Thermal metamaterials: The future of electronics

TakeAIM 2021 – 2nd Place

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The Smith Institute, enabled by the generous sponsorship of our leading corporate partners, ran the TakeAIM competition in 2021 to make visible the crucial role that mathematics will increasingly play in all aspects of our lives. The competition, also celebrating its 11th anniversary this year, was open to undergraduate and postgraduate students working in the mathematical sciences. The first-place prize was £1000, the two second-place prizes were £500, and the two third-place prizes were £250.

Designing thermal management devices for effective heat removal from electronics proves a significant challenge for engineers. Whether it's our laptops overheating or our phone batteries cutting out at 30%, we're always left feeling frustrated and looking for our next upgrades, but what happens to our old devices? Well, according to the e-waste research organisation Material Focus, UK households sent 155,000 tonnes of e-waste to landfills in 2017. This obviously has a huge impact on the environment and so, if the life of our electronics could be extended somehow, we would reduce both the hazardous e-waste piling into landfills and the energy needed to build, package and transport new devices – all whilst saving ourselves some money along the way!

So how can mathematics help? Well, in our research we use transformation-based techniques to design new and exciting materials, referred to as thermal metamaterials. These metamaterials control and manipulate heat transfer in some beneficial way. For example, our research focuses on heat spreader designs that help to extend the lifetime of electronic devices by avoiding the formation of hotspots and protecting temperature-sensitive components.

Metamaterials pave the way for future thermal management and energy harvesting applications. We extend existing work in this area by considering the interfacial effects that can dominate in these complex, multi-layered designs. These insights help to determine more realistic material properties and achieve more accurate results.