

## *Scientific report*

### **Spin-orbit interaction of light and matter waves**

In quantum theory spin-orbit interaction describes any coupling of the spin of a particle with its motion. For central fields this coupling is proportional to the product of spin and orbital angular momentum. Whereas many effects based on this coupling are hard to detect directly for particles, light beams with angular momentum offer a highly controllable and accessible system. Intriguingly, the angular momentum of light also has a spin and orbital part, and we can therefore expect a spin-orbit interaction for light. In addition, the recent creation of electron vortex beam offers another avenue of investigation, extending the topic of the workshop to relativistic particles with mass. The aim of this workshop was to bring together the experts on spin-orbit coupling in light and matter waves together with world leading researchers in optics and condensed matter physics to explore novel concepts in this field.

The session were organized around six main themes: spin-orbit conversion in optical materials, electron vortex beams, optical helicity, quantum weak measurements, spin-orbit coupling in condensed matter, and atomic systems. The colloquium by Erez Hasman (Technion and Stanford) on spinoptics offered many exciting analogies to condensed matter systems, such as optical realisations of spin-Hall effect and Rashba or Dresselhaus interactions. It culminated in the demonstration of coherent and spin-dependent thermal emission from nanoscale structures.

Through a series of outstanding talks by Etienne Brasselet (Bordeaux), ByoungHo Lee (Seoul), Natalia Litchinitser (Buffalo) and Aristide Dogariu (CREOL) other aspects of material based spin-orbit coupling were explored on the first day. Mohamed Babiker (York) and Lorenzo Marrucci (Naples) drew on analogies between optical and electron vortices, while Jo Verbeeck (Antwerp), Jun Yuan (York) and Ebrahim Karimi presented the experimental and theoretical advances in manipulating the angular momenta of electrons in microscopes. The subtleties of optical helicity and duality transforms are crucial for a complete understanding of momenta in all fields and were introduced in talks from Steve Barnett (Glasgow), Kostya Bliokh (RIKEN), Gabriel Molina-Terriza (Macquarie) and Gerard Nienhuis (Leiden). David Andrews (University of East Anglia) gave a very lucid talk that the angular momentum of the light is not readily translated into its atomic counterpart. Spin-orbit coupling in optical beam shifts and its connection to the Abraham-Minkowski dilemma, spatial coherence, and quantum weak measurements were brought to the audience respectively by invited talks from Vladimir Fedoseyev (Tartu), Marco Ornigotti (MPI for the Science of Light) and Mark Dennis (Bristol). The talk by Iwo Bialynicki-Birula (Warsaw) touched on many aspects of the workshop simultaneously, including the underlying geometry of spin-orbit coupling as well as some important differences between electrons and photons. Maarten de Kievit (Heidelberg) and Klaus Morawetz introduced a new theme by talking about spin-orbit coupling in atomic and condensed matter systems, which was continued by Sonja Franke-Arnold (Glasgow) and Manuel Valiente (Heriot-Watt). The workshop closed with a theme on focal properties of optical angular momentum with talks by Pepijn Pinkse (Twente) on spin-orbit coupling of focussed field in resonators, as well as surface and transverse angular momentum by Andrea Aiello and Peter Banzer (both MPI for the Science of Light). The final talk

was given by Miles Padgett (Glasgow) on the transfer of angular momentum to light by spinning disks.

Five promising young postdocs gave invited talks, and five shorter talks were presented by excellent PhD students. The session of 3-4 minute talks to introduce the posters on the first day was a formidable icebreaker and helped in integrating the younger participants into the more senior audience. As a result, the two poster sessions with 20 posters were very lively and lasted well into the night.

Spin orbit interaction for light and matter waves is an emerging field and this workshop came at a crucial moment in its development, perfect for taking take stock and reviewing the progress by relating it to established strands of research in optics and condensed matter physics.

In short the workshop was complete success. The scientific and social programme was extremely well received by the participants, with many attendees taking home new insight and ideas. We would like to thank the MPI-PKS for allowing us to host this workshop and in particular Mandy Locher for the impeccable organisation. JBG also acknowledges support from the Royal Society for individual attendees.