the domain, and the 2nd-4th columns indicate the number of agents, the number of sensing actions and deterministic actions, and the modal depth, respectively. In the last two columns, $A - B(X/Y)$ denotes A seconds of total time, B seconds of search time, X depth of the solution tree, and Y nodes explored during search. N/A denotes that the instance is unsolvable within the allotted time $(1000\,\text{s})$.

The experimental results show that our planner outperforms MEPK in three aspects. Firstly, from the aspect of the total time, MEPL performs much better than MEPK for most instances, especially when the size of the instances grows. Also, MEPL can solve some instances that MEPK cannot within the allocated time. It's reasonable due to the more space efficient normal forms and the more efficient reasoning and progression algorithm. Secondly, for all instances, the number of nodes explored by MEPL is less than that explored by MEPK, which shows the viability of our heuristic function and pruning strategies. Finally, the preprocessing of MEPL is much faster than that of MEPK in a way that MEPL can complete the preprocessing within $1\,\text{s}$ while MEPK may take more than $100\,\text{s}$ in some domains like SC. It's reasonable too since MEPL doesn't need to transform a random formula into an ACDF. In conclusion, MEPL outperforms MEPK in most instances, and solves some instances that MEPK cannot solve, which means that MEPL can handle larger instances, i.e., scales better.

6   Conclusions

In this paper, we have proposed two improvements, which are based on higher-order belief change and heuristic search, for the multi-agent epistemic planner MEPK. Firstly, we exploited alternating disjunctive normal form (ADNF) for multi-agent KD45, which is more space efficient than the normal form used by MEPK and also saves time in compilation, and proposed efficient reasoning, revision, and update algorithms for it. Secondly, we proposed a heuristic function for multi-agent epistemic planning based on the distance between ADNFs, and as the planning algorithm, we applied heuristic research AO* with cycle checking and two heuristic pruning strategies. We have implemented a multi-agent epistemic planner MEPL, which outperformed MEPK in most planning instances, and solved a number of instances that MEPK cannot solve. Like MEPK, MEPL can handle propositional common knowledge, called constraints. Nonetheless, MEPL does not handle complex constraints well. In the future, we are interested in overcoming this limitation and further dealing with general common knowledge.