Laudatio for Jan Philip Solovej on the occasion of his Henri Poincaré prize 2021

September 16, 2021

It is an honor and a privilege to present to you Jan Philip Solovej, who receives the Henri Poincaré prize 2021 "for outstanding contributions to the analysis of quantum many-body problems ranging from the electronic structure of large atoms to the Lee-Huang-Yang asymptotics of the ground state energy of dilute Bose gases."

Jan Philip received his Ph.D. from Princeton University in 1989 with Elliott Lieb as advisor and with a thesis entitled "Universality in the Thomas-Fermi-von Weizsäcker model of atoms and molecules". At that time, the study of large atoms was one of the central questions in Mathematical Physics. To set the stage, the famous "$2Z + 1$"-bound of Lieb had just appeared in 1984, and the papers by Hughes and by Siedentop and Weikard on the Scott correction must have been written up during Jan Philip's time as a graduate student—just to mention some of the important developments of the time. It appears clear that Jan Philip got strongly motivated for settling the important question of the maximum possible ionization of an isolated, non-relativistic atom while in Princeton. The ionization conjecture states that this ionization, i.e. the maximum number of electrons that can be bound to the nucleus minus the nuclear charge, is bounded by a universal constant independent of the nuclear charge. It is one the main achievements of Jan Philip to have proved this conjecture in the Hartree-Fock model; first in 1991 in a reduced Hartree-Fock model and later in 2003 in the full Hartree-Fock theory of atoms. The conjecture for the full quantum mechanical many-body problem remains open, but I am convinced that Jan Philip has not yet given up on proving it!

The subjects of semiclassical analysis, electronic structure, and stability of matter, are strongly intertwined. Jan Philip has made important contributions to them all. Let me here only briefly mention some. One highlight is the influential works, with Lieb and Yngvason, on semi-classical analysis and "Magnetic Thomas-Fermi Theory" in the presence of strong magnetic fields. Of fundamental importance is the beautiful proof with Lieb and Loss of stability of matter with magnetic fields. Together with Erdős he proved strong Lieb-Thirring type inequalities with variable magnetic fields and studied the structure of magnetic zero-modes. Also the proof, with Spitzer and Sørensen, of the Scott correction for a model of an atom including (some) relativistic effects deserves mentioning. Together with Erdős and myself, he proved semi-classical results for large atoms, including the Scott correction, in a model with self-generated magnetic fields.

It is also important here to mention the rigorous derivation in 2012 with Frank, Hainzl, and Seiringer of the Ginzburg-Landau theory of superconductivity from the underlying BCS-theory.

Another highlight in the list of scientific achievements of Jan Philip is the proof of the Lee-Huang-Yang term in the ground state energy of dilute Bose gases. The road to this proof is also long, and shows a determination and a willingness to work hard and develop the necessary tools along the way. An early milestone is the proof, joint with Elliott Lieb, of the formula for the ground state energy of the 1- and 2-component Bose fluid (jellium) in the large density limit in 2001 and 2004. In these works it is used that a simple "completion of the square"-version of Bogoliubov's diagonalization of quadratic Hamiltonians is a sufficient and robust tool for lower bounds, and localization techniques that do not disturb the condensate are developed. These tools were then sharpened over the years. Let me in passing mention the strongly influential lecture notes from Jan Philips course on Many-Body Quantum Mechanics during his semester as Mercator Guest Professor at the LMU, Munich in 2007. Our final joint proof in 2020 of the Lee-Huang-Yang correction term to the ground state energy of dilute Bose gases in the thermodynamic limit, combines versions of these techniques, with another "completion of the square" argument to take care of the correlation terms between excited pairs in the gas—an argument that has its roots in a paper he wrote with Gian Michele Graf in 1994—as well as the understanding that the remaining terms not present in Bogoliubov's calculation effectively cancel each other out.

In 1995, I started as a graduate student with Jan Philip, who had just returned to Denmark from the US, as advisor. My choice of advisor was only based on the suggestion of a trusted professor. This leap of faith has turned out to be one of the best decisions of my life! As the many postdocs and graduate students who have had the luck to work with Jan Philip can testify, he is a wonderful mentor and a generous and insightful scientist, who is never satisfied with the easy, partial solution, but aims for real progress and understanding. This generosity and insight has benefitted a large part of a generation of mathematical physicists in Europe, starting in the 1990's with European Research Networks with Jan Philip as an important participant and more recently with members and visitors of his group supported by the ERC and later the QMATH-centre funded by the Villum Foundation. I am convinced that I speak on behalf of all these mathematical physicists when I take this occasion to thank him for his wonderful gift of scientific inspiration.

Jan Philip Solovej has solved major, long-standing open problems in the field of Mathematical Physics and in the process developed the necessary novel tools without ever losing the balance between Mathematical beauty and relevance for Physics. This has enriched our field. He is a most worthy recipient of the Poincaré prize 2021, and I look forward to many more breakthroughs and inspiring discussions in his office at the H.C. Ørsted Institute in Copenhagen.

Congratulations to Jan Philip and a deeply felt "Thank you"!
Søren Fournais