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A review of the doctoral thesis:

Treewidth, Extended Formulations of CSP and MSO Polytopes, and Their Algorithmic Applications by Martin Koutecky

Summary of My Review.

The thesis achieves a number of original and substantial results that establish that the author has the ability for creative scientific work commensurate with the awarding of the Ph.D. degree.

Justification.

The results achieved in the thesis can be summarized as follows, in order of their importance, in my opinion:

(1) The investigation of novel extensions to MSO logic, completely classifying the parame-terized complexity of these extensions with respect to the parameters treewidth and neigh-borhood diversity.

• Monadic Second Order (MSO) logic is an important standard tool in the study of algorithms and complexity, for structural parameters of graphs such as treewidth and cliquewidth (where first order logic is the key). Key reference points are Courcelle's Theorem (for MSO decision problems for bounded treewidth, and the closely related seminal work on MSO optimization problems for bounded treewidth of Borie, Parker and Tovey. Looking for extensions of MSO logic is entirely natural, and the whole area of structural parameterizations and logic-based metatheorems is currently of intense interest, with a steady stream of international workshops (such as GROW) and conference special sessions devoted to the topic. The thesis achieves substantial results, both upper bounds and lower bounds.

• Results in this area may be becoming of high practical significance, even though for several decades results employing Courcelle's Theorem were really only of theoretical interest. The reason for the shift is that highly engineered solvers for problems such as CSP and SAT have become remarkably effective in practice, and this really changes the game, as noted in the recent work of Stefan Szeider and his PhD students in Vienna.

(2) Substantial contributions in the study of polytopes which is a subject concerned with the complexity of logical description for optimization problems. Lower bound results in this area are unconditional, that is, not dependent on hypotheses in computational complexity. Before the results in the thesis, there were a number of notable gaps in this literature. The thesis has contributed to filling in our gaps in understanding the complexity of these polytopes, based on some novel structural studies about glued products of polyhedra. The technical tools introduced in the thesis are interesting, and likely to be important in further developments concerning this topic.

• I am not an expert on this subject and cannot say what practical results these results in the thesis may lead to. The methods may extend two other logics, such as modal logics.

(3) The area of *shifted combinatorial optimization* was recently introduced by Prof. Shmuel Onn of The Technion in Israel, where Martin Koutecky has been offered a year of postdoctoral support. The thesis achieves some of the first results in this new area, including for a number of quite practical optimization problems. This is a good start. Personally, I have great enthusiasm for the recent work of Professor Onn, which I know about from a month-long visit to The Technion a few years ago. This led to some email correspondence beginning more than a year ago between myself and Martin. He recently visited Bergen, and through our conversations during his visit, I am much impressed with his scholarship, achievements, and potential, as testified to in this well-written thesis (and other recent papers that are not reported here).

Sincerely,

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