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Supercharging the 'Unreal' construction for Hadamard and Generalized Hadamard matrices

Over 40 years ago Turyn showed how Hadamard matrices can be derived from "complex Hadamard matrices", which may be described as (Butson-)generalized Hadamard (BH) matrices over the 4th roots of unity. In 2008, de Launey and I introduced a surprising variant in which BH's over the 6th roots of unity give (ordinary) Hadamard matrices, as long as they are "unreal"—that is, they contain no real entries. The question naturally arises as to which kinds of BH lend themselves to a similar construction, and under what constraints. It was easy enough to generate appropriate conditions, but quite another thing to find the necessary raw ingredients to make such a construction work. What we did not know at the time was that only a year earlier a bit of deft work with group representations and field theory provided just what was needed...