HADAMARD MATRICES OF ORDERS 116 AND 232

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A Hadamard matrix $H$ is a square matrix of ones and minus ones whose row (and hence column) vectors are orthogonal. The order $n$ of a Hadamard matrix is necessarily 1, 2 or $4t$, for some positive integer $t$. It has been conjectured that this condition ($n=1, 2$ or $4t$) also insures the existence of a Hadamard matrix. Constructions have been given for particular values of $n$ and even for various infinite classes of values. While other constructions exist, those given in (2) and the references of (1) exhaust the previously known values of $n$. In this note we construct a Hadamard matrix of order 116, the smallest unsolved case. Taking the tensor product of this matrix with the Hadamard matrix of order 2 yields a Hadamard matrix of order 232, also previously unsolved. This leaves $n=188$ as the only unknown case less than 200.

The matrix of order 116 is of the Williamson type, i.e.

$$
H = \begin{pmatrix}
A & B & C & D \\
-B & A & -D & C \\
-C & D & A & -B \\
-D & -C & B & A
\end{pmatrix}
$$

where each of $A, B, C, D$ is a symmetric circulant of order 29. We specify the first rows below (here + stands for $+1$ and $-$ for $-1$).

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
$A = + + - - - - - + - + + + - - + - + - + - + - - - + - - - - +$ \\
$B = + + + + + + + - - - - + + + - + - - - + + - + - + - + - + +$ \\
$C = + + - - - - - + - - + + - - - - - + + + - - - - + - + - - +$ \\
$D = - - + - - + + + - + - + + + + + + + + - - - - - - - - +$ \\

REFERENCES


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