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On Ramanujan derangement graphs arising from linear groups of degree two

Let X be a connected non-bipartite k-regular graph on n vertices with eigenvalues $\lambda_1 > \lambda_2 \geq \ldots \geq \lambda_n$, and let $\lambda(X) := \max\{|\lambda_2|, |\lambda_n|\}$. The graph X is called a Ramanujan graph if $\lambda(X) \leq 2\sqrt{k-1}$.

Given a finite transitive group $G \leq \mathrm{Sym}(\Omega)$, the derangement graph Γ_G is the graph whose vertex set is G, and two elements g and h of G are adjacent if hg^{-1} is a derangement, that is, a fixed-point-free permutation. In this talk, we will show that Γ_G is a Ramanujan graph for every subgroup $\mathrm{SL}_2(\mathbb{F}_q) \trianglelefteq G \leq \mathrm{GL}_2(\mathbb{F}_q)$ acting transitively on the non-zero vectors of $\mathbb{F}_q^2$ such that $[\mathrm{GL}_2(q) : G]$ is odd.

This is based on joint work with Roghayeh Maleki.