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Many flows in the group connectivity setting

Two well-known results in the world of nowhere-zero flows are Jaeger's 4-flow theorem asserting that every 4-edge-connected graph has a nowhere-zero $Z_2 \times Z_2$-flow and Seymour's 6-flow theorem asserting that every 2-edge-connected graph has a nowhere-zero Z_6-flow. These results were extended by Dvorak et al., proving the existence of exponentially many nowhere-zero flows under the same assumptions. We revisit this setting and provide extensions and simpler proofs of these results.

The concept of a nowhere-zero flow was extended in a significant paper of Jaeger, Linial, Payan, and Tarsi to a choosability-type setting. For a fixed abelian group Γ, an oriented graph $G = (V, E)$ is called Γ-*connected* if for every function $f : E \to \Gamma$ there is a flow $\phi : E \to \Gamma$ with $\phi(e) \neq f(e)$ for every $e \in E$ (note that taking $f = 0$ forces ϕ to be nowhere-zero). Jaeger et al. proved that every oriented 3-edge-connected graph is Γ-connected whenever $|\Gamma| \geq 6$. We prove that there are exponentially many solutions whenever $|\Gamma| \geq 8$. For the group Z_6 we prove that for every oriented 3-edge-connected $G = (V, E)$ with $\ell = |E| - |V| \geq 11$ and every $f : E \to Z_6$, there are at least $2^{\sqrt{\ell}/\log \ell}$ flows ϕ with $\phi(e) \neq f(e)$ for every $e \in E$.

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