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Spectral gaps for higher Laplacians and group cohomology

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I will focus on the cohomology of finitely presented groups. I plan to investigate two conditions concerning it: vanishing and reducibility (for all unitary representations). These conditions are related to Kazhdan's property (T): vanishing and reducibility coincide in degree one and are equivalent to this property. It is already known, due to the work of Dymara and Januszkiewicz, that this does not hold in higher cohomology. However, In 2020, Bader and Nowak gave a sufficient condition for vanishing and reducibility in two consecutive degrees. This condition translates these cohomological questions to the existence of a certain spectral gap of a Jacobian matrix, defined in the language of group rings. We were able to prove the existence of such a spectral gap for $SL(3, \mathbb{Z})$, the special linear group of degree three. It was already known that this group does have property (T). The question of reducibility of the second cohomology remained opened, however. The existence of such spectral gap proves the reducibility. The key new tool we applied to prove this existence is the Fox calculus which can be used to compute group cohomology in lower degrees. I also comment on an application of the spectral gap for $SL(3, \mathbb{Z})$ to expanders. This is the joint work with Marek Kaluba and Piotr Nowak (arxiv.org/abs/2207.02783).

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