The CSR Function

\[ A = \sqrt{a_1 + \sqrt{a_2 + \sqrt{a_3 + \sqrt{a_4 + \sqrt{a_5 + \sqrt{a_6 + \sqrt{a_7 + \ldots}}}}}}}, \]

The function \(A\), named CSR for "continued square root," is most interesting.

If the successive \(a\)'s are:

\[ A_{28387} \quad 1, 5, 11, 19, 29, 41, 55, 71, 89, 109, 131, \ldots \]

(successive differences are 4, 6, 8, 10, \ldots)

the CSR converges to precisely 2.

But if the \(a\)'s are the factorials:

\[ A_{142} \quad 1, 2, 6, 24, 120, 720, 5040, 40320, 362880, \ldots \]

(which are vastly larger)

the CSR converges to the following (computed by Dorothy Cady):

\[ A_{99876} \quad 1.82701 \quad 47176 \quad 08592 \quad 22637 \quad 38431 \quad 92852 \quad 89247 \quad 37479 \quad 36296 \quad 08254 \quad 85442 \quad 61624 \quad 62956 \quad 21001 \quad 52387 \quad 09672 \quad 78310 \quad 72441 \quad 66143 \quad 0554 \]

This is fun. If the \(a\)'s are all one, the series converges to the Golden Mean, \((1 + \sqrt{5})/2\).

Other values to try for the \(a\)'s are the following:

A) Consecutive integers starting with 1.
B) Consecutive odd integers starting with 1.
C) Consecutive even integers starting with 2.
D) Fibonacci numbers: 1, 1, 2, 3, 5, 8, 13, \ldots
E) Squares, cubes, and higher powers.
F) Prime numbers, starting with 2.
Herman P. Robinson has shown that the a's can be chosen to converge to any positive number, if both negative and positive terms are used, and that there are infinitely many ways in which this can be done for any number desired. To produce the integer A, one method could be:

\[
a_1 = 1
\]

\[
a_n = (A^2 + (n - 2)K - 1)(A^2 + (n - 2)K - 2) - K
\]

with K arbitrary

For \( A = 2, K = 1 \), we have the sequence given above (at \( \beta \)) that converges to exactly 2. For \( A = 2, K = 5 \), the sequence of a's is the following:

1, 1, 51, 151, 301, 501, 751, 1051, 1401, 1801, ...

The sequence of a's can be made to converge to irrational (or transcendental) numbers, and even have various constraints applied to its values. For example, the following sequence contains only prime numbers and converges to \( \pi \):

5, 17, 37, 53, 131, 181, 263

317, 859, 887, 1637, 2837, 3413, 5861

6491, 10531, 13399, 14083, 14563, 21433, 29717 ...

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