



SEVEN YEARS OF QUANTUM MUSIC – AND BEYOND

International
Conference

Keynote Address

Prof. Dr Klaus Mølmer

(Niels Bohr Institute, Copenhagen)

“Science and Music – Where Curiosities Meet”

Serbian Academy of Sciences and Arts
Institute of Musicology
AVA Center
15–16 December 2022



Co-funded by the
Creative Europe Programme
of the European Union

BEYOND QUANTUM MUSIC

The Art & Science project ***Beyond Quantum Music*** (2019-2022, co-financed by the **Creative Europe** program of the European Commission) is an extension of the maverick European cooperation project *Quantum Music*, which started in 2015 (also supported by *Creative Europe*). The original idea was to study the sounds and “music” of the quantum world, through joint efforts and experiments of musicians, quantum physicists, and engineers. The coordinator of the project is the Institute of Musicology of the Serbian Academy of Sciences and Arts. The partners in this project are DUALITY (Belgrade), Ars Electronica (Linz), and the Mediterranean Institute for Life Sciences (Split), in association with the Universities of Oxford and Aarhus, the Technical University of Delft, the Sonar Festival (Barcelona), and the Incontri Institute for Contemporary Music (Hannover). The project has received support from the Ministry of Culture and Information of the Republic of Serbia, Desk Creative Europe, the Serbian Innovation Fund, and SOKOJ.

The musical part of the project *Beyond Quantum Music* encompassed four concerts by **LP Duo**, who performed their original compositions created during their artistic residency at the Technical University in Delft (The Netherlands) in the first half of 2022. During this period, Sonja and Andrija had the opportunity to collaborate with the most prominent quantum physicists and microbiologists from around the world. LP Duo captured the sounds of quantum computers, moving atoms, and genetic code (immersed in their own, already recognizable musical language) and transformed them to be performed on innovative instruments – DUALITY Hybrid Pianos. Sonja and Andrija developed these new instruments at their eponymous company, in cooperation with engineers from the reputable American company HTEC and with the financial backing of the Serbian Innovation Fund.

The concert was premiered in Novi Sad, as part of the program *Novi Sad 2022 – European Capital of Culture, Kaleidoscope of Culture* (4 September 2022), then at the famous *Ars Electronica* festival in Linz, Austria (9 September 2022), as well as in Split, Croatia, under the auspices of the Mediterranean Institute for Life Sciences MedILS (19 September 2022). The final concert was held at the Yugoslav Drama Theater in Belgrade on 3 October 2022 and included in the program of the event *Night of Researchers 2022*. This was followed by a multimedia exhibition with installations and live performances *Beyond Quantum Music – Music, Sound, and Audiovisual Art* at the Center for Cultural Decontamination in Belgrade (10 October 2022).

PROGRAM

Thursday 15 December 2022

AVA Center, Serbian Academy of Sciences and Arts

Knez Mihailova 36, 1st floor

Plenary Session

Moderators: LP Duo (Sonja Lončar and Andrija Pavlović – DUALITY)

- 11:00 - 11:15 Opening Address
 Olga Sismanidi (EACEA, Brussels)
- 11:15 - 11:50 Ivana Medić (Institute of Musicology SASA, Belgrade)
 “Seven Years of Quantum Music”
- 12:00 - 13:00 Keynote Address
 Klaus Mølmer (Niels Bohr Institute, Copenhagen)
 “Science and Music – Where Curiosities Meet”
- 13:00 - 13:30 Discussion
- 13:30 Lunch and Cocktail (at the Institute of Musicology SASA, 4th floor)

Friday 16 December 2022

Institute of Musicology, Serbian Academy of Sciences and Arts

Knez Mihailova 36, 1st floor, Room 410

<https://zoom.us/j/95417342969?pwd=UG13MC9HdmorNTh5MnNqU3Z0OXI0Zz09>

Moderator: Ivana Medić

- 10:00 - 10:30 Aleksandar Brkić (Goldsmiths, University of London)
“From STEM to STEAM: LP Duo and Translating and Interpreting Between Art and Science”
- 10:30 - 11:00 Dimphna Meijer (Delft University of Technology)
“How Neurons Form Networks”
- 11:00 - 11:30 Eliška Greplová (Delft University of Technology)
“Quantum AI Meets Quantum Music”
- 11:30 - 12:00 Sander Otte (Delft University of Technology)
“Jazz Improv With Atoms”
- 12:00 - 12:30 Discussion and closing remarks

Abstracts

Dr Ivana Medić, Senior Research Associate
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Seven Years of Quantum Music

In this introductory talk I discuss cooperation projects *Quantum Music* (2015-18) and *Beyond Quantum Music* (2019-22), co-financed by Creative Europe and Serbian Ministry of Culture; the development of new hybrid instruments DUALITY was also supported by the Serbian Innovation Fund.

When starting the project, there were several pressing questions to answer: Is it possible to write "new music" in the 21st century? What does it mean to be "new"? Can the present-day "new music" be as relevant as it was some 50-60 years ago? Being a fan of the maverick avant-garde period in postwar European music, I have felt for quite some time that contemporary music has become boring and predictable, so I jumped at the opportunity to get involved with something new. In this presentation, I will describe this project and its main objectives – to bring the imaginary principles of quantum physics closer to a wide audience through music and to demonstrate how the laws of quantum physics and the aesthetics of music interact. The research has taken us in several directions simultaneously; I will outline them all and present our results. I will also dissect the "newness" of our project, as well as the possibilities of marketing such a project when the network and the infrastructure that used to support the post-WW2 "new music" have largely dissolved.

Ivana Medić is a Senior Research Associate at the Institute of Musicology of the Serbian Academy of Sciences and Arts, Associate Lecturer at the School of Computing in Belgrade, Visiting Research Fellow with the Center for Russian Music, Goldsmiths, University of London, and a convener of the REEM/BASEES Study group. She is Head of the international projects *Quantum Music* (2015-18) and *Beyond Quantum Music* co-financed by the EU program *Creative Europe* (2019–22), and Head of the project *Applied Musicology and Musicology in Serbia: Making a Difference in Contemporary Society* (2022–24) financed by the Serbian Science Fund. She is Vice-President of the Serbian Musicological Society.

KEYNOTE ADDRESS

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Science and Music – Where Curiosities Meet

Along with my research and teaching in university environments, I have carried out many outreach activities in schools and given talks to general audiences. These have brought me in contact with people from all strands of life and have led to discussions of quantum physics with poets, authors, painters, theatre directors, composers, musicians and ballet choreographers. Such discussions have been extensive and systematic with Danish composer Kim Helweg and with Serbian composer and musician Andrija Pavlovic, and they have led to an exchange of inspiration and content for orchestral, solo cello and piano duo concerts and for ballet performances, and new musical scales that all incorporate narratives from quantum physics. In this talk, I will share my experience and my thoughts about the process of establishing a common working language for scientists and artists. I am deeply thankful for these interactions, and apart from sharing my excitement and enthusiasm for every process and project that we have entertained, I will try to articulate my thoughts about how these provide not only new material and insights for the arts but also for the sciences.

Klaus Mølmer is a theoretical physicist, born in 1963. He obtained his PhD in 1990 and was appointed associate professor in 1991 and full professor in 2000 at Aarhus University, Denmark. Since June 2022 he has been full professor at the Niels Bohr Institute, University of Copenhagen. Klaus Mølmer has led several research centers and programs on quantum optics and quantum information. He has contributed to the understanding and application of dynamics, dissipation and measurements in quantum mechanics and quantum optics. He has developed key concepts for quantum computing gates with ions, atoms and photons. Klaus Mølmer has popularized science in more than 100 talks and in articles and book chapters, as well as in a Danish textbook on Quantum Mechanics. Klaus Mølmer has contributed to “quantum composition” of music and stage performances with composers, musicians, ballet dancers and other artists.

Dr Aleksandar Brkić, Lecturer
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From STEM to STEAM: LP Duo and Translating and Interpreting Between Art and Science

Working as a creative producer of LP Duo on a number of projects, initiatives and project ideas, including (Beyond) Quantum Music, often placed me in challenging situations that required engagement in the processes of (re)interpretation and translation. Artistic and scientific research are colliding, with different challenges in professional, social and creative realms asking interdisciplinary teams to work in spaces of insecurities hoping it will lead us to successful innovations. I will discuss different challenges that we faced together in the process of developing creative spaces that engage artists, engineers and scientists in efforts to move towards the unknown and construct the "spaces of potential", translating and interpreting them in and for the world of arts and science. This process of bridging the perceived differences between the worlds of STEM ("useful") and STEAM ("useless"), is one of the main pillars of LP Duo's art&science methodology.

Aleksandar Brkić is a scholar in the field of cultural/arts management and cultural policy, with significant experience as a creative producer and arts manager, working in the intersections of performing arts, visual arts, and design. He joined the Institute for Creative and Cultural Entrepreneurship (ICCE), Goldsmiths in 2016. Prior to that, he was teaching at LASALLE College of the Arts in Singapore and the University of Arts in Belgrade. He is a Fellow of the Higher Education Academy (FHEA) and a guest lecturer at the University of Arts in Belgrade and Ben M'Sik, Hassan II University, Casablanca. Aleksandar Brkić is a member of the Regulations Committee of Goldsmiths. He is a series editor of "Routledge Focus on Global Creative Economy" published by Taylor&Francis and an Associate Editor of The European Journal of Cultural Management and Policy.

Dr Dimphna Meijer, Assistant Professor
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How Neurons Form Networks

In my research lab at TU Delft, the Netherlands, we study how neurons form networks at the molecular, cellular and tissue level. In this talk, I will give an introduction to the basic principles of neuronal network formation and zoom in on the cell biology of the neuron, the main functional unit in our brain. I will emphasize the current outstanding questions in our field, and explain how we can tackle these questions with a bottom-up approach. I will discuss how interactions with writers, artists and music composers are a driving force behind our team science, create novel insights and foster new collaborations.

Dimphna Meijer is an assistant professor and tenure-track group leader in the Bionanoscience Department of the Applied Sciences Faculty of Delft University of Technology (TUD) since 1-10-2018. She obtained her MSc (*cum laude*, 2008) in Experimental and Clinical Neuroscience from Utrecht University (UU). She carried out her PhD research (2009–14) on biochemical characterization of neuronal transcription factors in the Neurobiology Department of the Harvard Medical School (HMS) in the research group of Dr. Charles Stiles. After returning to the Netherlands for postdoctoral work in the Crystal and Structural Chemistry Department at Utrecht University, she joined the TU Delft Faculty in 2018 where she established the Quantitative Neurobiology group.

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Quantum AI Meets Quantum Music

At Quantum Matter and AI Lab at TU Delft we are working on merging artificial intelligence and quantum computing with the ultimate goal of making these two fields mutually beneficial and more widely applicable in the new generation of technology. Trying to combine two radically different emerging technologies oftentimes leads to interdisciplinary collaborations and exciting intersections with other fields. One of our recent use-case playgrounds has been neuroscience and specifically processing of the large amounts of data biological neurons exchange with each other with the help of artificial intelligence and potentially also quantum computing. It was no surprise this interdisciplinary project that caught the attention of LP Duo, our artists in residence at the time. They worked with us to create a composition that has ingredients from all the fields mentioned above, thus adding to the efforts of merging and information exchange within diverse scientific efforts. In this talk, I am going to explain how one can conceptually combine artificial intelligence, quantum computing and neuroscience and how can all these fields contribute to the work of innovative music composers.

Eliška Greplová is an assistant professor at Kavli Institute of Nanoscience at Delft University of Technology in the Netherlands. She leads "Quantum Matter and AI" group which works at the intersection of quantum technologies, artificial intelligence and condensed matter physics. She is a visiting researcher at Microsoft Research Amsterdam and a member of World Economic Forum Global Future Council on Quantum Computing. She co-founded Virtual Science Forum, a platform for online scientific events. Previously, she was a postdoctoral researcher at ETH Zurich in the group of Sebastian Huber. She obtained her PhD under the supervision of Klaus Mølmer at Aarhus University and worked in the group of Ignacio Cirac (Max Planck Institute of Quantum Optics) during her master studies.

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Jazz Improv With Atoms

In our research, we study the interaction between quantum spins of individual magnetic atoms. We use scanning tunneling microscopy to position the atoms in arrangements of our choice. The exact placement of the atoms on the underlying crystalline surface determines the sign and strength of their magnetic interactions as well as the spin-orbit coupling experienced by their spins. As such, the positioning of the atoms offers us a toolbox where we can tune various design parameters that influence the resulting physical behavior of the combined spin system. There exists an interesting parallel between this approach and my hobby, jazz piano improvisation, where a limited set of tools can also provide a seemingly unlimited wealth of unexpected possibilities. In this talk, I will give a brief introduction to both my research and my hobby and elaborate on how each provides inspiration for the other.

Sander Otte works as a professor of physics at the Faculty of Applied Sciences at TU Delft. He is currently a teacher in the Applied Physics program providing courses in both quantum and classical mechanics. Sander Otte is involved in the Pre-University Physics MOOC, because he wants to reduce the gap between physics taught at a high school level and at an academic, more formal, level. Having performed research in various labs in The Netherlands and the United States, he now leads his own research group, which investigates atomic scale phenomena using low-temperature scanning tunneling microscopy. In particular, his group focuses on the transition between quantum nature and the classical manifestation of matter.



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The Institute of Musicology of the Serbian Academy of Sciences and Arts was founded in 1948 as the first institute of musicology in Yugoslavia. The Institute conducts the study of the history and theory of music, as well as ethnomusicology, music aesthetics and related disciplines. The Institute has its archive, phonoarchive, photographic collection, and a vast library. Besides scholarly research, the Institute has always been engaged in a spectrum of educational and cultural activities, targeting not only an expert audience but also a wider circle of the public interested in Serbian musical heritage and its position in the Balkan and European contexts.



Institute of Musicology
Serbian Academy of Sciences and Arts

The project *Beyond Quantum Music* (2019–22) is a continuation of the pioneering scientific and artistic project *Quantum Music* (2015–18).

www.quantummusic.org

PARTNERS

Institute of Musicology SASA, Belgrade, Serbia

<https://www.facebook.com/musicinstsanu>

DUALITY, Belgrade, Serbia

<http://www.lpduo.com>

Ars Electronica, Linz, Austria

<https://ars.electronica.art/news/en/>

Mediterranean Institute for Life Sciences, Split, Croatia

<http://www.medils.org> <http://www.medils.hr>

Associate Partners

Delft University of Technology, The Netherlands

University of Oxford, United Kingdom

Incontri Institute for Contemporary Music, Hannover, Germany

Sonar Festival, Barcelona

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SOKOJ – Organisation of Music Authors of Serbia

European Researchers' Night 2022

Center for Cultural Decontamination

Yugoslav Drama Theatre