Magnetolectric phenomena and devices

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In 1600, William Gilbert of Colchester published the standard treatise on the difference between magnetism and electricity. He died a few years later, and his analysis was the canon of European thinking on the subject for 300 years. In 1894, Pierre Curie suggested that electricity and magnetism might be coupled in materials, but theoretical and experimental validation only came at the end of the 1950s. Roughly half a century has now passed since the discovery of the magnetolectric effect, but it is only in the past decade that there has been an explosion of research activity. It was therefore timely to meet, summarize the state of play, discuss recent developments and propose future applications.

The Royal Society Discussion Meeting held in London treated multiferroics as well as magnetoelectrics, by drawing on interdisciplinary expertise in magnetism and ferroelectricity. Although there are parallels between magnetism and ferroelectricity, there are also significant differences. For example, ferroelectrics must be electrically insulating, whereas ferromagnets tend to be metallic. In another example, magnetism may be measured by detecting stray fields, whereas ferroelectric measurements typically involve electrodes, and therefore the sample is part of a more complex system. The related strands of magnetism and ferroelectricity are therefore complementary, and their joint study in the meeting represented a good opportunity for cross-comparison.

The terms ‘multiferroic’ and ‘magnetoelectric’ have distinct meanings, but, in practice, they have stubbornly become somewhat inseparable. Multiferroic materials possess more than one type of ferroic or antiferroic order, for example, ferromagnetism and ferroelectricity. Magnetolectric coupling between magnetic and electrical order can arise in single-phase multiferroic materials, or two juxtaposed materials that might even show no ferroic ground states at all. Materials and their combinations may be magnetolectric but not multiferroic, multiferroic but not magnetolectric, or both magnetolectric and multiferroic.

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The presentations on magnetoelectric and multiferroic materials included theoretical treatments, and work on bulk samples, thin films and devices. Each of these subfields could have filled the entire meeting. We were therefore delighted to welcome an entirely fresh set of speakers to the subsequent Satellite Meeting on ‘Magnetoelectrics at the mesoscale’. This was held at the Kavli Royal Society International Centre in Chicheley Hall, a stately home set in the beautiful Buckinghamshire countryside. We are grateful to the Royal Society for its tremendous financial and administrative support. Both meetings were characterized by friendly and free-flowing discussion, demonstrating scientific exchange at its best.