Researchers from Ukraine, France and England show that a fundamental theorem for phase transitions is violated on annealed scale-free networks.

Mariana Krasnytska

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--- Interview ---

Who are you?

We are:

- **Mariana Krasnytska**, co-tutelle PhD student at the Institute for Condensed Matter Physics (ICMP) of the National Academy of Sciences of Ukraine, Lviv, Ukraine and at the Statistical Physics Group, Université de Lorraine (UL), Nancy, France;
- **Bertrand Berche**, Professeur at UL,
- **Ralph Kenna**, Professor at the Applied Mathematics Research Centre, Coventry University, England;
- **Yurij Holovatch**, Professor at the ICMP.

We are each members of the *International Doctoral College for the Statistical Physics of Complex Systems, Leipzig-Lorraine-Lviv-Coventry* ($\mathbb{L}^4$). The college comprises the above three nodes in addition to the Institut für Theoretische Physik, Universität Leipzig, Germany. The principal goal of $\mathbb{L}^4$ is to facilitate collaboration between its four nodes in particular through co-supervision of PhD students.

What prompted you to pursue this field of research?

Phase transitions are important for many research areas where complex, cooperative phenomena emerge in many-body systems from simple rules applied at a microscopic level. While such phenomena occur in many areas, including biology, cosmology, economics, sociology and beyond, it is the field of statistical physics which offers quantitative explanations of the macroscopic universal behavior from a microscopic basis.

The four nodes of $\mathbb{L}^4$ are united by a common statistical-physics background, especially in the theory of critical phenomena and phase transitions. The Lorraine node has expertise on lattice spin models; the Lviv node is expert on scale-free networks; the Coventry node has experience in the Lee-Yang-Fisher formalism. The research was a natural marriage of these various elements and their successful combination shows the advantage of collaborative research such as promoted by $\mathbb{L}^4$.

What is this latest paper all about?

The Ising model is an old favourite of statistical physics, especially for the analysis of critical phenomena. While in previous years spins were usually considered on a lattice substrate, complex networks have come to the fore in recent years. Borrowing ideas from T.D. Lee, C.N. Yang as well as from M.E. Fisher, we decided to investigate such systems when the temperature and magnetic field are allowed to become complex. As a test, we first investigated complete graphs but our real objective was to examine the properties of such zeros on annealed scale-free networks.

In particular, we were interested in the status of an especially important theorem which is so important it has been called the *fundamental theory* of phase transitions. The theorem holds when the model is defined on a lattice and says that, in a certain parametrization, the Lee-Yang zeros of many models lie on a unit circle in complex magnetic field. The surprising result of our investigation is that this is not always the case when the lattice substrate is replaced by an annealed scale-free network. Thus the result is important to statistical physics at a fundamental level.

What do you plan to do next?

Our work opens up possibilities to apply the Lee-Yang-Fisher approach to analyse criticality on and of many other models defined on many other types of networks. It shows also that the area of critical phenomena, which is over 150 years old, continues to deliver interesting and surprising results and continues to be of profound significance to understanding our world.

Dear Ms Krasnytska,

Thank you very much again for your recent submission to Journal of Physics A: Mathematical and Theoretical, "Partition function zeros for the Ising model on complete graphs and on annealed scale-free networks". We feel the article will be of high interest to our readers and would like to draw further attention to it by making it our 'Publisher's pick'. You can find previous interviews online at http://iopscience.iop.org/1751-8121/page/Publishers-pick. In order to make your article our 'Publisher's pick?, we would very grateful if you could answer some interview questions for us. We will then feature this interview and photograph(s) of you and your coauthors on the Journal of Physics A home page, along with a link to your full text original research article. We would also be grateful if you could supply us with a strapline, one sentence summarising the main result of your work: this should be approximately 10-20 words long. Examples can be found on the Publisher?s pick home page (see above link).If you are happy to answer these interview questions, we would like to have your replies and photo(s) within the next few weeks. If this timing is a problem, please do not hesitate to let me know. I look forward to hearing from you.

Best Regards,
Eimear O'Callaghan
Dr Eimear O?Callaghan
Publishing Editor
Journal of Physics A: Mathematical and Theoretical