Farhad Babaee, Lecturer
School of Mathematics,
University of Bristol
Fry Building, 2.13
Woodland Road
BRISTOL, BS8 1UG

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To whom it may concern,

It's my pleasure to recommend **Dr Jack Southgate**'s application for the Heilbronn Research Fellowship position at the University of Bristol.

My acquaintance with Jack began when he contacted me in May 2019 regarding a Master's project on toric and tropical geometry. We decided that the project should include reading the background material to understand the Chow cohomology groups of toric varieties and, depending on the progress, considering some research problems on the topic. Throughout his project, Jack demonstrated the ability to grasp complex concepts in algebraic geometry and tropical geometry, despite time constraints.

The following year, Jack started his PhD under the supervision of Dr Louis Theran at the University of St Andrews in September 2020. I met Louis in the summer of 2023 who expressed his contentment with Jack's progress throughout his PhD as well as his interpersonal and communication capabilities. During his PhD, Jack produced two interesting solo articles on Rigidity Theory. Roughly speaking, rigidity theory concerns classes of graphs that are resistant to certain group actions when they are embedded in $\mathbb{R}^d$. Usually a graph with a fixed embedding is called a framework. Therefore, there are many notions of rigidity with various applications.

Jack's research during his PhD was mainly concerned with volume rigidity and rigidity of hypergraphs under different geometric constraints. In his first article, Jack studied the geometry of certain spaces associated with the volume measurement map to determine the non-genericity of global volume rigidity. Jack has also been using methods from combinatorial algebraic geometry to study volume rigidity.

Dr Southgate is currently completing a short-term postdoctoral position at Brown University, and his current projects involve

- Realisation numbers of g-rigid frameworks. This project is related to his arxiv paper on volume rigidity on which he collaborates with Dr Sean Dewar (Heilbronn Fellow at Bristol), and Dr Ben Smith (Research fellow at Lancaster and a former Heilbronn Fellow), among others.
- Incidentally symmetric flexible frameworks. Such frameworks constitute examples of frameworks in $\mathbb{R}^d$ that we expect to be rigid, but they are flexible due to symmetry between their vertices and edges. Jack and his collaborators plan to generalise this notion in view of Jack's previous work on volume rigidity.
- Necessary conditions for g-rigidity arising from algebraic shifting. Using Gil Kalai's work on algebraic shifting, Jack looks to find necessary conditions for g-rigidity. This work relates to matroid theory and in particular algebraic matroids, which are currently one of the hottest topics in combinatorial algebraic geometry.

I have discussed various topics with Jack on many occasions, and he also gave a presentation to my group in Bristol in July 2023. I was impressed by the incorporation of diverse elements from matroid theory, polytope theory, and combinatorial algebraic geometry in his articles. I believe that given Jack's background, enthusiasm, and interpersonal skills, he would be a valuable addition to the mathematical community in our department. Furthermore, his problem-solving abilities align well with the diverse aspects of a Heilbronn Fellowship. Consequently, I strongly support Jack Southgate's application for this fellowship.

Should you have any further questions please do not hesitate to contact me.

Sincerely,
Farhad Babaee