Take AIM

Smith institute
for industrial mathematics and system engineering

Modelling the next generation of batteries

TakeAIM Winner 2017:
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What feature do many modern gadgets have in common? No, not the ability to play videos of cats – they're powered by lithium-ion batteries!

From handheld devices to electric cars, lithium-ion batteries cater to a variety of products. They boast many strengths including a high energy density, a low self-discharge, and low maintenance. Yet many smartphone owners still reach for their chargers before the end of the day, as the cost of providing higher capacity batteries at a convenient size is a huge challenge for manufacturers.

One option is to replace the lithium component with a more attractive alternative. Sodium is cheaper, more readily available, and more environmentally friendly than lithium. However, charging a sodium-ion battery presents a more complicated chemical process, and whereas lithium-ion batteries work with a graphite electrode, sodium-ion batteries require a different electrode material in order to be rechargeable. Hard carbon is a promising electrode candidate, and mathematical modelling provides a useful tool to optimise its potential.

My research focuses on the charge-discharge cycle of sodium-ion batteries. Modelling the movement of sodium inside hard carbon particles offers insight into the microscopic level behaviour otherwise inaccessible to practical experimentation. Current battery charge rate and capacity limitations can be better understood, improvements can be trialled virtually before conducting costly experiments, and different hard carbon prototypes can be ranked according to their numerical parameters. This mathematical approach saves time and resources, and hence helps to efficiently develop the next generation of batteries.

The Smith Institute, enabled by the generous sponsorship of our leading corporate partners, ran the TakeAIM competition in 2017 to make visible the crucial role that mathematics will increasingly play in all aspects of our lives. The competition was open to undergraduate and postgraduate students working in the mathematical sciences. First prize was £1,250 of Apple vouchers, second prize £500 of Apple vouchers and six runners-up each received £150 of Amazon vouchers.