997	6605191
979201	3402177	6921073
9317151	4456302	5549103
2207131	316810	3352032
3279324	7711955	7435797

9_6		11
453533	3752063	6336249
6008961	4803335	781564
8569244	7026152	7945816
5370725	3	6149935
3642627	7100740	9218436
1128476	1756658	3932387
2415741	9566193	3512171
3914386	4080582	9033459
9546467	2859084	3591944
6482506	9999997	5154627
8204866	2650546	7571553

9_7		10
8621576	6406690	6420376
5306877	3	5624193
2077432	6429689	6571083
6971836	9999997	2575524
4467779	3201772	3000518
8011270	7733775	7424476
5800695	2003082	3559337
4511325	9101534	4344377
7255009	2610586	6078324
1378424	6857078	6394289

9_8		10
2136448	7256860	7298659
6671596	2099655	3130812
5344405	9999997	2532110
8707607	4627639	7467890
1028598	6048361	5583842
6309589	3	5836361
8971402	7534552	6661349
3430092	1787238	5768293
6970304	8867553	4400331
5355485	1074860	3304169

9_9		10
283797	2618330	1426351
8252942	20799	4820214
4956956	8333264	6166375
1001769	1384568	1942058
9999997	735671	2561385
3167840	1365658	8451843
7483141	8459383	4869945
3	4157824	7566608
4582112	9979201	2381187
5753847	3494357	8573649

9_{10}		10
8475443	3814793	3271844
965804	8771624	4238764
2790247	3	5515420
8441936	7056521	5110766
2272056	1342724	1766384
9034196	7335248	2279120
4482253	797574	6573118
3255004	8777440	2484672
8781757	2560883	6049670
4113808	9999997	8233616

9_{11}		11
7161616	9999997	3086723
1352560	3516976	3192239
7528122	3	8220076
1801447	6541581	8665904
2843734	110607	2891649
2163262	8619686	4599967
8134356	2527489	2863015
9685445	9209819	8222718
4697466	7351653	1334096
314555	5222410	8548126
7807784	1751241	5793437

9_{12}		10
3261215	4032566	8659326
6847726	9999997	3834097
8846268	1776537	4203772
2181702	6429489	1818456
5376602	3	6314060
1153732	7255168	5180007
6762367	2199591	1340674
6839225	7540937	7914884
1704082	3518394	2510666
8740572	8097846	3638741

9_{13}		10
2700638	1968172	7857590
4881555	8105311	2142410
3908523	3	5047810
5268292	8551315	4715769
9605619	1130364	5811779
2551675	4605804	2172087
8899238	9000767	6106157
394381	7411708	6582029
6246172	1982738	3210533
5626726	9999997	6439155

9_{14}		10
7868890	7345478	3026975
6588336	3	8467061
6942526	9101693	6975704
5706442	1750587	1532939
4775553	9283787	6784101
1143083	1108936	4510923
2361824	9999997	6668252
8856917	3703286	4836432
2253133	9837060	2847156
1700757	1252569	6192564

9_{15}		11
5590395	4056073	9077733
4757257	4984993	922267
9131579	8942641	6690365
1483935	9365432	3623865
8826938	5836045	4924776
868421	4040361	6152033
6162810	9999997	4025814
8581327	2403404	1901862
2383298	7810091	2550543
4798653	3	3662839
8146844	7344745	1956088

9_{16}		10
7871407	3	7584671
4834920	8137827	8014914
4834313	1871191	1985086
7895484	9999997	2410872
1328592	5147140	5403404
8653890	1626396	2309231
4455736	9124876	3642589
4457977	864981	6363558
8673013	8355049	7690924
1326987	4882613	4591306

9_{17}		10
7343199	8511352	2128666
9420497	1857360	9395847
3528187	9864105	7791038
9819300	3235485	3561855
147956	3465379	6357379
9852044	1160872	4970797
5875326	9999997	2239810
4960621	106027	604153
9436271	7399932	5911714
2692004	3	4835327

9_{18}		11
1176822	5046609	4948491
8823178	4788995	6722883
3487231	439818	2942153
2085852	5957705	8352390
6646816	2261191	3135591
7023165	9999997	4420440
8121354	3446288	8606664
6739082	6228162	1393336
5963367	96860	6239675
6036184	7769631	4564896
7182680	3	4570300

9_{19}		10
9248478	6220028	6250385
751522	3671490	6057896
6354010	9999997	3357437
5161652	1403406	1511560
2254642	8997784	5061922
6029487	1606653	8200723
8135302	8771685	3409251
8077209	3	4745132
3724702	6307030	9218101
2711779	3750698	781899

9_{20}		10
7859319	8661886	4994972
6965892	103058	738565
7834682	4436029	9261435
3	4208482	3717539
8649507	1815175	7127366
5960627	9288479	1733999
2361636	1928587	6738797
9999997	3271785	1080175
3704998	9896942	4021095
3479780	352677	3008659

9_{21}		11
8408869	9999997	3806615
6179703	3572799	5830645
1591131	8109770	2875029
7420031	6895966	6738365
6578483	1495524	2210477
5601740	5772785	7789523
3442428	3	4269991
4131162	7063383	4174814
5154647	559140	6824729
1618507	6712754	6765571
7114995	3032136	4193330

9_{22}		10
1095369	2782321	5425299
5492748	9999997	4221813
1710394	3676096	8532526
3341667	8525484	1698599
2963603	3	1467474
8500418	3717174	6797249
2208620	8154297	3108700
5420503	245669	2976128
818729	6371732	6741125
9181271	5515210	5253025

9_{23}		11
7667079	8563652	2098054
5540455	2700445	5891776
5632798	9999997	5899374
7489365	3068625	7241491
2369967	7510010	4528946
7664816	2484512	4497522
2585363	6938768	7263531
4402948	3	5906339
4511807	7299326	5897817
2332921	1435964	2134110
5034545	5003224	7901946

9_{24}		10
7659515	7696535	2992925
2007529	749953	2680332
2334560	9692519	2210005
8003832	2969988	3931803
3356737	9999997	6978300
3996843	2777096	1713547
9222438	7868349	6916427
777562	5202875	8286453
6866942	7026769	1970558
6971845	3	7530344

9_{25}		11
5697644	9601833	5578061
4511031	2615692	7863735
8716027	6520867	3119671
2350164	9999997	4795966
7453313	4639812	5611325
1283973	478469	5858277
8413083	2507296	5152462
2210199	6620663	4945179
5285050	3	3478660
5078452	5555380	8431804
2541183	4180001	1568196

9_{26}		10
2913565	8307300	2363979
4900988	1846982	7918810
4535559	9999997	4766587
4922136	1283393	5409300
8912068	8698916	3036083
1710387	5933585	7162878
9174261	2093766	4695472
825739	1996643	2081190
5099293	7402018	7471957
5616696	3	2836854

9_{27}		11
9555279	6357331	6438202
2805910	940237	7349970
8589232	5801016	3030683
444721	8781391	3747985
7553478	4320714	1446212
7147082	9325455	8553788
8343222	1774218	4397072
5776861	9999997	5613863
6561110	1655626	7956225
6341942	8509579	2598471
4605837	3	3149186

9_{28}		10
4099175	846061	6060208
7625134	8319774	4614710
7031130	3	5512938
1087092	5909815	5165424
8912908	3630162	7149865
2603553	2694697	1700537
5622560	9999997	4510593
4635052	1879419	2650679
2091482	7195796	8620991
6318790	7444388	1379009

9_{29}		10
4595634	9999997	4964240
1496298	1613344	3905257
9492900	5266272	5847869
2262847	3875298	665708
4241267	2459391	9334292
1767258	8359957	2999792
4906629	3	1851402
6990873	8718963	2687432
507100	5432676	8000085
7813102	1611094	4383303

9_{30}		10
7363837	9382925	2516844
2422560	3530227	9324180
7184194	783810	675820
4233769	9999997	4047318
5372641	3	5974284
366243	8579782	3457644
9921992	4995861	4381371
78008	5591550	1597269
6842960	9326768	8327327
2364170	765152	4914222

9_{31}		10
7325526	1728222	1362692
1395200	4039706	8087154
4822410	9999997	1885600
6993091	1799464	5596330
1949724	9285465	3533722
6759299	3239681	8637308
1199743	1338337	1481448
8800257	6262126	3409809
1981159	3	3535598
3784491	8597135	6462614

9_{32}		10
6278006	1469258	2427806
7027282	8049828	7859799
4833473	3	5920883
7535181	6836322	1523452
801004	7472601	6778724
9198996	5819783	7116049
3223822	260274	4515853
1782238	8682864	5110561
7633258	3409576	8476548
6680097	9999997	3088625

9_{33}		10
9114792	2218794	5138518
3168107	9168814	3842768
9408212	2965243	1028232
4804372	3989802	8971768
8330627	8572246	1766800
5590202	3	3852837
6992204	8267967	7728399
1355224	4824584	1269886
8643651	9999997	3601998
591788	5471647	3681752

9_{34}		9
4539023	7714636	8543901
8715512	1928431	2427539
512797	4858118	5958191
9487203	7036641	4212577
3843963	3	6853158
2517124	7579209	1456099
6696448	868859	6539165
5205604	9999997	4886045
1855317	1796510	1753715

9_{35}		10
786277	2718663	6861829
8698841	8562504	8908065
1607655	3460142	3945485
9213723	9999997	4514908
9209059	3	5487695
1610638	6548887	6055435
8695638	1438833	1091935
790018	7291626	3139424
7003506	353574	6908007
7009253	9648994	3094695

9_{36}		11
6756795	4784185	1187240
1406025	9999997	4823730
5083560	2925257	2482085
8668130	9225551	6546154
4141567	2635238	8812760
8388696	6558153	2843494
1516887	1983681	3798457
8557820	4549037	7390632
2449329	7612679	2662002
4616550	3	5193765
1331870	7441751	6893993

9_{37}		10
2762708	727868	1839279
8853788	6508242	2688490
4556328	431786	6668899
7947600	8152533	6316106
3	5668626	4937326
6476110	260805	4712287
3451640	8020216	6083147
9999997	3712472	2953052
4091221	9739195	2963043
7341880	3938118	8160721

9_{38}		10
5280254	9594290	3255683
1377867	1438865	3821872
9798777	4499772	5155763
2858345	9999997	3248389
2046427	1006529	2528342
5094669	7354414	8226826
6847774	3	3236895
201223	6037099	4435635
8612347	5539029	1109216
5105984	2503774	8890784

9_{39}		10
1794227	8298721	6592453
7932875	2200346	6477490
1631331	6197342	2095599
3285780	3	7904401
3385793	8635101	7346306
2076863	1534941	2575475
8368669	7352264	3783085
1948760	1797221	5460185
4546308	9999997	4536272
5960728	1593483	3047535

9_{40}		$9\star$
9999997	9989784	5008123
4053639	2545331	1359911
5925178	9444406	8639239
7281965	10216	5000050
3816478	8890102	1363220
8843958	3804817	8640089
3	7354575	4996989
9427253	5924467	1367905
2501691	4097265	8633332

9_{41}		$9\star$
8470602	944454	2836431
2673057	9061634	5065993
9999997	3424921	9426555
1300381	958759	4661495
6150332	9050123	8595816
6257297	3448419	47100
6471333	938366	9952900
7470006	9052491	3818187
3	3451776	7977770

9_{42}		$9\star$
5694340	7580132	751975
4065510	3	6034369
2453066	8980055	3849460
9450984	3906566	201997
4616974	9999997	5447717
3727413	1068115	2719111
9510884	8062977	5093664
489116	6692841	2915235
6712795	5311375	9798003

9_{43}		10
8720135	4740945	5585444
1035148	6932006	7122287
6489453	3048827	2497015
3771334	9999997	5739657
1548964	2271336	6984865
6076834	9020143	7401605
2763870	3522168	2399784
8964852	2670703	7600216
3505506	7021721	3418607
2350332	3	7366102

9_{44}		9
6525120	3	7236356
6905493	7436030	2343761
1716820	2417024	7565249
9258678	6845194	5865728
741322	6484638	3277037
8132787	1798361	4944885
4860530	9999997	6129018
7281547	2602322	1794304
7757375	8770328	8205696

9_{45}		10
1118621	4056998	1562877
5438017	9690776	8698047
2072985	828547	5315040
7026853	8634078	1335070
17427	7033639	8378778
6251581	1554979	2684316
777931	9999997	2851979
695030	3	3992387
3946530	9137650	1301953
9982573	2691968	6131721

9_{46}		$9\star$
6356933	1091173	7062913
6195499	9999997	5425888
5459651	1801970	1641190
7540249	7856497	8051094
3064597	3	8614207
8243247	5674579	3812767
884165	8253012	8424562
9115835	5037063	6431989
1719022	6414062	1385793

9_{47}		9
4138859	307946	8372891
6249106	6942781	1627109
3	1031768	6097946
8557556	4978125	8372658
1756166	3488147	1627228
9999997	1031778	6097715
2303819	6469858	8372775
6994424	1324424	1627221
4999991	9692054	6097653

9_{48}		10
2720370	8353245	9193340
9766746	2033309	6395218
5359839	8872145	806660
1932926	648291	5054834
5863700	9691355	5495865
7561100	3	6282647
815657	6362522	2900364
7520269	9999997	9164504
233254	4029660	6218831
8680310	6238010	1615254

9_{49}		9
3	9120826	4531169
9999997	7255620	3732267
2892515	1448	4721110
9828255	5758581	9503166
4764995	9745609	1592153
4781807	2952631	9206107
9858284	4532213	496834
6813094	9998552	8556802
6234424	1096607	3603255

10_{1}		11
2916819	3502785	3001525
9999997	6634292	4452180
5212439	773491	2258452
5306040	8036880	5310756
4607789	193126	5575551
4682289	7319073	2214379
5580680	1820318	7785621
3607612	9422305	7153992
6357330	3303017	3021738
3	7903672	3729211
7633912	9806874	3300944

10_{2}		11
7341321	7675421	5667618
4831478	3	7123230
8297504	7420356	6618076
1333647	6129049	2474722
9245500	4618277	4040065
2713032	8793075	6728573
8176785	2679101	6417318
4758159	9999997	4986361
5647361	1979629	3498690
6046806	9396038	6986879
754500	3148497	7525278

10_{3}		12
8674246	7555409	4627953
7528055	14213	7559226
6478317	6050540	2152142
1657474	99883	5002564
3924932	7623054	2758398
5382349	3	5315892
1325754	7092261	5175634
7753604	2143781	4190213
5773343	9999997	5255197
6367000	2590969	1859665
4261878	7376093	8140335
3343665	1868930	2173443

10_{4}		11
5023304	9683698	4072383
6800185	3796059	7635878
8560973	9999997	4647422
2604562	6540221	6399910
5960535	465355	4865780
1439027	5891459	4069881
7019014	2858524	7261298
6458499	9704248	5433189
2048821	4224668	4408964
7386509	3	2364122
3195678	3448513	6953763

10_{5}		11
636500	3417782	3230268
9054320	8505736	1103477
691874	4877596	5366845
9363500	1268353	8978838
1064030	6829383	7768900
6735078	1973720	1021162
1383661	9416281	5173371
2530632	3	1813552
2245584	9999997	2904002
2148227	874672	7145367
7551795	9357038	7493382

10_{6}		12
3458535	4235068	2811236
6177035	9676985	5857635
6452536	2947223	4898653
3010322	8743863	5812639
6091093	2997955	3868767
1351006	7365411	6046414
3862090	1126990	7076855
4055943	6576618	3008781
4348458	3	4725704
2807974	6294512	6797253
8005160	9999997	4442709
8648994	3808882	7188764

10_{7}		12
5801727	4359072	1040418
3360177	4370037	8959582
8054895	9999997	5094658
8709612	1752342	4623495
6301848	8733536	8383822
806822	3010937	5989870
6531530	8005099	2679203
5549477	3	4584055
693384	6660480	3729156
5182169	1891394	8806663
2224473	9359817	6769718
9306616	5409316	8475954

10_{8}		12
1490759	7307198	5037401
5993422	3	3333603
7528625	8384699	5311490
1902151	1702018	4804949
806482	9708481	1448153
3656078	3882866	7323017
9193518	8692119	2550193
3043420	2575160	3703933
3449733	9848718	8551847
2792216	1470236	6114487
4744594	9999997	6172804
8364922	2034046	6266938

10_{9}		11
5359206	45732	5302979
2735892	7652794	2314575
3	546725	6276699
2482913	8762295	6137755
5588585	1497380	2782826
6874427	9954268	3495139
647211	4059292	3106851
4442442	9867451	8160686
2667066	4255218	1913237
9999997	1436512	5371959
5587303	7896256	1839314

10_{10}		12
9793899	3759687	285815
7150036	5386357	9835686
2594684	2958450	1222316
9912334	9640111	2848206
50139	8517316	1327498
6695415	1248050	3285606
4548541	9999997	7716233
4852026	3	6853612
8662773	9268805	7488918
9949861	65522	3683779
6629588	8864684	164314
1904019	2548821	6378409

10_{11}		11
5256148	456456	7271044
6278095	5477844	1865745
2613944	7137891	8134255
3770057	3	6348221
7747102	6092775	4755360
923334	4311037	2360039
5138128	9999997	4672442
5948529	2834907	2806780
7631779	8800819	6936008
9076666	1834225	4732638
4003776	7285532	4574520

10_{12}		11
436556	5398131	8124515
5637298	495016	3605531
2625618	8367251	2922024
3495830	3	2060990
7532249	5046434	7515377
950367	1872360	3259374
2715321	9999997	4787749
2667700	1625941	5963500
9563444	6182387	4175488
5018600	831080	8889020
4992909	4149350	1110980

10_{13}		11
8998233	3381856	6454934
3361987	5730250	1069119
4564567	3	6726618
1011518	7135733	8383853
3874357	2192589	2582240
5747768	9999997	3932774
7628357	2080641	4123606
6383207	8532690	8930881
5946463	739323	6615299
7661174	7956599	3259717
1001767	3582857	4936594

10_{14}		11
9189948	3090745	4502319
778297	2707385	6871642
4003157	9999997	3275169
2919702	1344308	2625787
8241114	8242616	3408376
6008868	3	5303881
9221703	7840101	7478068
4492670	2943186	1985073
1346192	8443828	8014927
5490077	979278	6110920
2478720	8235113	2263697

10_{15}		12
9082359	6080879	3577799
917641	3364753	3242321
5230865	9279634	7776941
4968425	718664	8667682
3186865	5913281	2034848
8189189	3	5798143
7726156	8512888	7010118
7157919	2074865	1319647
7576324	9999997	4661759
5769316	1662769	3487940
1878602	9176211	5088888
3797015	1588486	8680353

10_{16}		12
5824442	7292652	8215579
262192	4807797	3310271
5371317	9999997	6158614
8204917	3824447	2284539
5539986	3	8565218
9737808	5748169	5322990
2977702	9679226	5171582
6330656	3016947	7526770
8349391	9203443	3187745
6136845	1909135	1434782
9697723	7335211	5799758
6544133	230523	4931747

10_{17}		11
7944364	5490838	8158487
1982791	6530471	2482965
9936375	4308034	3279213
2062981	1915100	2222670
5150382	9384195	4097055
1508627	1990234	5045577
2656725	9999997	6878144
1534836	1824029	7731171
3370975	7371395	1841513
6272161	3	4306962
63625	5356838	5568363

10_{18}		12
2879414	3650101	1176918
3785999	2392536	8823082
8530205	6207123	3943674
1320141	3486621	2726693
7553022	563671	6397490
3411479	6427780	3343470
8679859	1043644	1313089
6537359	5534811	7321941
1820230	3	4496735
2471646	7488371	6586520
8154015	2432973	4848467
6667206	9999997	3666626

10_{19}		11
2831073	6299402	7487355
9999997	3344598	4441405
3253481	8218452	4077790
5856110	315040	4483444
3	5984989	2763023
7674060	9160637	3415906
2403423	3285157	6080728
7641100	9684960	7086423
4011519	2239769	7979412
4069119	8764027	2799365
5452655	585917	2020588

10_{20}		12
3179216	1595343	2285012
9999997	2968233	5401728
3638837	4004606	1329459
7098755	9475538	5356824
3	7071245	3960796
6379021	3560905	1700831
5237040	690221	8670541
7153544	2184126	1444404
1541403	3273731	6488057
5707615	7651876	1840872
3909373	524462	3862774
5251255	7492450	6649939

10_{21}		12
1997901	8042066	3259779
2893277	3	2212044
1863073	6170641	7449995
8319486	2025630	4673697
6718955	9999997	4024093
4181731	2981236	7321623
3520497	9471782	2421643
1680514	1963609	5032395
5111410	8834566	7787956
2329791	1231638	6771935
2673921	9381770	6595479
8240967	3464949	5838219

10_{22}		12
7921925	259810	4596023
4650681	8640463	6492762
1789650	3	5192395
2544646	8319392	9033196
2074342	1200584	3233593
4696313	9999997	3712762
5269413	1884151	7995122
107784	4197781	746763
7609986	9305533	2217080
1005296	4428929	6356018
9892216	2072770	6427980
1719639	5197017	9253237

10_{23}		12
8030448	4509814	1711819
3393790	3781483	5995681
8658934	355437	6955371
4242901	1476737	2525713
1341066	6843455	4302855
6874577	3771994	3731087
8136463	9999997	3718681
6922354	3982486	2076721
5798462	4714039	8288181
6354304	3	4063321
4609954	6110456	4075087
3567781	50332	2472183

10_{24}		12
2126606	760277	5464325
2090958	7596964	3109388
5467247	2671345	7186917
8362951	8462922	3968250
1431776	6798473	5183037
3830307	3	4621663
6649369	5957664	7595961
7787210	1869742	1740920
8404343	4194175	8560264
7146515	4251143	1439736
4781228	9999997	5133430
8568224	3879798	4434066

10_{25}		11
3370997	1509608	5427202
1951986	8698951	2333460
5854316	4626957	7942576
5714395	9999997	2078929
3824775	2273396	2057424
5393492	9370108	5289651
9255843	3197345	2087977
4358933	6545583	7387133
3524142	3	2945288
744157	7439983	3381032
8689832	7129867	3584876

10_{26}		12
5437677	2008910	9479713
9743229	8989219	5052189
5704057	614049	5690221
742577	8475235	6361737
2950137	3	9549616
3692762	4532760	1439864
8993399	4732274	9103343
256771	5579080	5969701
7216144	2756012	450384
7057547	8729111	7603173
3187698	1106783	3889705
1825971	9999997	6323201

10_{27}		11
237398	5357195	4448670
8902902	1888085	8221888
719550	7752735	8260578
2952923	224166	1960137
4127944	9999997	4061403
1739689	666091	6983271
1139948	9548572	2281706
3241257	3	4684245
3619286	9948263	6184935
1908182	1078517	1739422
9762602	7375269	1887279

10_{28}		12
4239863	1444916	4240882
6805516	8649292	4483564
8925696	1380432	3382195
2380749	5283702	2694696
7123726	9999997	6410236
1074304	5326811	6078083
6471008	3	7100430
7637904	7515629	6264834
1617459	2920856	7354239
6459944	3075591	1432171
5708040	5732941	8567829
2897517	8661640	2081830

10_{29}		11
8824398	3909520	3641828
3056559	8517121	8447090
3200845	3036432	1552910
7223521	9999997	5146700
9564286	1720477	7033193
4555764	6838478	1903938
2170885	3	6917529
2655447	8576261	4967789
6864550	1024134	6652225
5912865	9764340	7192213
435714	2945101	6149488

10_{30}		12
4791630	77026	6718572
2969010	8411553	7918577
5490301	2598031	2081423
5710235	9999997	6484699
796682	4074503	2615354
9203318	4810935	4350994
2292861	627178	7345666
4611970	7289118	2399294
6092252	3	6747153
7858480	8350340	5573008
6152476	204294	3346398
2042617	7753329	3935839

10_{31}		12
7581056	3044656	3068006
7289694	9364654	7248917
2139868	6590217	2423040
5846348	662305	5360585
8189517	7060209	2031370
2137991	9665599	5786136
8461627	9999997	1613955
5954407	7867738	8445836
3591781	9972527	1554164
8385779	5056380	4772297
2846803	3	3649760
1538373	7433461	4383930

10_{32}		11
7036405	539090	3394730
8555746	9999997	3798701
5514698	2890299	9471846
4855641	6289767	528154
9753684	4754178	8629481
246316	5679684	7772889
9629507	7663017	7822637
4756078	190521	4302431
6826430	9250942	6669447
9105415	3	7767948
2677265	7016187	8964781

10_{33}		11
8586891	2875729	1620178
833863	2812709	4908208
9094508	4343232	4321864
3377049	9999997	6819110
8384458	3228799	6783085
1749141	3322328	1597683
9166137	6720182	3687496
4889662	3	6421635
7714817	7683942	4446757
7424654	254681	8402317
5201470	8276450	7124331

10_{34}		12
3077603	2346029	8738719
5913150	5200541	1261281
6655807	9430861	8586135
1521510	3748754	4918264
8729939	8226310	5219364
8135918	212345	7962380
8402344	7242932	3208382
3	6262506	3943268
6341026	964921	1986830
5231024	9255113	3450124
9999997	2312593	4526665
6440688	9787655	6412243

10_{35}		12
6931677	6124582	394295
2768978	870920	7199441
4403537	9678525	3883820
7214779	658536	2478208
9427404	9928441	3120218
1360963	5202151	5078215
9999997	6870970	8795899
1160937	9356970	6163434
8323940	3520256	8584838
3	2021915	4145685
9297648	71559	5140141
4592860	7083174	9605705

10_{36}		11
731092	4377061	2054284
4670884	7223089	9227829
8570930	3728529	2324259
2175781	2798335	8096467
6749068	9999997	6579003
7695480	1397248	6156387
6491300	8078697	772171
4994061	3	3524364
9268908	6528431	7290914
789922	7589158	5854517
5869212	948335	8130890

10_{37}		12
3243093	1215515	4980153
7576831	6175306	8467220
8146684	3505240	1532780
7893900	9999997	5178968
6533124	3154533	7792081
149892	6191790	5432023
5076092	1305939	8152586
2532255	6908335	3947531
4944813	3	2535101
2811438	4988055	7644749
9850108	4303780	5293293
3956508	8472683	3442296

10_{38}		12
760491	5708823	4426588
5774174	3	4295190
4573260	6854452	1242447
2376776	4129366	7987391
5906378	9612457	4085785
3670591	3142345	786722
8920223	6484396	5147566
3778065	890567	5037139
3412120	8311939	6629063
9239509	4421131	3688307
4107565	9999997	4221511
6598115	4840121	9213278

10_{39}		13
7244183	5115567	7628467
1347419	891772	4137536
3267809	7097474	8891506
4580384	5516099	1108494
586044	3690726	7854762
7286954	807990	4450867
4959863	7610445	8071657
2878052	3	6476006
2934478	7974534	5379405
9413956	3256155	6122461
5078683	9999997	5397986
3944084	2117704	4222824
3559671	9933838	2336255

10_{40}		11
6760811	4196703	1096782
7599877	3	8714478
8258094	6621844	3052007
2932417	835618	6860203
4665633	9231412	5171356
8207211	2011036	1755364
807975	4769301	5495536
8982169	1770353	6226605
6046914	9999997	6173231
4800989	1672585	3839248
9192025	7277994	8903218

10_{41}		11
8006114	6600154	4508549
1274070	6495574	8292855
2697199	3	4364167
2406684	7007815	1130209
1579628	2619824	7432100
3163439	9999997	5795973
8775795	4704676	5459282
1730116	7762518	6271892
6536720	2303599	8869791
4167621	9638979	8388249
1224205	3067598	5594404

10_{42}		11
3072646	7495821	813141
9255049	2711157	6225352
744951	6912106	6806229
9225681	5505124	2743622
1295921	655990	4746607
2490852	9541608	1580368
5775387	873348	3697027
7337987	9999997	5857979
2549460	2556790	2382949
3208784	9165818	9186859
3283223	3	6659124

10_{43}		12
8678458	2725795	6205659
3484585	9340958	7338049
3685909	1092530	5352624
3	8655073	6466647
5977196	4950067	1716373
1310919	3031998	8540293
6549332	8786005	5153636
5526025	659042	7372718
7269140	8964237	7307282
2357519	2965611	3855983
9999997	6099695	5802533
2718054	6463243	1459707

10_{44}		12
3865171	5068141	1134008
5280368	9763630	8143136
1835823	2118489	6450440
6240599	8960296	3811138
9999997	1277873	3971101
4290843	7564813	2942395
3	236370	3972397
7733092	2998066	6370449
594191	6249543	2958373
8711108	3780145	1864755
4295063	9674267	6216323
4924526	1564933	8865992

10_{45}		11
8927592	1275585	2377629
6275259	7520115	9138365
9999997	3678740	1194390
2870849	826407	6919425
2441402	8232845	861635
8586044	4962858	7440931
2134960	154013	2245250
3934161	9371495	4126070
7367552	501045	5250134
6980650	9845987	3186413
3	3544344	5002026

10_{46}		12
804696	1599219	7236951
6362810	4599237	1202732
1650375	9164731	6969340
6097694	1774443	5587474
3	7713116	3624090
2996661	1750505	9260743
2033642	4996589	1208409
9999997	5054408	4791480
2915382	777729	1994555
2795771	9222271	4226133
559171	1531766	739257
5397358	8156190	3741507

10_{47}		12
8532307	2023244	3233045
5645337	6409969	8148839
1303617	5680966	2460166
4453884	471077	6291074
4893421	7036193	3384350
6372097	3	3604649
8425326	6679516	5310912
2758445	2962938	2899175
8696383	6885377	1851161
6489188	3978775	8049785
3721214	9999997	5252252
1842865	3068436	5662430

10_{48}		10
4343586	7967121	8840373
7188509	3	4773054
7791499	9349148	4188647
552878	3792102	1990183
6977955	3708164	8832916
6466216	9090581	1159627
1705262	5548425	8432735
9447122	2748156	3923440
3492708	9999997	4183066
2330355	737234	3202352

10_{49}		11
2068771	1512672	4668052
6529915	9392037	7749418
3146575	4141526	506065
9766516	9999997	4157876
7337931	1371082	822488
233484	7354731	3103670
8903854	3974477	894690
5540281	1480407	9493935
3674896	7436276	2246247
9450431	3	3927335
7264385	9143317	2166079

10_{50}		12
1721351	5298064	1473132
8268690	1019583	4760923
8512270	9314782	2996568
6432567	3024476	8296520
4598217	9999997	3828872
4820993	1521930	4064177
1676838	8745319	7213710
7937011	7974091	1539378
1487730	3200394	4296406
8441260	7859538	5683276
6741424	3	2977564
6304665	6402899	8526868

10_{51}		12
1456315	9999997	6011226
970335	1726051	5844151
9029665	2089108	3936886
1654190	4816515	1312787
7913172	8197612	5569030
7928079	3	4335640
4298994	7295041	2807752
1149598	53296	5329797
8299288	3763363	7289286
3638288	1106959	969408
1744973	1500578	9030592
4162657	3663516	1401780

10_{52}		11
5091496	2346331	9144364
2875488	9548666	5150303
6282513	1785486	4221823
9999997	9308687	5744525
3158501	6136770	1760843
6970152	166244	6510682
6567647	7942860	3032307
3	7391628	8445167
4089372	1537001	3782843
5771854	9833756	4817236
3126049	2759698	855636

10_{53}		12
9543302	5605044	6613143
2024354	2362661	8064088
6705094	3364807	1264144
7892466	7982884	8077101
4440235	1686827	3882505
4268287	9999997	3762080
8190651	3126920	6317220
456698	6082184	5539239
5140882	3	8735856
5311564	8296720	8198998
3189745	592969	5896179
1854143	8771888	6584893

10_{54}		12
4667533	8910758	5772447
6500890	1244029	8864361
7774945	9133415	6065390
6006368	866585	6546551
1784275	5826002	1135639
5808980	4481217	8463201
9999997	1354029	1803176
5930821	7080117	6531133
3	1199501	5136999
3230515	8914630	6456259
8798108	2648369	5258031
525492	1586384	6719494

10_{55}		12
9000799	3958644	3423204
999201	4869585	2358405
8746974	7279698	1967807
2655596	2808963	4950564
5052325	9999997	7871849
4883381	4487651	1907397
7940393	3	7949323
5978930	7881711	8092603
5550557	940136	3894959
8847175	8339914	3290989
5666266	2287907	7677812
3969205	9954480	5596267

10_{56}		11
5186711	1983981	2370017
1655395	6191534	6627190
2902276	3	3727631
5295704	6471611	4556488
1545592	1492906	7629983
3747211	5994589	2814909
8630489	3670890	7179681
3216367	3565157	2823844
5224966	9999997	4513690
7024642	3292526	4774864
1369511	7329647	4639390

10_{57}		12
3709720	9472972	7306282
1570285	2342153	4362589
9513546	1524859	3790117
4805124	7901454	4913011
3537538	3	4686311
2635537	7307284	1542886
6356232	2003615	6245929
5997839	9999997	6102662
486454	4228725	5463802
8469958	3848502	5922261
1355507	1390695	8648954
3145578	4152446	1351046

10_{58}		12
3636575	9999997	1743413
5630815	4811812	8569036
3792935	3	1430964
2656606	7630433	5669913
7376842	230352	6334424
1826722	6992097	7313387
9290538	6280545	2701605
709462	5179905	4325523
8297137	9615974	4807056
5563747	1266935	5359792
4570887	9986787	4680229
2777281	1437555	3595329

10_{59}		11
1398770	9999997	3290391
3125871	666613	3543590
2699732	8255013	9235131
7039279	3	7451261
340305	3743521	1859403
6925940	9445208	5638190
3938384	549334	4190090
9746429	8016049	5010964
253571	7812646	5068659
8306306	5206902	764869
2984423	1833742	7868277

10_{60}		11
5456754	7170209	7521214
7438752	197919	4181348
1413875	3598997	8159963
8846943	3700864	5255660
1124129	1689671	5160291
8875871	3	6027108
2414267	3885868	3411084
6903460	9999997	5893104
4392992	2582840	7435566
4419882	8273638	1840037
3877240	479247	3467572

10_{61}		11
639313	9655389	7176408
8559476	8283647	8229031
1371803	7826011	4507929
9360687	6579621	5093520
4972603	3	3312506
3394487	6002547	8527646
2856647	9654632	1310190
2578864	2166212	4402934
4371715	9999997	5468844
2745352	2740590	8689810
7661204	7153034	3990512

10_{62}		12
923501	6826473	4456082
8348965	5266735	8365600
7196464	3	1748357
6696550	8520081	1634400
8827575	2201452	6962466
3812290	9087658	6431704
4500684	1187147	3275334
4241326	9708257	2853373
1591623	2852580	7193118
5966844	9999997	5572473
2443703	2898320	2408885
9076499	8270467	2382892

10_{63}		11
9321215	1441075	2562731
476984	3614829	3561887
7910275	8351744	1061531
9773034	3	4336053
4137126	6727232	1704536
3842760	1112294	8938469
6386751	8461140	4094244
226966	2010714	1998297
3534075	9999997	5027874
3208687	1268511	2271206
5801658	7434655	8532125

10_{64}		13
4385600	4921697	6213327
5294446	9999997	2520112
4673933	6336545	7662976
9155276	7066811	3231357
5524206	2649422	5980353
1507536	5942973	2337024
6820824	3137538	4375032
6240237	9309257	5726981
844724	5999177	5294795
6831073	7035473	7123645
2956903	2912353	4252120
8355894	6234711	4512501
7503861	3	3701685

10_{65}		12
6359193	3	5474004
1298608	6844059	2689201
9234983	4471165	6093473
765017	1823964	4886110
7073106	6974709	1160044
2468277	7117008	8839956
8327008	1624125	4876466
6053317	9999997	7085728
4713394	1255016	5694454
5635998	9164218	1595788
3838127	395551	1885412
5119902	8828015	4616042

10_{66}		12
4683313	3633001	8086953
3672984	8537171	2706234
7525192	2336576	3564669
2534809	6492498	7006790
8492212	5297669	2870906
4010706	3	5294670
4273119	7107302	7149724
5477058	677542	3798231
8488003	7025048	5958595
1507788	5640549	4119149
7357359	9999997	5014428
1774537	6361683	1913047

10_{67}		11
5880717	1904174	287199
5710548	3718966	9712801
319711	7193030	2568982
8049461	2837077	6235183
5104327	9999997	562163
820678	3701638	6405571
9680289	3070495	2762311
623297	137970	4001498
3126446	8719142	7503230
5841026	3	4541463
8417297	9117060	6092750

10_{68}		12
4628054	9999997	7441427
6808656	6754902	46973
6447241	2792745	7404575
3916494	9702286	3427494
1014171	2912099	7356041
7417858	4811283	2321213
5630876	7731166	9953027
177406	9830587	3968405
7554484	7416189	7084975
4458448	3	4765847
9822594	6248352	6231338
2578246	2445917	4492228

10_{69}		11
454008	6220171	2440096
4202642	3	5775408
3452933	7929846	6425475
9036620	2445772	4808556
4763577	8425762	7946690
1773127	3398598	2501335
6255076	9999997	2053310
2858920	4696787	6973590
9545992	2807998	3026108
2370823	148240	5330389
7570879	6170829	6075310

10_{70}		12
3321790	3	5095019
3984750	7381835	4439308
6378602	676767	6600894
1109063	5110204	3783534
6861670	3052265	8030100
6896194	9999997	5367628
2072322	4347880	4987154
8890937	2278830	2845555
2332402	1426326	6254336
5093901	7914350	3879342
7529383	1148008	1969900
7139837	5802952	7761331

10_{71}		12
4102675	9885316	5808014
7705360	3729729	7721725
7658046	9999997	3821163
3477129	5092755	7422801
6384263	3	2934447
6399440	7373032	2520819
4770796	1511311	6706583
1771151	7874712	4461113
8618325	5201876	5171775
1381675	3733010	5250647
7416090	6729968	8273389
5510513	3894238	1726611

10_{72}		12
5985834	3	2925245
5927786	5733635	8659587
5868658	8848882	1172777
1863655	4938327	7040322
9585999	3340270	5150296
5043590	9951445	3958884
2940322	2351536	5850505
8373209	7584458	8827223
8095684	2246249	2729101
7787861	9999997	5083932
7388195	2184987	7211480
414001	5573344	4836562

10_{73}		13
7816800	2533958	3596595
6099875	9999997	6418628
2043202	3403098	9002768
6960952	7917123	4302474
5528483	3	2916586
6265370	7964643	1281059
1536433	2324158	4813132
5575629	8259432	8700402
562461	8131571	2257946
3690680	881418	4332308
1865048	8823095	4832593
9437539	5800967	4411213
2362770	8024889	997232

10_{74}		12
5588798	8727218	3083141
7453093	2236489	5150368
2608944	6880408	7351918
7259431	6046723	2102487
4780902	9999997	7404101
5973297	5812899	1843076
8687265	4185539	8156924
3676265	3	5464388
8227682	5372607	4918213
1312735	6687736	4341556
8104951	7357391	6157031
3407853	2247170	4852616

10_{75}		12
2120626	4948838	3118935
6580807	5245524	7752803
4880738	1257834	2992333
2632718	7173590	4177328
7927804	3654035	5191613
1571491	4671190	5320673
6586777	7628146	2571619
5207156	3701595	7484136
5079689	9999997	6154527
5923726	4952785	2247197
3620493	3	5655870
8428509	3740602	3571433

10_{76}		13
2103868	5932105	5715110
6033719	3	5591059
5796944	6963547	7040866
2119090	1564798	4216711
2390860	7986854	7271592
5517133	1595225	7421448
4770069	8670799	7586084
6318119	2760508	3936297
3197621	9150782	4211683
6331714	3634689	7436451
5815551	8442414	2214545
2900581	5108219	7785455
7896132	9999997	6457327

10_{77}		12
3546028	8662706	3934408
4965988	3	2508019
3383231	5506390	9310069
1195640	5537227	689931
8277944	984921	3555376
1137050	5570838	6214380
7993470	8802803	1562799
1629821	2794554	3143369
8862950	7291228	5703654
2584283	1355393	7810193
4491509	9999997	6957776
8379243	2009573	7321021

10_{78}		12
2982920	9999997	3185810
6495519	3470489	7665553
232527	1979391	1869651
3729604	7629662	7427152
4906222	3	3497164
2473606	8124284	1730990
5858509	1012814	5337978
7795578	9357448	4051208
7582066	1160294	1258000
3815240	3360681	8742000
9767473	4753292	2604208
1960191	1493566	4464711

10_{79}		12
5017433	717211	7372443
9099403	7238654	5564834
1607311	7852518	3125393
3652645	3214272	9188596
6577197	3	2587489
7145328	7874221	2222708
1317433	5714112	7104176
7030938	647699	5067886
8748430	7827549	7889078
7064732	4740344	811404
5345006	9999997	6453898
900597	5042849	2195605

10_{80}		13
7387247	8656970	4634665
2186716	3284358	4903463
4523178	9999997	7232385
7155044	2999228	7445125
1147705	794259	3567918
6212936	6275137	3032983
5417782	167137	7280665
2617171	6567409	4601890
8852295	3070300	2393678
6205930	5993594	8752439
6349387	3	4275942
6260605	6841331	1247561
8823340	1389448	5685139

10_{81}		11
6997331	3	4456498
2298805	7632151	7041571
9843397	7053709	1586943
2875805	1124682	3405658
8704430	8388261	3930988
156603	5719621	1319201
6781577	9172970	6904228
6432333	1493904	1620441
3343468	9999997	3881795
4410386	2072849	8680799
2722710	7729738	1458626

10_{82}		12
4375248	3	5298971
3471779	7440533	5235391
1157492	312161	5125074
4221131	6244148	8532042
8671195	2159163	4094519
4668401	8433495	3204476
5082333	2906517	8250560
2931574	9999997	7137653
7670406	4338260	8429934
5110454	5414977	1467958
1736884	3316835	7823948
8842508	5656285	7356116

10_{83}		11
8731381	8523108	1899936
2170488	3286647	3386072
8973442	4835240	8284655
1250019	6346807	5007714
5892521	3	1715345
5157413	8490268	1937751
5682035	1541081	6847742
6371016	9999997	6043699
992608	3523875	4699447
9007392	624402	4524129
2997213	5827437	7603191

10_{84}		14
7708498	4047274	2558298
753389	6401532	4500662
5880425	938325	3253376
1063444	3241510	8655308
6530614	6629402	4615371
2831255	3	4381557
7817800	3897810	8580404
2433544	7924706	5047313
7183160	2017955	5537502
7469372	9590712	6047688
3584955	3628486	8703252
4643038	4937311	1296748
9246611	5706014	7288831
3524606	9999997	4737516

10_{85}		11
1819944	9839960	7915194
3745617	2608431	5347658
4194325	9999997	2562181
4013169	2137770	3427070
2849448	9886499	4521789
1079883	2416346	6435142
6281565	7583426	3462052
6919643	3	5625386
2646563	5919716	2576904
8920117	8803187	6440010
3654036	4816202	2084806

10_{86}		11
2167728	1344277	3196129
1635696	8945038	4495651
6395563	3473378	7169223
29148	4582395	2928677
5234451	3	6341870
3084868	7395202	5683300
9970852	5132373	2998860
3362297	3876798	6805949
6807216	9999997	3583782
5929109	2570921	1639266
5093842	6294843	8360734

10_{87}		11
1932118	6844009	2283281
7062721	1139798	3860934
9999997	8398339	3670974
4263877	3172545	2604155
2721639	9403163	7093142
7625015	3462394	5673892
3	3469187	3882455
5327403	8427771	6777512
5171610	596837	6729584
6637830	6022751	1274335
5346777	3982909	8725665

10_{88}		11
1876650	7299131	7731819
4747609	3	6924932
3285099	6987515	3577322
7534984	527371	5118675
1816432	5855264	6159093
8183568	9741722	3604532
6995210	2410949	6253743
5313842	9999997	4930829
2947625	2598478	3593193
8100134	6960543	7666862
4671582	2348600	2268181

10_{89}		11
3453366	8204368	7052827
8415333	5178653	1868477
1147197	6876536	4092201
8346686	6162777	6975161
5663363	3	3041518
7262053	7618657	2809428
6236041	2026147	8131523
8590762	8692582	4865410
3539778	2829531	3990334
6492099	9999997	4712682
8852803	2691192	6001866

10_{90}		11
2719147	8222166	8291609
4758984	835771	3788651
6104914	9612882	4172311
6568309	1546290	7875250
2138045	9137327	6554147
3654920	387118	6913767
9999997	6332989	5074468
2110620	4004116	1708391
8357878	3828749	8027996
3	3710323	5006690
8289112	5092910	2112642

10_{91}		11
9111878	5112620	5130077
1913940	6358597	8934851
3387184	4425616	1065149
5902532	7003093	8472491
3064456	3	5195124
4055394	7959062	3321490
8560018	2737942	7825639
6983948	9999997	4273507
5010020	2693366	7522481
888122	9823051	7393520
1571917	1824587	5550676

10_{92}		11
5958011	4949245	2590294
4619069	894274	7034575
2008676	6476800	6942699
4710690	1466738	4579315
7991324	6356063	6401162
2225206	4304564	5672862
6293664	3	7377443
2928231	2484249	2850903
7703238	4365628	6263660
5266782	9999997	5711611
2116220	4982267	7409706

10_{93}		11
2179538	2643705	7513285
8809715	5827707	3454411
1583111	8027061	7130088
2223931	311991	3868400
6657429	5304085	8966895
7015958	2565839	1033105
6850957	8214711	7248777
5189996	3	7824407
1190285	6250175	3886230
8104463	3406512	7717586
4365376	9999997	4095880

10_{94}		11
8421943	9999997	6704829
3021889	1589721	6476781
3180342	9710704	648414
4972359	5415395	9496257
9339407	5509756	503743
4862693	8355891	8977460
6623090	3	3778857
9789782	9322724	5512141
210218	6637898	6496511
8289152	822293	5571913
796700	6085807	1558946

10_{95}		12
2303474	9999997	4749230
8961759	6945797	7202441
1325858	7810375	7992795
5606539	2508371	4353610
6431621	9944841	6276445
8482265	2720661	8088962
4524928	6269002	2482902
3900656	3	6953817
6434523	6320342	3305260
1038241	2572518	7368891
5172005	9081795	6899377
4643452	3206742	1911038

10_{96}		11
1320016	9999997	4498657
8780614	5635637	4657583
1321576	3013853	8153639
7413577	7988627	4565805
1219386	2418307	2255623
6507896	7928706	6305387
3363111	3	4898469
2911259	8544951	6128554
6684399	2051904	1846361
2811616	9741506	2624175
6098193	3519501	7645977

10_{97}		12
3968144	7985264	9085205
5739254	6815403	914795
4927082	430372	6376734
7639920	8390108	5639079
290473	4505364	7107210
7920293	1658855	4883644
8820061	9999997	3947273
1221050	6385101	3277512
8473491	6642884	7589897
6254728	3	2877123
2589509	7470958	1458667
9709527	3986937	4361761

10_{98}		11
1718706	5323848	4916262
6633160	3	5035878
8153722	6967606	3751397
2637743	5404865	8183249
5222342	7706398	1816751
3713338	1563639	5352132
3081544	8766329	4870895
7379410	3014015	5844925
5475679	9999997	6130172
3989732	3913451	2489374
8281294	7446790	7137761

10_{99}		11
8187044	8228220	3383816
4561412	1142540	1044643
4803447	3629671	8955357
9999997	4856447	2605972
3590444	9724576	4616630
677763	2020482	3623145
7652721	3908031	7698794
4608397	8973678	1876842
6726991	987549	1130445
3	4897640	4008399
6771747	275424	5274257

10_{100}		12
4569644	3694846	8349164
2807002	3529801	1412740
4663603	9999997	3849485
9264274	4741525	5408470
2318739	4063066	7004518
7150842	3	3629545
1102577	2900134	6130717
7897974	3272828	3909948
4937921	7812539	8587260
4517566	1153785	5992567
735726	6279355	2725405
7272923	8824959	4151266

10_{101}		12
5416685	7694394	8136131
7072470	3	5394547
5917859	7460749	1863869
2389691	1124348	5970401
9318260	3673155	2102577
1412358	1047276	2353623
8933461	4289152	3897903
681740	3120588	3969330
5383222	9999997	4146410
7862543	2790674	7513929
2922330	8460084	3920374
7800409	1806149	2740950

10_{102}		10
6450586	7949998	1411605
1795059	3722486	7711767
8884064	8514327	5257770
7000329	3	3470129
5110529	7534983	7816457
2855943	1457164	1716065
5042182	9999997	2931873
8966004	2107527	4177010
897129	5480834	5835888
9102871	3400612	8588395

10_{103}		11
9999997	3594350	2310739
5331850	6433974	8871252
6315104	1653184	1866064
3	6754567	4510075
7818443	7332510	1128748
7974938	231563	5866623
2838153	5461051	1489262
8010049	9768437	6742196
5229301	1753863	5778123
5952606	9097300	1483224
1678260	1911336	3211603

10_{104}		10
8085876	3440843	8641648
2403536	1540554	2550078
3088246	8692151	7175351
9166556	4312194	3067134
833444	2966560	4392211
5605704	9999997	5266059
5953456	1652953	7058612
8181216	7615455	1358352
5591836	3	4240593
2096338	7795492	4379044

10_{105}		12
6043030	9161542	3708614
593893	3438695	4547816
7418242	3	2367908
2205605	5959751	1691042
9406107	5962244	5052753
2925997	2300383	2269358
4592347	9999997	3312216
4081750	4234735	8757340
3085065	6618960	1242660
2959465	162646	5873920
1724617	7953221	4909332
4978704	1661596	1307289

10_{106}		11
672839	7976399	4132541
3755409	3	8999099
5021998	9435698	6514759
3779766	394268	2838085
5102991	9999997	1168483
146217	3647544	6815186
9853783	4583260	8117534
1842504	9635773	5452944
1321922	439611	1993446
4345319	6527416	9107251
8723334	3339397	892749

10_{107}		11
5617383	1309473	9538639
2296442	4912072	1665129
7418645	9999997	7485402
5740761	1461698	4278896
416298	8939523	5594854
2686957	3	6558499
3603270	9011732	4571383
9470348	3122366	461361
3041778	2162924	7075926
9583702	8735804	7076037
739962	7456127	4596076

10_{108}		10
1553987	6822907	9420915
9655321	4329460	4763964
344679	1817634	4029970
7055702	6711583	8984515
2896925	9075773	579085
2991446	1519519	6614826
6550103	9999997	3622581
8990619	700710	4672921
4828662	9394181	5471513
4443119	3	3205051

10_{109}		10
5059218	7438291	1414361
6469367	3	4544248
1154852	6064399	5990577
8395136	2664583	7760426
5469398	9999997	5582220
6204236	2903355	1555992
1704249	5148492	8023008
8061899	8039234	3740868
3453598	1359231	4860665
8845148	6275387	8585639

10_{110}		12
8409784	7956613	4977426
3	5915126	4542588
6449999	265736	5792835
3016406	8048703	7441179
9999997	3072571	6196692
4727736	9734264	4491908
4486233	1073759	4627914
8595480	8544604	6171202
1222630	5240018	9302012
7767936	8237722	4479781
6815116	743119	8722921
3797669	1998763	697988

10_{111}		11
9059362	3452425	7470278
3483308	7602670	3623099
2521915	3	5719019
7171797	5588080	2514383
2026224	3209861	8080787
7757289	7690965	4888249
3964584	1141221	2472895
940638	8275473	4226716
6743981	3002492	2948214
3792587	9999997	5280999
3411984	2811726	1919213

10_{112}		11
3709926	787402	1550315
7000890	5012411	7274194
3	6539193	4096073
5661817	1393748	5802591
5789245	9212598	5261025
2514483	2135075	6053842
9999997	3913083	4553937
3718906	8587949	4924710
5312503	926004	4478619
6523423	8375677	2362020
3463692	4499813	8449685

10_{113}		10
4951970	9488398	1911608
5572290	303254	4163254
5304144	9696746	5392877
1978335	1553440	1864826
9999997	2097753	6882619
975581	4954523	7352039
8470636	1062558	3051070
3	5239406	3840941
8244922	9604298	5511453
1993583	2981728	8135174

10_{114}		10
4501881	329235	3933664
2893319	8422318	7511326
9999997	6152244	2488674
3712482	1863523	7280246
2721664	9670765	2927043
3124767	868601	4728304
5387740	9511110	5763250
7018535	666629	5735313
3	5898310	3672584
8070130	7970448	7058500

10_{115}		11
8367870	2990051	3332777
3481906	9999997	3907150
4107714	1469579	4334023
6341527	9573289	5971660
7372179	2677307	999228
7032224	5710720	9000772
1705703	7063868	2432740
9116008	7941716	6634959
5920784	3	6883209
7389740	7621925	3265150
883992	3888714	7397978

10_{116}		10
639754	8537959	3734554
9281476	7328475	2237461
3596114	2531069	7037987
1262158	9427807	2001009
7800449	6925028	7420451
1688538	1332435	4297799
3485847	9999997	4134828
9360246	3488865	2918232
2773441	6519276	7998991
2248352	3	2031843

10_{117}		12
8122184	3	8970025
6419586	4556683	2330684
7725335	9999997	8364619
8367031	6321104	1029975
859256	6033877	4390606
8539548	8520182	5995106
6347602	606295	5439412
9140744	7451256	1821693
2045410	7525502	5992274
7635672	2117834	3299854
4996517	9792439	4670374
2904721	2023618	2934622

10_{118}		11
217014	6299280	6412792
9362807	9339678	8131742
6797047	3	6706375
3928096	6875595	355022
1780137	284714	7268118
3887300	9836205	7684312
9782986	2911004	4061218
1412421	2531478	9124215
3345465	9999997	3096870
9536930	6174766	9644978
7137881	1596125	1330837

10_{119}		11
6872364	7775314	8694710
6994830	869862	3300978
5078664	9184797	1305290
6460233	3912055	8166927
3	633324	3236617
8032713	3184011	5637069
2370389	9745363	4341176
2911337	1244204	6397937
9999997	2394835	1376030
4882606	8924543	4198761
4067086	254637	5178684

10_{120}		10
8446958	2764393	6707919
4855005	9999997	5974229
2813964	2603435	3343752
8454462	6209532	7923625
5357451	1517774	2076375
1782938	7274314	6535019
5341961	3	6074420
7372902	7401332	3449539
1545538	3935457	7901946
4980017	8509543	2150730

10_{121}		10
6290328	9999997	2963390
1284421	2237311	6670563
9862158	4870886	2363795
623999	1184533	2722599
6439033	6593286	8721956
6016744	3	1278044
4531913	9832356	1704234
8507518	2848430	7576274
137842	7333443	4593875
6850365	74622	3447971

10_{122}		10
6381754	4952415	9335024
4619395	9145659	1978946
5735445	854341	4172019
1742466	7566415	7887562
9999997	7523603	5316099
3022165	5407476	664976
5600996	8960969	8116378
2810582	1123484	5752381
8094912	6967797	2185739
3	8585266	4765918

10_{123}		11
4518168	9749087	6251775
1289159	3533210	3589450
6327338	3	7865523
7619180	6415812	4215846
603315	8712841	5501495
2714060	1539117	5017724
9396685	4924825	4841329
4974772	9999997	8133883
3362950	6222600	1866117
776118	1476043	7055538
7538204	3172369	4308128

10_{124}		$10\star$
2507518	1354260	2659902
8744254	3747105	6883490
5913157	9999997	2965900
1212595	3696689	3762334
8706563	1276616	4429390
3131954	5408483	8212601
7719578	5771462	1787399
3410509	3	5040622
8787405	5742070	5801493
1418998	8595116	5634193

10_{125}		10
7572270	1360362	3770414
8030630	7784108	8126956
2525598	7321983	2655656
3685673	3	5000204
9210044	5466300	4765725
2299372	8382277	6813590
8290649	7995420	1873044
8180304	2710705	7575120
6330457	9999997	5600696
789956	4550216	5839018

10_{126}		11
3742759	4972968	8372193
6320650	8214593	2104652
4487687	1030040	3312200
3	6989717	4194624
3560015	413878	4916006
4123178	7641934	6884200
9999997	3979401	3971370
3007747	2645743	6372519
4881917	9586122	4192072
7615089	2753150	5700713
1302646	2738056	1627807

10_{127}		10
7865434	9999997	4776742
7464545	3	4002680
688338	7201245	5730364
8439906	944943	6967963
6580681	9690087	2404466
1534129	1258277	4453041
9311662	7596153	4770963
3047256	53347	2620832
2517970	8755759	7595534
7616559	154101	6714824

10_{128}		10
884836	6550320	1180295
9828374	7820338	5404564
608908	9488429	8819705
3246861	3344938	1420855
7725558	9999997	7345020
171626	3490425	7256372
7109615	8813521	2463333
6018309	844916	8358640
4112731	9235971	3318479
7765258	3	4213018

10_{129}		10
618059	2596239	4533226
6445146	8774804	1850734
7559894	3	2892645
9381941	8213314	5816178
4393265	2270076	1443946
4014065	9999997	5851884
8246348	2166058	5645593
2647501	7356621	1059054
4572464	3715617	8956078
8423243	5092082	1043922

10_{130}		10
7098802	9999997	8075406
5279194	3	8463487
8036434	7508121	2179600
1843137	742437	6576194
8505691	8281427	5081049
3486542	175511	1536513
987285	9036830	5859961
9012715	2856785	4932064
1784900	9496694	2261527
7620230	1198516	3003572

10_{131}		11
4944919	3	5940307
9896309	5900936	8693185
5044953	1941896	3429541
5703203	9999997	4674256
5720303	3085406	9045038
5991196	4265608	954962
2336458	8571150	6872799
8925323	3891310	5607274
1676000	253795	6670951
7449269	4243401	2467618
103691	6555100	5226991

10_{132}		10
4738755	1490566	5202084
2233240	9999997	5884395
4210015	3102866	623642
3920909	8459243	7721474
6671414	3	7549572
9403117	7343379	3334576
721580	6415934	5044643
8324403	8024317	9376358
596883	4148508	7274667
5418976	9963375	2574847

10_{133}		11
7015528	2422357	1458420
8380353	9073654	5722138
607756	7135782	5385731
6516135	2729711	8541580
5137956	9999997	5455263
8846070	3125942	3644449
1438869	2493385	6646955
9392244	2236424	7626543
5297902	7469347	3139376
2957626	3	4875407
6324191	6362083	8406974

10_{134}		10
9999997	7424780	5158665
3	7820387	5420334
6401527	143435	5976881
3825866	9817669	5980253
7532435	972516	8852441
2149595	2730064	596478
6062208	9856565	6438507
4243230	192081	4563962
8218588	9275271	3179388
1021479	6162935	9403522

10_{135}		10
6111470	8889243	7734695
1435643	2472504	3078592
8980258	7607219	4274706
1083477	3381178	6395702
6169396	9443844	1695202
8397399	2889469	7760956
2578308	9999997	8304798
9064303	4052577	5607159
935697	8365301	5398888
4756952	3	5769017

10_{136}		10
279312	6768598	7047573
7278254	8710328	3350736
7483974	2552912	8686092
9160646	5596231	1313908
4536083	9999997	6377738
5895928	2282224	4139677
9720688	8751097	7293566
2493578	8258989	3558754
9233301	5672476	7341371
4081031	3	4566612

10_{137}		11
6007611	2025972	1948403
5199139	6662608	7535033
8149795	3	7019501
5547919	5927623	3634828
2210727	794689	7619622
6779917	6477853	8051597
2391824	2931262	3411684
2822206	9999997	5203391
3461773	2726207	4990359
8430651	8029436	4249779
1569349	6206965	5971285

10_{138}		11
4818359	9999997	3040077
2840994	2385968	6762369
8023885	7382872	1872845
3752337	3	3600843
4101024	8131629	6682065
1315781	1294160	2074430
7816899	5169250	6370709
1701072	8344872	1055548
8684219	4001928	3903943
2483632	7449370	8944452
8083501	2151554	4905458

10_{139}		10
536313	2111353	8379636
8419054	6971420	7803888
3825401	3	3755797
8332081	8045679	4778678
3992754	1314536	9463901
1992852	9999997	6884655
8064135	3024067	7636499
2897081	6019932	536099
2474943	9666951	9057273
9463687	4025736	6728430

10_{140}		10
6331740	9002545	3034305
1204260	2434165	4537559
9483935	4204514	4622973
3427528	9999997	3428506
4974924	1901963	1499299
8269964	7230103	7195619
6274759	3	3266339
516065	5915612	5147153
7911147	5377618	1058417
6005014	2945173	8941583

10_{141}		10
7141979	3	5079786
1994960	5684202	1400248
6518235	5903412	8599752
5945239	683929	1908743
1273602	4882191	7643839
9144689	4589517	4434282
855311	2998787	3387038
5287699	9999997	5304829
6131063	1776303	7304961
8416437	7655155	1599079

10_{142}		11
7883258	6219992	6138153
1737121	5000194	5000173
7883107	3780008	3861795
8262879	9999997	5175342
5687253	4491730	7068238
7643302	4985372	1027701
4247679	1841416	5402994
4247796	8158741	4597201
7643603	5014714	8972299
5687119	5508364	2931903
8262747	3	4824522

10_{143}		11
8832942	5284225	3249510
5245209	1601285	9999997
3681168	8340786	5086969
5452268	1784039	3
8901831	4567443	7235895
1503865	2484954	3638913
6505485	9102700	5426142
7362991	808044	3855058
8562812	9191956	4379828
7597699	1245394	7195080
1098169	6651071	6460424

10_{144}		10
7024944	8395224	6790552
3	4772070	2354702
8106312	888948	1187263
2599460	5185961	6963426
9999997	9782882	4462593
7041900	1411752	6286775
1918529	8063770	2872757
3320047	1362563	8812737
3866205	9041681	4028738
5718734	217118	3107320

10_{145}		10
248824	1506400	8635906
9751176	4927030	5637355
275197	9422994	4647992
7086879	1656007	6712358
2521789	9714960	1692405
3464826	3	5656870
8311422	9351099	5889734
2495525	1649628	1664879
5487021	9999997	7348979
7870020	1663980	1364094

10_{146}		10
3754161	9427313	5027209
4839259	3	7441652
6467330	6804780	591431
9304044	5664172	9893753
1456375	1191231	6113803
9704069	6403019	5280765
295931	8609783	3700167
6267409	857912	3338095
7307431	9999997	6687988
9296444	3028221	106247

10_{147}		11
2481575	4827742	6945399
6880441	6004103	4830100
3906748	9999997	5461220
4330210	5017621	5913926
4231439	3	6062526
6164511	4468463	7289076
2818708	6884602	4429669
7518425	6763836	6192170
4334216	3841386	3637091
3985812	7755009	6762870
5171107	5037447	2710924

10_{148}		11
542933	3	4676755
4975296	7291843	3458919
4538051	400696	8618454
601356	6330851	3756810
7778227	2100169	5968990
5934530	9999997	3054649
275446	8448979	9368839
2906784	3531190	2796830
9724554	5460432	7705591
5116123	3724145	631161
3432356	7263942	8308052

10_{149}		11
4317021	796354	4233537
8793055	7846210	4747330
3346728	2045020	2162171
2067436	9999997	4416298
1600762	1844082	2610031
5090613	8333172	6573865
5834164	3	6642788
2729440	5784310	1456093
1206945	1607681	8543907
7708940	3364385	3580301
1435518	8541704	5539605

10_{150}		10
8914207	6622548	2806080
2667462	9999997	5802940
1804205	3396611	1922189
5056956	5960179	8422795
5889951	9403167	1577205
3286376	3395558	5644168
1821716	9993287	1938107
8758155	7199889	3807032
1085793	6587160	3395238
4983604	3	2486069

10_{151}		10
9259569	1432043	8011781
6403188	7428871	2406692
4503054	3	6498061
8140093	7846549	7359185
4624762	1987108	1988219
4042865	9999997	5303771
6352289	2017080	2758684
740431	7423981	6607104
8046403	6238269	2051368
1250956	1475800	4635679

10_{152}		11
8250003	1185992	4161550
3125531	4356355	7179596
7417212	4620050	1989996
7010685	7622424	8010004
5863230	3264659	2998692
6098212	9999997	2993963
7089067	4298705	6448452
1749997	6275511	2841987
7967932	4834195	5005300
3272303	3	5046292
4420300	6639870	5165847

10_{153}		11
9521228	3970116	3071016
478772	1335061	3394147
8917003	4564671	6073667
2257511	7851836	271971
6619192	1077285	5160238
6742841	9999997	8190728
4652742	3543746	1651442
791988	6489468	9728029
5807012	3	5085796
3099166	8581089	2284637
1682313	575904	7051553

10_{154}		11
6027095	317461	8498130
5380202	6047039	2424943
1184857	3	6420260
4720309	7586238	6137884
4582422	613542	1501870
1203504	6414574	6507975
8815143	4232863	3781581
2092409	9178707	3093394
6508312	2147468	4184997
6947492	9999997	7061633
3441739	4554082	1752976

10_{155}		10
3282009	6660103	9074716
3907720	3817807	925284
8278671	1218943	7927005
5131484	8536081	4544975
6228192	209896	2458039
9999997	7944347	1544161
5558334	1192453	4637212
6289921	9790104	3982545
3	4170993	2047102
8558224	3377423	3052343

10_{156}		10
957621	8540543	2450613
2117321	2378365	9013122
4113431	6117190	986878
7640355	9999997	8394204
8988470	2595508	3320745
689332	5472441	5607975
7820402	3	4349356
5796599	8846899	4206160
1818562	690481	4384829
9310668	5803632	4713307

10_{157}		10
9088304	5945784	6801123
911696	6231887	8722046
3649600	3453741	1277954
8976111	4078586	7748393
4583810	9999997	3714374
7364116	2136005	4742120
4727853	9155516	8537555
5085855	763739	8257098
6831355	7398006	3402361
3336217	3	5321291

10_{158}		10
5475661	8457652	3686775
2955202	1284356	8418854
7897422	3	1061792
7312190	7059086	6541602
473335	1886745	3957339
9143953	4047585	4551149
2577960	9999997	5838781
3728446	1123221	5554718
6488142	9571521	4453914
9526665	2439905	8938208

10_{159}		10
913662	3637285	7601996
9086338	5200983	7660311
3795382	3146505	1575405
2262164	9999997	6038595
6708799	3383682	8424595
6413356	9282264	2562801
6555660	1100775	4074145
4585657	8098016	8123698
4614041	3	6209916
7924813	7602256	5512989

10_{160}		10
8017892	8758450	5199031
452736	3413966	5038131
6462445	9810845	8001964
6570835	2995750	1727914
3	7908884	6029804
4886807	189155	4498164
3846996	9390131	4784193
9999997	2899420	7199195
4532419	7766649	1521462
2674307	1938485	8478538

10_{161}		10
2312614	9600936	7732892
3161443	2023903	2249503
7791756	9981623	4102713
6613436	728349	3012777
6113688	9999997	4422129
5977723	1561299	8541519
5683474	8845409	2620824
8018931	3	4743066
541831	4637240	1458481
9458169	7536620	1998859

10_{162}		10
3326645	2910636	1583650
7473833	4115481	6870973
5476380	9999997	4044446
1659607	4459856	5204485
8340393	5863302	5140860
4887942	3	4585056
3263166	6138754	2078574
1806293	4061081	8416350
6534810	2879745	3635955
3254674	8626440	5316077

10_{163}		10
7268529	6948556	7433328
2781943	940009	3865721
9865974	3166848	7582925
3330136	8238035	6857799
2662508	3	7663412
5471771	3841433	858166
5876429	4262154	9141834
1888703	9999997	4654617
6565554	3435334	2656574
134026	2720553	7860847

10_{164}		11
4877615	3	3228708
3890518	6595252	9207336
4808150	9522183	792664
1927693	3685218	6944776
7889361	9999997	9135152
1589055	8315075	2996517
9321515	5092293	6164860
1803938	9913535	6841113
4120905	1265416	6601610
9348208	7712597	3236373
651792	7599348	5375341

10_{165}		10
2812261	5821472	2562273
8214541	3871331	7623489
3897440	96016	2552669
2106413	7102078	5064820
5405838	221137	4456523
7645550	7375742	2907686
1785459	2863233	4882572
3796699	9999997	6786540
7598074	5029607	2376511
4492663	3	7240983

Table 2. Minimal stick representatives and candidates. This table contains conformations for the seven knots that we found to have stick numbers lower than their equilateral stick numbers. The first line of each entry indicates the knot type and the provisional stick number, $stick_p(K)$, for that knot. A $\star$ indicates that the value shown is known from theoretical studies to be the actual stick number $stick(K)$.

8_{19}	not eq	$8\star$
6029799	3	8433120
6060406	9999997	1573848
3607	3960221	8429939
9996393	3960220	1567031
3959880	9985379	8454178
3958382	25418	1544761
9987385	6027133	8455239
23091	6063673	1554457

9_{29}	not eq	9
4772110	1775158	8720545
5803984	7854373	956331
1226643	3621876	6959139
8952420	1413283	1287424
1351643	9999997	5035078
5921328	4775625	4913828
1047580	3	3885235
8428201	7844842	9043669
1828674	6341874	2009924

10_{16}	not eq	11
7217186	3	4760156
9025310	1727814	3970782
974690	1907658	2188908
8010936	8863748	4470469
3951251	6021718	7224842
6597499	1071877	1807033
8820466	1591721	5625625
3061251	5520937	3413751
5138125	5382031	2402189
3745626	3655782	8192967
7449686	9999997	2811251

10_{79}	not eq	11
4490625	9999997	7408827
1911564	3287501	2527736
2955939	5009687	7402420
5016562	4921563	6412109
4010626	6243749	3099298
1119846	3320001	7472264
8880154	8023123	4736485
1133596	9962810	6956014
5784062	4663750	5085078
1258440	7042968	3349142
5312656	3	7140702

10_{107}	not eq	10
7611873	8435154	3388751
5616406	3920157	8202186
5850312	3815938	1797814
7874686	5414531	7013280
2433127	4385938	4708594
3589063	6340468	5090000
7877030	3	5785625
6212968	9999997	6409062
7032030	4094219	3425626
2122970	4182657	5488906

10_{119}	not eq	10
4726094	5242344	2821251
8290779	4709375	6304374
6274530	2419689	7150467
4679844	6726561	2107970
3940001	6962811	7892030
9554060	4217188	4387188
445940	5513281	5927187
9176091	9999997	6378749
5626093	3	6290780
4684531	9091404	6792030

10_{147}	not eq	10
7404452	3	4684297
4363047	8777810	4535860
4258360	4076719	6405390
6131484	3652032	4211797
6343359	4652344	4856641
2595548	1942189	5224140
6445546	9999997	5205547
4393516	3740313	3161954
5239140	3817344	6838046
3522423	4758906	4168829

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