FAST MOVING FRONTS - 2009

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Oleg V.Yazyev talks with *ScienceWatch.com* and answers a few questions about this month's Fast Moving Front in the field of Physics.

Article: Defect-induced magnetism in graphene
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SW: Why do you think your paper is highly cited?

Our work is at the intersection of two rapidly evolving fields—the science of graphene and also that of magnetism in carbon-based materials. Five years after the first isolation of graphene, this material has become a major research focal point in the field of physics.

And now graphene has also penetrated into the fields of chemistry, materials science, and the engineering disciplines. Magnetism in carbon-based materials and nanostructures is another rapidly evolving field of research with strong implications for spin-based information technology. These are the two main vectors which have stimulated attention toward our work.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

In our theoretical work, we proposed a novel mechanism of magnetic ordering in graphene induced by point defects. The work was motivated by the experimental observations of ferromagnetism in proton-irradiated graphite.

SW: Would you summarize the significance of your paper in layman's terms?

Magnetic materials constitute an essential part of modern technology. All magnetic materials used in current technology are based on the elements belonging to either the d- or the f-block of the periodic table. For instance, Fe, Co, and Ni (d-elements) are ferromagnetic at room temperature.

However, magnetic ordering at sufficiently high temperatures is not common for the lighter p-block elements such as carbon, despite the fact that this element is able to form an extraordinary number of different molecular structures.

Magnetic materials based on carbon are nevertheless considered to be very promising for technological applications as they may possess a number of attractive properties such as low density, low production costs, biocompatibility, etc. The long-awaited breakthrough in the field happened in 2003 when ferromagnetism with Curie temperature well above room temperature was observed in proton-irradiated graphite. This experimental finding has quickly attracted considerable attention from the scientific community.

"Our work may potentially lead to novel materials and devices to be used in this field of technology"

Our theoretical work explains the observed magnetic ordering in terms of the spin-polarization of the flat impurity band. This band is formed by the quasi-localized (QL) non-binding states induced by point defects formed upon irradiation.

These QL states are a unique feature of graphene—two-dimensional layers which form graphite upon stacking—and had first been observed in STM images of graphite some 20 years ago.

Proton-irradiated graphite is not considered of use for any technological applications. Nevertheless, understanding the origin of magnetism in this material will play an important part in the development of more practical magnetic materials and nanostructures which are based on carbon.

SW: How did you become involved in this research and were any particular problems encountered along the way?

The story behind this project is a bit unusual. In 2007, I was a chemistry graduate student at the Swiss Federal Institute of Technology in Lausanne, Switzerland (Ecole Polytechnique Fédérale de Lausanne, EPFL). My Ph.D. project, which was performed under the supervision of Professor Lothar Helm, my coauthor on the highlighted paper, was related to the theoretical investigation of magnetism in bioinorganic systems.

However, the emerging field of graphene had attracted my attention and so I decided to investigate. Initially, it was just a curiosity-driven project, but it had a great influence on my academic interests which then shifted from chemistry towards physics, materials science, and information technology.

SW: Where do you see your research leading in the future?

Currently, as a postdoctoral associate at the University of California, Berkeley, I continue my theoretical research in the field of graphene. However, my current interests go far beyond the problem of magnetism in graphene nanostructures. There are strong indications that graphene will become one of the core materials in future technology and I believe that it's worthwhile to continue working within this field.

SW: Do you foresee any social or political implications for your research?

No doubt, information technology plays a very important role in today's society. Our work may potentially lead to novel materials and devices to be used in this field of technology.

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