A MODEST FLOURISHING QUANTUM GAS IN THE MIDST OF HUMANITIES

ETIENNE WAMBA

Etienne Wamba was born in the Toko family, a hundred-wife and three-hundred-child polygamy leaving in Baleveng, a modest chiefdom of the West region of Cameroon. He studied Physics at the University of Dschang and got his B.Sc. in 2002. Then he moved to Cameroon's capital city, Yaoundé, where he received a Diploma in Education in 2005 and his M.Sc. in Physics from the University of Yaoundé 1 in 2006, studying out-of-equilibrium stochastic systems and critical behaviors with application to the hearing organ. He then did his Ph.D. (2013) at the same university, studying the matter-waves of Bose-Einstein condensates, followed by a two-year tutor position at the African Institute for Mathematical Sciences in Limbe, Cameroon. He did a post-doc at the Technische Universität Kaiserslautern, Germany on a fellowship from the Alexander von Humboldt Foundation. He studied spacetime mappings of quantum gas experiments. He was a joint associate of the Simons Foundation and the Abdus Salam International Center for Theoretical Physics (2015–2021). Starting in 2020, he joined the University of Buea, where he is now a Lecturer. His research focuses on the theoretical investigation of the dynamics of quantum many-body systems. – Address: Faculty of Engineering and Technology, University of Buea, P.O. Box 63, Buea, Cameroon. E-mail: etienne.wamba@ubuea.cm.

On April 1, when the taxi took me to Grunewald and dropped me off at the location that would shortly after become my new home, the address Vera Pfeffer communicated to me pointed to a grand bourgeois-style building, the main building of the Institute, located in a very peaceful and wealthy area of Berlin. The coming days would let me discover that I was accommodated near the bus stop of line M19 at a working distance to main grocery

stores, shops, and restaurants. Being in the main building made everything just so easy for me since the restaurant, seminar rooms, offices, table-tennis area, and washing machine were all close at hand.

With time, I have discovered the Wissenschaftskolleg zu Berlin as a unique place for doing research while living a balanced life in many ways. The Kolleg, far from the urban noise and in the middle of the greenness of trees, nurtures inspiration. My office was equipped with all the basic stuffs needed for doing my research. And I met very lovely people at Wiko, both the staff and Fellows. The staff has been so kind to me, always willing to provide help wherever and whenever need be, and I am really grateful for that. Wiko is suitable for thinking with a free mind and for taking interdisciplinary research to the next level. As one of the few research centers where natural scientists, humanities scholars, artists, and social scientists can gather together and discuss ideas at seminars, it is appropriate for the cross-fertilization of ideas between the sciences and the humanities. Furthermore, this may provide a way of seeing how our research is perceived by people outside of the research field and by the entire society. I found both the staff and Fellows to be nice, wonderful people, humble, and easy to talk to. Lunch and dinner times were real socialization moments, and I had open discussions with Fellows on all kinds of topics, ranging from science to daily life matters. I happened to have my birthday during my three-month stay at Wiko, just three weeks after my arrival. I was still shy, as I was still trying to get to know my new family members. But without having Facebook connections with Fellows, Teresa sent me a surprising birthday wish, with an invitation to celebrate it in a restaurant. I had informed no one, and who could have informed her, I wondered! I finally knew that she conspired with Jana Petri to offer me such a great surprise. We celebrated my birthday in an Indian restaurant at Halensee, with Sabina whose leg was to undergo surgery in the coming days. The joy I felt that day is simply indescribable. Remembrances of Anna's Spaghetti Theory around the gnocchi table, full of fun, during one of those joyful dinners still resonates in my mind! Wiko is a very inspiring place for the mind. How can one forget the end-of-year party?! I was part of the decoration team along with Mark, Eva, Elisa, and Sanyu. The party was a moment of great excitement and a joyful conclusion to my stay. I found it very interesting, and that makes Wiko a unique place in the world of research institutions. All that put together allowed me to quietly do my research work. I really enjoyed my stay at Wiko.

While at Wiko I was able to visit many places in the city of Berlin, including the Brandenburger Tor, the botanical garden, the Berlin-Hohenschönhausen Memorial, the

former Stasi (East Germany's Ministry of State Security) prison, Berlin's waters on a sightseeing tour by boat, and the Bundestag. I also had the opportunity to visit Potsdam, thanks to Jana Petri, the Academic Coordinator of the College for Life Sciences, who offered me the visit. I then visited, among other places, Sanssouci Palace and its surroundings. Jana was extremely helpful in suggesting places to visit.

During my stay at Wiko, I had the opportunity to attend German courses. I was attending B1 slots offered by Eva von Kügelgen. I received a lot of resources that allowed me to improve my German. I also took a few weeks of an A2 slot offered by Reinhard von Bernus.

One of the most important things I got at Wiko is an account to have access to online resources of the Freie Universität Berlin. The library's head, Michael Dominik Hagel, helped me in that respect. It gave me the opportunity to get the papers I needed for my work. This was really vital for my research as a scientist.

On April 29, 2022, I attended a workshop held at Wiko on the theme "Genomics of coevolution" convened by Dieter Ebert. Participants were visitors coming from many institutions throughout the world. During the workshop, apart from interesting discussions on coevolution, I had the opportunity to start discussions with Aurélien Tellier of the Technical University of Munich about possible supervisions of students at the African Institute for Mathematical Sciences in Cameroon.

On June 1, 2022, I gave a colloquium talk on the topic "From Classical Lines of Thought to the Quantum World: What Place for Ultracold Gases?" The talk aimed at raising awareness of the quantum world and how it can affect our future, as well as the kinds of ongoing research therein. I had to prepare the talk with great care, as it was meant for a very diverse audience of great minds. And I felt honored to give such a talk at Wiko. I was overwhelmed by the questions, which really impressed me a lot. A peculiarity of Wiko's colloquia is the traditional introduction by another Fellow or staff member. I was introduced in a very special way by Alberto Pascual-García, and that really made the colloquium ambiance exciting.

During my stay at Wiko, I worked on two aspects of the dynamics of quantum gases.

First I worked on the heating suppression in quantum gases under periodic driving that can be prepared with Floquet engineering. The driving is a certain periodic but anharmonic modulation of the gas's two-body interaction, at a particular frequency, which makes it possible to map the Floquet-engineered experiment onto an evolution with slowly varying parameters. Such a mapping between a Floquet evolution and a slow process

allows us to investigate non-equilibrium many-body dynamics and examine how rapidly driven systems may avoid heating up, at least when mean-field theory is still valid. We learn that rapid periodic driving may not yield to secular heating, because the time evolution of the system has a kind of hidden adiabaticity, inasmuch as it can be mapped exactly onto that of an almost static system.

Second, I built a numerical code meant for simulating on Matlab the nonlinear dynamics induced by the modulation instability of a binary mixture in an atomic Bose-Einstein condensate under the joint effects of higher-order residual nonlinearities and helicoidal SO coupling. The analysis relies on a system of modified coupled Gross-Pitaevskii equations on which the linear stability analysis of plane wave solutions was performed, from which an expression of the MI gain was obtained. A parametric analysis of regions of instability was carried out, where effects originating from the higher-order interactions and the helicoidal spin-orbit coupling are confronted under different combinations of the signs of the intra- and intercomponent interaction strengths. Direct numerical calculations, on the generic model, have confirmed our analytical predictions and have showed that the higher-order interspecies interaction and the spin-orbit coupling can balance each other suitably for the instability to take place. Mainly, it was found that the residual nonlinearity preserves and reinforces the stability of miscible pairs of condensates with SO coupling. Additionally, when a miscible binary mixture of condensates with SO coupling is modulationally unstable, the presence of the residual nonlinearity may help soften such instability. Our results finally suggest that MI-induced formation of stable solutions in mixtures of BECs with two-body attraction may be preserved by the residual nonlinearity even though the latter enhances the instability.

My short-term fellowship at Wiko was fruitful in terms of networking, as I was able to establish new scientific contacts and strong bonds with leading German scientists in my field of research, notably at the Technische Universität Berlin (TU Berlin) and Heidelberg University.

It all started with the in-person FINESS 2022 conference I attended in St. Martin from May 2–6, 2022. The conference is usually organized every two years and regroups forefront experts of the field of finite temperature and out-of-equilibrium dynamics across the world. The conference was an occasion to meet closely and discuss with leading scientists in my field. I contributed and presented a poster on the theme "Using a space-time mapping for probing heating suppression in periodically driven many-body quantum systems: a mean-field example with Bose gases."

Next, I contacted, met, and discussed with André Eckardt, Head of the Quantum Non-Equilibrium Dynamics research group at the Institute for Theoretical Physics of the TU Berlin. He invited me to visit his group and give a talk on "Exploring heating suppression in periodically driven quantum gases using an exact space-time mapping." The contact with Prof. Eckardt was suggested by Jana Petri and the talk was given on May 16, 2022.

While at Wiko, Tao Wang invited me to deliver an online talk on "Mapping as a probe for heating suppression in periodically driven quantum many-body systems" in the Department of Physics and Chongqing Key Laboratory for Strongly Coupled Physics of Chongqing University, China. The contact with Prof. Tao was facilitated by my German collaborator, Axel Pelster of the TU Kaiserslautern, and the talk was held on May 30, 2022.

Finally, Tilman Enss invited me to deliver an on-campus talk on "Using a space-time mapping for probing heating suppression in periodically driven many-body quantum systems" at the Institute for Theoretical Physics of Heidelberg University on June 16, 2022. My contact with Prof. Enss was established around my poster presentation during the FINESS 2022 conference.

Although my stay at Wiko was shorter than that of other Fellows, it was very pleasant and fruitful. I am very grateful to all the Wiko staff for this wonderful opportunity I was given and for the treatment I received. I achieved my personal goal, and I rate life and work at Wiko with a Distinction grade. I will not hesitate to come back to Wiko whenever there is any occasion. It would be helpful if the following points can be considered:

– The use of microphones by participants during the questions-and-answers phase of the Tuesday Colloquia should be made systematic, since the hall is big.

– While at Wiko, Fellows should be able to participate in conferences and workshops outside Wiko, using Wiko as their affiliation, and such participation should be supported.

– The lecturer replacement support was vital in my case, since without it I could never have gotten permission to travel. I really appreciate the idea.

I am very grateful to all the Wiko staff for this wonderful opportunity I have been given and for the care I have received during my stay in Grunewald. I especially thank Barbara Stollberg-Rilinger for the invitation; Vera Pfeffer, who prepared my trip and organized my stay; Jana Petri for her constant care; and Eva von Kügelgen for her commitment in teaching me German. Finally, I wish to thank Stellenbosch Institute for Advanced

Study (STIAS), Wiko's partner, which made it possible to get the present fellowship through the Iso Lomso program. Words cannot describe the feeling of satisfaction I had through these ninety days spent at the Wissenschaftskolleg zu Berlin. All I can say is "Zaandi" (Many thanks, in my mother's Yemba dialect!).