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Cyclic partitions of complete and almost complete uniform hypergraphs

We consider cyclic partitions of the complete k -uniform hypergraph on a finite set V , minus a set of s edges, $s \geq 0$. An s -almost t -complementary k -hypergraph is a k -uniform hypergraph with vertex set V and edge set E for which there exists a permutation $\theta \in \text{Sym}(V)$ such that the sets $E, E^\theta, E^{\theta^2}, \dots, E^{\theta^{t-1}}$ partition the set of all k -subsets of V minus a set of s edges. Such a permutation θ is called an s -almost (t, k) -complementing permutation. The s -almost t -complementary k -hypergraphs are a natural generalization of the almost self-complementary graphs which were previously studied by Clapham, Kamble et al, and Wojda. We prove the existence of an s -almost p -complementary k -hypergraph of order n , where p is prime, $s = \prod_{i \geq 0} \binom{n_i}{k_i}$, and n_i and k_i are the entries in the base- p representations of n and k , respectively. This existence result yields a combinatorial proof of Lucas' classic 1878 theorem.