

Opinion

Reflections on the 66th Lindau Nobel Laureate Meeting

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Academic Editor: Antonio Bianconi

Received: 11 November 2016; Accepted: 14 December 2016; Published: 20 December 2016



Figure 1. This year, the 66th Lindau Nobel Laureate Meeting dedicated to physics attracted 30 Nobel Laureates (in the photo) and 400 selected young scientists from all over the world, mainly Ph.D. candidates and postdocs. Credit: Lindau Foundation.

This June, I was one of a group of young scientists sat in the whispering Theatre of Lindau—the place where everything began 65 years ago—when the lights dimmed and the opening ceremony started. I will never forget how, after being announced, the thirty Nobel Laureates stood up from their first-row seats and turned to us, probably smiling. In the half-shadows they looked more like the kings of the past, giants, and the surrounding silence was truly epic. I am not sure whether it was intended this way, but this was a unique moment: they appeared to be very friendly, open-minded, ready to discuss things, and share their personal experience and anecdotes. Such a striking contrast.

This year, the 66th Lindau Nobel Laureate Meeting was dedicated to physics. The selection process was very demanding, and the selection committee judged not only the conventional records—such as CV, publication list, and teaching record—but also “dedication to physics”. Looking back, I think what worked in my case is that I have published two single-author papers in *Physical Reviews* [1,2], I was 24 years old, and had a warm recommendation letter from Professor Rønnow. I think I spent a hundred hours writing and polishing my application for the two-step selection procedure. Was it worth it? Totally! I met, shook hands, and exchanged business cards with 29 Nobel Laureates in Physics and Chemistry, and Vinton Cerf, the creator of the Internet and recipient of the 2004 Turing Award.

To pay tribute to the organisers of the 66th Lindau Nobel Laureate Meeting, there was a very rich and diverse scientific program: lectures, panel discussions, a poster session, short talks, master classes, question and answer sessions, scientific breakfasts and much, much more on an informal basis—chatting with the peers over a cup of coffee or over dinner. I think the most moving and inspiring lecture was given by Stephan Hell [3], who was himself a theoretical physicist for many years. He had quit science due to the difficult circumstances, had become very depressed at his job as

an optical technician, and decided that the only way for him to survive was “to do something cool”. “Breaking the diffraction limit could be cool,” he said to us, smiling. And he did it. He received the Nobel Prize in Chemistry in 2014. I am preaching the same as Stephan Hell: you should do something cool.

An interesting part of the Lindau Meeting is the unofficial part: personal discussions, breakfast and dinner with peers, coffee breaks with lively discussions. On a frequent basis, someone would meet a Laureate in a corridor, start talking and spend the next two hours discussing a particular problem; actually, that is the way I missed some of the official afternoon events. Another morning, you can find yourself sitting between two laureates during breakfast. It is really interesting that these people are sharing their unique experience and lifestyle, and you start talking more confidently, and become more friendly and open. That is how the 66th Lindau Meeting is changing people, it is the way it has changed me.

I would say that it is not only due to the Laureates, but also due to the young scientists that this event is very useful. With such a diverse and smart climate, everyone wins: including us, the young scientists, by seeing how we can compete globally, what are our chances for future applications, and where we should pay more attention. Making friends and socializing is a pleasant bonus. Finally, there is a feeling of belonging to something unique, exciting and limitless that unites all of us. What Countess Bernadotte calls the “Lindau alumni”.

The 66th Lindau Nobel Laureate Meeting was very useful for meeting new people in my research field. For my Ph.D. thesis, I am researching the theoretical study of topological magnetic vortices (skyrmions) and vortex matter in chiral magnets. The skyrmions are topologically protected from field fluctuations, so they act more like quasiparticles. With their stability, they are considered promising future information carriers, so we hope to create new types of racetrack memories and ultra-dense magnetic storage. This is a new and exciting field of physics with rich and beautiful theoretical concepts and research methods (see the review [4] and references therein). This year, the Nobel prize was awarded to David Thouless, Duncan Haldane, and Michael Kosterlitz “for theoretical discoveries of topological phase transitions and topological phases of matter”, so I feel lucky to be studying similar topics as part of my Ph.D. research.



Figure 2. Alex Kruchkov in discussion with Nobel Laureates Serge Haroche, Gerardus 't Hooft, William Phillips, and David Wineland during the panel discussion “Is quantum technology the future of the 21st century?”. Moderator: Christian Meier. Credit: Lindau Foundation.

This year’s Nobel prize was given for a combination of diverse theoretical concepts, carefully developed and tested across several decades, and the topology of the system and vortex–antivortex phase transitions play an important role in the key models (see for example [5,6]). Imagine a two-dimensional charged gas, cooled down to zero Kelvin. If it were a typical three-dimensional gas, at low temperatures, it would overpass the known transitions, such as Bose–Einstein condensation (if bosons), or Fermi liquid (if fermions). However, it was considered for a long time that for

flat (two-dimensional and uniform) systems, such phase transitions are forbidden (the so-called Mermin–Wagner theorem [7,8]). However, even though early numerical studies of such systems showed no singularities, there was an indication that something strange is going on: the correlation functions (the functions which show how much a small part of the system knows about the other parts) behaved differently above and below some critical temperature T_C , the signature that one would normally expect for phase transitions! This was striking as it opposed the Mermin–Wagner theorem, which had been proven in different contexts. The apparent contradiction was first qualitatively explained in the 1972 paper of Kosterlitz and Thouless [5] in which they argue that below some T_C , it is very easy to create vortices, but only in pairs—a vortex and an antivortex. Of course, the evolution of the vortex pairs is complex, but intuitively one could expect that if we heat the system, we can destroy these vortex pairs. Indeed, the calculations show that above the T_C , all the vortex pairs decay into single (uncorrelated) vortices. Such a subtle topological mechanism gives no physically measurable singularities at T_C in thermodynamic properties, however it does, indeed, change the correlation functions of the system below and above T_C . The corresponding order in the system is a topological order, which supports this quite strange (topological) phase transition. It is interesting that in mathematically similar earlier arguments of Berezinskii [9,10], there was no mention of superconductivity or vortex–antivortex physics at all. Well, indeed—strange things happens with the strange matter.

There is much more fun to be had in topological matter physics, and I strongly encourage the reader to open the original papers of Kosterlitz, Thouless and Haldane. They are written in a very clear and distinct manner. After the 2016 Nobel Prize was announced in October, journalists baptized it “strange matter”. Indeed, the topological matter physics therein is strange, striking and conceptually beautiful. I am preaching as Hell: you should do something fun.

Strange Matter. And nothing else matters.

Conflicts of Interest: The author declares no conflicts of interest.

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