From: Paul Attfield [mailto:j.p.attfield@ed.ac.uk]
Sent: 04 February 2013 13:31
To: EVANS I.
Subject: Re: PANalytical Theis prize 2013: Mark Senn

Dear Ivana,

I am writing to recommend Mr Mark Senn for the PANalytical Thesis prize. I have known Mark for four years as the supervisor of his PhD research. I can confirm that his thesis has recently been examined and approved.

Mark Senn is an outstanding young researcher. He is the most able of the ~25 doctoral students I have supervised. He quickly picked up a range of methods, from materials synthesis and experimental diffraction methods to computational symmetry analysis and electronic structure calculations, demonstrating real insight into all of these.

Mark Senn's studentship was funded as a 4-year project by EPSRC and STFC to undertake research on magnetic and electronic materials making use of national synchrotron and neutron radiation facilities. After surveying a range of problems, Mark chose to work on the most important and difficult one available - the Verwey structure of magnetite.

The presence of a complex low temperature structure and electronic order in magnetite (the original magnetic mineral, known for ~3,000 years) was first identified by Verwey, a Dutch scientist, in 1939. Gradual progress was made through numerous theoretical and experimental papers over subsequent decades, but the complexity and a physical limitation (microtwinning of domains within single crystals of magnetite) had prevented the full structure and hence a clear understanding of the Verwey state from being obtained. It became a canonical unsolved problem in the field of electronic solids.

Mark Senn worked with Jon Wright at ESRF to collect data from very small magnetite crystals, thereby circumventing the microtwinning problem. After two years of careful analysis and hard work he succeeded in solving the complete Verwey structure. This is a major scientific achievement in itself, but further analysis of the crystallographic information was required in order to understand the underlying electronic order. Mark quickly mastered modern techniques of symmetry (representation mode) analysis, and his interpretation of lattice and local distortion modes revealed the charge and orbital ordering, settling past debates about these orders. We had not previously made use of these methods in my group, so Mark's distortion mode analysis of magnetite and other materials is self-generated.

Most intriguingly, Mark Senn discovered that electrons in the Verwey state of magnetite are spread over three iron sites. A three-site solution had not been proposed over the previous 70 years of investigation, so this insight has proved particularly original and important. When I challenged him to devise a name for these objects he came up with 'trimeron' - a term that is already being accepted and used by the scientific community.

Mark Senn's solution of the Verwey problem was published in Nature in January 2012. While the two other authors (Jon Wright at ESRF and myself) also contributed, the credit for this work very much belongs to Mark - without his devoted efforts and brilliant insights over the last four years I believe that the Verwey problem would still be unsolved. Mark has already received two conference speaking invitations in the months since this work was published.

While most of his PhD work was devoted to magnetite, Mark Senn has also developed interests in related electronic oxides such as hexagonal perovskites, where his work has been published in PRL, (also one PRB manuscript is submitted and another is in preparation.) He has collaborated with other members of my group, contributing to the symmetry analysis of complex new oxygen-vacancy ordered perovskite materials for example.

Mark shows great potential for further original research over many years to come. I have no doubts that he will be a future leader in the field of electronic materials.

I am aware of the high standards and strong competition for the PANalytical Thesis prize, nevertheless I feel that Mark Senn is a truly outstanding candidate who has performed significant original research of very high impact in its field that is well-written up in his thesis, and I recommend him in the highest possible terms.

Sincerely,
Paul Attfield

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