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Can we detect (Di)Graphical Regular Representations easily?

Graphical and Digraphical Regular Representations (GRRs and DRRs) are a concrete way to visualise the regular action of a group, using (di)graphs. More precisely, a GRR or DRR on the group G is a (di)graph whose automorphism group is isomorphic to the regular action of G on itself by right-multiplication.

For a (di)graph to be a DRR or GRR on G, it must be a Cayley (di)graph on G. Whenever the group G admits an automorphism that fixes the connection set of the Cayley (di)graph setwise, this induces a nontrivial graph automorphism that fixes the identity vertex, which means that the (di)graph is not a DRR or GRR. Checking whether or not there is any group automorphism that fixes a particular connection set can be done very quickly and easily compared with checking whether or not any nontrivial graph automorphism fixes some vertex, so it would be nice to know if there are circumstances under which the simpler test is enough to guarantee whether or not the Cayley graph is a GRR or DRR. I will present a number of results on this question.

This is based on joint work with Dave Morris and with Gabriel Verret.