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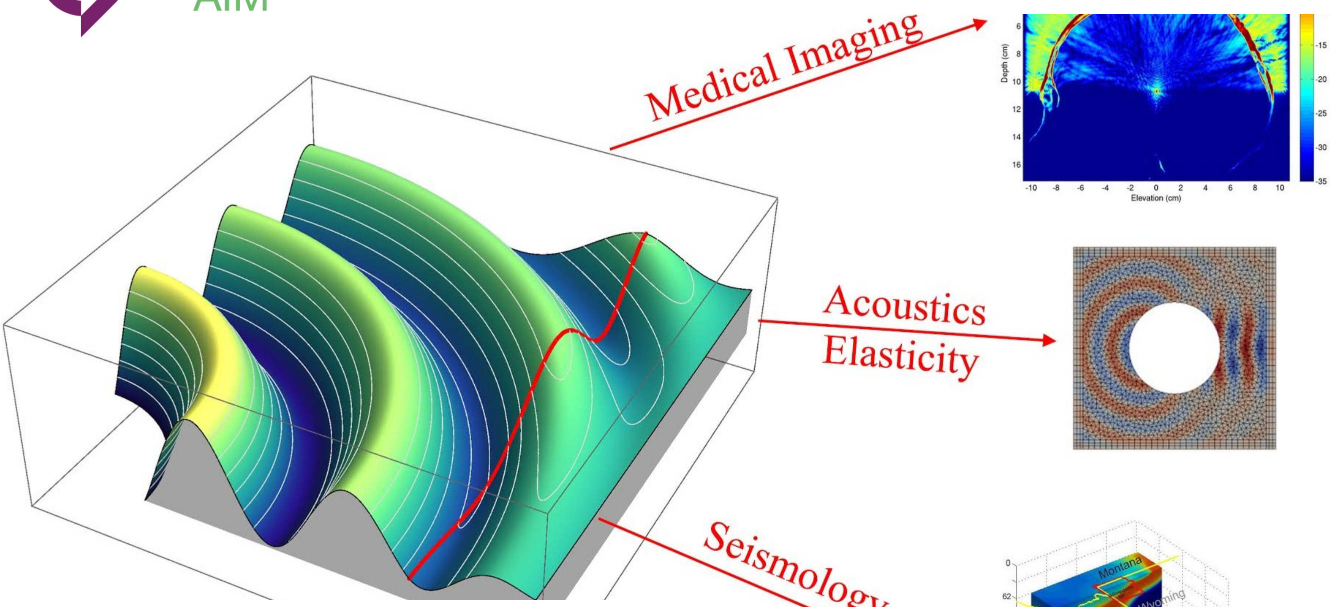

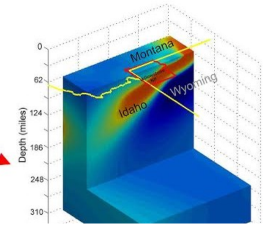

Perfectly matched layers: the right way to catch a wave

TakeAIM Winner 2015:
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A devastating earthquake has just hit one side of the world! Whilst on the other an improved non-invasive ultrasound treatment for cancer has been announced. What do these scenarios have in common? Waves! Wave propagation lies at the heart of many of the phenomena we encounter on a daily basis. Scientific progress in this direction underlies important discoveries in many fields such as electromagnetism, acoustics, seismology, material sciences and medicine, with a direct impact on our everyday lives.

In many industrial contexts complicated geometries, heterogeneous media and small wavelengths translate into extremely difficult systems, often ruining the simplicity and elegance of the mathematics. Theoretical solutions exist in infinite domains, but in practical situations these are most often inapplicable. For many decades increasingly complicated boundary conditions were introduced to handle the infinite in the computationally finite. This search was ended when the computational domain was instead surrounded by the so-called perfectly matched layers (PMLs).

There is of course a catch. In these layers we still need to solve the underlying wave equation which might become computationally expensive, especially in realistic scenarios. In addition to this, there are many parameters inside the PMLs that require optimisation. Our research focuses on eliminating these drawbacks completely. We proposed an adaptive technique that produces extremely accurate results and requires minimal computational effort. The developed method also retains generality at the level of numerical treatment, thus making it an ideal candidate for many of the fascinating questions and applications that are based on wave propagation theory.

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The use of mathematics has profound consequences in all walks of life, but the opportunities that it opens up often go unrecognised or underexploited. The Smith Institute, enabled by the generous sponsorship of our leading corporate partners, ran the fifth annual TakeAIM competition in 2015 to make visible the crucial role that mathematics will increasingly play in all aspects of our lives. The competition was open to all undergraduate and postgraduate students working in the mathematical sciences. The authors of the two best entries each received £1,000 of Apple vouchers as their prize, with £100 of Amazon vouchers being awarded to four runners-up.