

Међународна
интердисциплинарна
конференција

**КВАНТНА МУЗИКА
(И ИЗВАН ЊЕ)**

МУЗИКА И НОВЕ ТЕХНОЛОГИЈЕ
У 21. ВЕКУ

International
Interdisciplinary
Conference

**QUANTUM MUSIC
(AND BEYOND)**

MUSIC AND NEW TECHNOLOGIES
IN THE 21st CENTURY



Institute of Musicology
Serbian Academy of Sciences and Arts



CENTER FOR
THE
PROMOTION
OF SCIENCE



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Technological Development of
the Republic of Serbia



Међународна интердисциплинарна конференција

КВАНТНА МУЗИКА (И ИЗВАН ЊЕ)

МУЗИКА И НОВЕ ТЕХНОЛОГИЈЕ У 21. ВЕКУ

Организатори:

Музиколошки институт САНУ, Београд

Центар за промоцију науке, Београд

21–22. март 2018.

Српска академија наука и уметности, Београд

International Interdisciplinary Conference

QUANTUM MUSIC (AND BEYOND)

MUSIC AND NEW TECHNOLOGIES IN THE 21st CENTURY

Organisers:

Institute of Musicology SASA, Belgrade
Center for the Promotion of Science, Belgrade

21–22 March 2018

Serbian Academy of Sciences and Arts, Belgrade

Програмски одбор

Председница Програмског одбора

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QUANTUM MUSIC (AND BEYOND)

MUSIC AND NEW TECHNOLOGIES IN THE 21st CENTURY

Programme

Wednesday 21 March 2018

Hall 1 Serbian Academy of Sciences and Arts

16:00 Registration

Hall 2 Serbian Academy of Sciences and Arts

16:45 Welcome address by Katarina Tomašević, Director of the
Institute of Musicology SASA

Session 1

17:00 Chiara Marletto (University of Oxford, Wolfson College)

BEAUTY IS TRUTH: CAN QUANTUM MUSIC BRING US CLOSER TO
OBJECTIVE BEAUTY?

17:30 Andrew Garner (National University of Singapore, Centre
for Quantum Technologies)

THE MUSICAL MACH-ZEHNDER INTERFEROMETER: HOW TO
DEMONSTRATE QUANTUM PHENOMENA WITH TWO PIANISTS

Keynote

18:00 Vlatko Vedral (University of Oxford, Department of Physics)

CAN WE HEAR A QUANTUM SUPERPOSITION?

20:00 Dinner

QUANTUM MUSIC

QUANTUM MUSIC

Thursday 22 March 2018

Hall 1 Serbian Academy of Sciences and Arts

Session 2

10:00 Klaus Mølmer (Aarhus University, Department of Physics and Astronomy)

THE QUANTUM VIBES OF ATOMS AND ICHTHYOSAURS

10:30 Kim Helweg (Danish National School of Performing Arts)

"SPOOKY FREQUENCIES FROM A DISTANCE": COMPOSING WITH QUANTUM INFORMATION

11:00 Ivana Medić (Institute of Musicology, Serbian Academy of Sciences and Arts) and Jelena Janković-Beguš (Faculty of Music, Belgrade; Centre of Belgrade Festivals — CEBEF)

WHAT DOES QUANTUM MUSIC SOUND LIKE AND WHAT WOULD PIERRE BOULEZ THINK OF IT?

SUPER-POSITION (MANY WORLDS) BY KIM HELWEG (2017)

11:30 Coffee break

Festive Hall of the Serbian Academy of Sciences and Arts

12:00 Vlatko Vedral

WHAT IS IT LIKE TO LIVE IN A QUANTUM WORLD?

[КАКО ЈЕ ЖИВЕТИ У КВАНТНОМ СВЕТУ?]

A lecture in Serbian, open to the public

Organised by the Serbian Academy of Sciences and Arts

14:00 Lunch

QUANTUM MUSIC

Hall 1 Serbian Academy of Sciences and Arts

Session 3

- 15:00 Dragan Novković, with Marko Peljević and Mateja Malinović
(The School of Electrical and Computer Engineering of Applied
Studies, Department of Audio & Video Technologies, Belgrade)
SYNTHESIS AND ANALYSIS OF THE SOUNDS DEVELOPED FROM THE
BOSE-EINSTEIN CONDENSATE. THEORY AND EXPERIMENTAL RESULTS
- 15:45 Sonja Lončar and Andrija Pavlović (Faculty of Music,
Belgrade; NOVA Academy; New Art Centre, Belgrade)
HYBRID DUO: LP DUO AS AN EMBODIMENT OF DUALITY

16:30 Coffee break

Session 4

- 17:00 Alexis Kirke (University of Plymouth, School of Humanities
and Performing Arts)
REAL-TIME USE OF QUANTUM COMPUTER HARDWARE AND SUBATOMIC
PROCESSES IN MUSICAL PERFORMANCE, AND REAL-TIME USE OF
MUSICAL PERFORMANCE IN QUANTUM HARDWARE
- 17:30 Olof van Winden (TodaysArt, The Hague)
CREATIVITY AS HARD CAPITAL
- 18:00 Snežana Nešić (University of Hannover, Institute for New Music)
PLANNING THE „QUANTUM MUSIC – #HANNOVER SESSION“ 2018
- 18:30 Closing remarks
- 19:00 Dinner

ABSTRACTS AND BIOGRAPHIES



Vlatko Vedral

University of Oxford, United Kingdom
Department of Physics
Fellow of the Wolfson College

(Keynote Speaker)

CAN WE HEAR A QUANTUM SUPERPOSITION?

In my talk I will discuss the quantum aspects of sounds and what it means to be in a genuine quantum superposition or even entangled states of sounds. Much as we never see a spatial superposition of an object, I would like to argue that we probably cannot hear a quantum superposition of sounds. However, it would be interesting to explore what it would mean to be able to do it. I will speculate on this in my presentation.

Vlatko Vedral is a physicist and Professor of Physics at the University of Oxford and Centre for Quantum Technologies at the National University of Singapore and a Fellow of Wolfson College. He is known for his research on the theory of Entanglement and Quantum Information Theory. He was awarded the Royal Society Wolfson Research Merit Award in 2007. He has held a Lectureship and Readership at Imperial College, a Professorship at Leeds and visiting professorships in Vienna, Singapore (NUS) and at Perimeter Institute in Canada. He is the author of several books, including *DECODING REALITY*. He is working on problems related to the validity of quantum physics in the macroscopic domain. His latest popular book *FROM MICRO TO MACRO* is an entertaining exposition of this topic.

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Chiara Marletto

University of Oxford, United Kingdom
Wolfson College

BEAUTY IS TRUTH: CAN QUANTUM MUSIC BRING US CLOSER TO OBJECTIVE BEAUTY?

Quantum music is an idea to compose music based on a fundamental physical theory, quantum theory. One of the underlying theses of the project is that by merging a deep theory of physics with music one can provide a more interesting musical landscape.

An interesting problem opened by quantum music is whether this idea will, or will not, allow one to move closer to objective beauty, if such a thing exists. I will explore what the implications of quantum music are for this issue. Can the marriage of science and art permit the achievement of a richer set of aesthetic outputs?

Chiara Marletto is a quantum physicist working at the University of Oxford. Her interests span solid state physics, quantum physics, thermodynamics, and information theory. Having previously dabbled in Italian Literature, Engineering Science and Quantum Computation, she is currently focusing on developing Constructor Theory – a recently proposed new fundamental theory of physics – applying it to address problems at the foundations of physics. She has also applied Constructor Theory to reconcile probability with deterministic dynamical laws, and to express explicitly the theory of evolution in physical terms of physics – explaining what constraints that theory puts on the laws of physics. She is also writing a popular book, *THE SCIENCE OF CAN AND CAN'T*.

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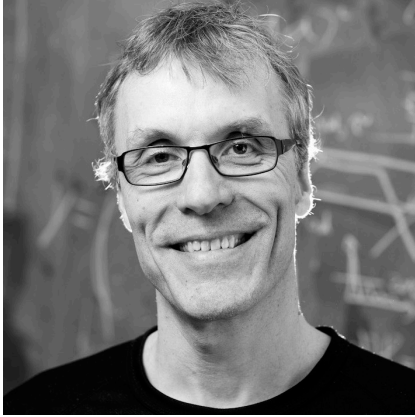
Andrew Garner

Centre for Quantum Technologies
National University of Singapore

THE MUSICAL MACH-ZEHNDER
INTERFEROMETER: HOW TO
DEMONSTRATE QUANTUM
PHENOMENA WITH TWO PIANISTS

Andrew Garner is a post-doctoral research fellow at the Centre for Quantum Technologies in Singapore. His research interests include the foundations of quantum physics, information thermodynamics and complexity science. He completed his DPhil in Atomic & Laser Physics at the University of Oxford in 2015, and his undergraduate degree in Physics at St. Edmund Hall, Oxford in 2010. Beyond physics, he also has a keen interest in music and music technology, composing and producing the incidental music for two plays staged in Oxford, incorporating sounds from software synthesisers of his own design.

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Klaus Mølmer

Aarhus University, Denmark
Department of Physics and Astronomy

THE QUANTUM VIBES OF ATOMS AND ICHTHYOSAURS

Klaus Mølmer is Professor at the Department of Physics and Astronomy, Aarhus University, Denmark, working on the research programme Quantum Interactions Between Matter and Radiation. His publications include a book QUANTUM MECHANICS: A WILD WORLD OF THE ATOMS. He was awarded the status of Fellow of the American Physical Society for his outstanding and insightful contributions to theoretical quantum optics, quantum information science and quantum atom optics, including the development of novel computational methods to treat open systems in quantum mechanics and theoretical proposals for the quantum logic gates with trapped ions.

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Kim Helweg

The Danish National School for
Performing Arts
Copenhagen, Denmark

"SPOOKY FREQUENCIES FROM A
DISTANCE": COMPOSING WITH
QUANTUM INFORMATION

Kim Helweg began composing at the age of 13 and made his professional debut in 1974. The first published work *Hvidheden og Stilheden* (The Whiteness and the Silence) from 1975, shows clearly which composers influenced his formative years – namely Cage and Penderecki. A chance encounter with American fusion-music drastically altered his course and led to an extended period of jazz/rock compositions. In 1985 and 1988 Helweg won the 1st prize for compositions made for The Danish Radio Concert Orchestra. In 1986 his anti-musical *The Kreutzer Sonata* (based on Tolstoy and Beethoven) won a prize at the European Broadcast Union in Monaco. Since 1988 Helweg has chiefly composed for classical ensembles, but still with a visible jazz/rock influence. He has written music for more than 50 dance performances and one opera, *Stalingrad*. In addition, Kim has composed music for a variety of scenic experiments and a lot of works for orchestras, chamber ensembles and not least two pianos. The work of the dance has resulted in intense work with the wider musical spectrum within both the new choreographic practice and inside the ballet. He teaches at the Danish National School for Performing Arts.

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Ivana Medić

Institute of Musicology SASA, Belgrade

Jelena Janković-Beguš

Centre of Belgrade Festivals (CEBEF)

WHAT DOES QUANTUM MUSIC
SOUND LIKE AND WHAT WOULD
PIERRE BOULEZ THINK OF IT?

As identical twin sisters, throughout their lives Ivana and Jelena have often felt as living and breathing embodiments of duality, entanglement, superposition and other quantum phenomena. In this presentation they focus on Kim Helweg's 2017 composition SUPERPOSITION (MANY WORLDS) inspired by quantum mechanics, and place it in the context of the musical avant-garde.

Ivana Medić is a Research Associate with the Institute of Musicology of the Serbian Academy of Sciences and Arts. She is Head of the international project QUANTUM MUSIC co-financed by Cultural Europe and Head of the Belgrade team of the project CITY SONIC ECOLOGY – URBAN SOUNDSCAPES OF BERN, LJUBLJANA AND BELGRADE, funded by the Swiss National Science Foundation. She is also Head of the main project of the Institute of Musicology SASA IDENTITIES OF SERBIAN MUSIC WITHIN LOCAL AND GLOBAL FRAMEWORKS: TRADITIONS, CHANGES, CHALLENGES. She received her PhD from the University of Manchester, and she is now Visiting Fellow with the Centre for Russian Music, Goldsmiths, University of London.

Jelena Janković-Beguš is a Programme Editor at the Centre of Belgrade Festivals (CEBEF) and a PhD candidate at the Department of Musicology, Faculty of Music, University of Arts in Belgrade. She completed her MPhil at the University of Arts in Belgrade and Master 2 studies of cultural management at Université Paris-Dauphine. She has worked extensively in the fields of cultural production, management and organisation.

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Dragan Novković

with Marko Peljević and Mateja Malinović

The School of Electrical and Computer Engineering of Applied Studies, Department of Audio & Video Technologies, Belgrade

SYNTHESIS AND ANALYSIS OF THE SOUNDS DEVELOPED FROM THE BOSE-EINSTEIN CONDENSATE. THEORY AND EXPERIMENTAL RESULTS

Two seemingly incompatible worlds of quantum physics and acoustics, have their own touchpoint in experiments with Bose-Einstein condensate. From the very beginning the Quantum Music project was based on the idea of converting the acoustic phenomena of quantum physics that appear in these experiments into the sound domain accessible to the human ear. The first part of this paper describes the experimental conditions in which these acoustic phenomena occur. The second part of the paper describes the process of sound synthesis which was used to generate final sounds. Sound synthesis was based on the use of two types of basic data: theoretical formulas and the results of experiments with Bose-Einstein condensate. Process of sound synthesis based on theoretical equations was conducted following the principles of additive synthesis purposely realized using the Max MSP software. Synthesis of sound based on the results of experiments was realized using MatLab software. The third part deals with the acoustic analysis of the generated sounds, indicating some of the acoustic phenomena that have emerged. Also, the way of using such sounds in the process of composing and performing music is explained.

Dragan Novković is a professor of acoustics and audio engineering at the School of Electrical and Computer Engineering of Applied Studies. His main topic of interest is acoustics of closed spaces, both at theoretical and practical levels. He is known for his extensive cooperation with a number of scientists and artists, implementing several projects in the fields of technology, art and science connected with sound and music.

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**Sonja Lončar &
Andrija Pavlović (LP Duo)**

Faculty of Music, University of Arts
NOVA Academy, Belgrade
New Art Centre, Belgrade

**HYBRID DUO: LP DUO AS AN
EMBODIMENT OF DUALITY**

In this paper Sonja Lončar and Andrija Pavlović present segments of their doctoral artistic projects *HYBRID DUO — NEW SPACES FOR CONTEMPORARY INTERPRETATION AS A PIANO DUO* and *CONTEMPORARY CHALLENGES FOR WORK AND COLLABORATION OF MUSICIANS IN A PIANO DUO* conducted at the Faculty of Music, University of Arts in Belgrade and inspired by their involvement with the Quantum Music project.

Sonja Lončar and **Andrija Pavlović** are pianists who founded LP Duo in 2004, as well as the NGO New Art Centre in Belgrade. LP Duo has since become one of the most successful European chamber ensembles. Both musicians completed their undergraduate and postgraduate studies (specialized in piano duo) at the Faculty of Music in Belgrade. They further studied at the Hochschule für Musik und Theater Rostock (Germany), completing postgraduate and PhD studies in chamber music and piano duo with honour. As solo musicians and piano duo members, they won over 30 awards at international music competitions. LP Duo has performed in Serbia, The Netherlands, Germany, Slovenia, Croatia, Denmark, Singapore, Switzerland, Finland, Macedonia, San Marino, Poland, Italy, Hungary, Bosnia and Herzegovina and the USA. They gave Serbian and world premieres of more than 30 contemporary pieces. Many composers have dedicated their music to LP Duo.

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Alexis Kirke

Plymouth University, UK
School of Humanities and Performing
Arts (Faculty of Arts & Humanities)

REAL-TIME USE OF QUANTUM
COMPUTER HARDWARE AND SUBATOMIC
PROCESSES IN MUSICAL PERFORMANCE,
AND REAL-TIME USE OF MUSICAL
PERFORMANCE IN QUANTUM HARDWARE

This talk will detail my work with subatomic processes and controlled quantum dynamics in relation to music and processing. It will start by describing 2011–2013 performances for violinist and live cloud chamber-based granular synthesizer at a public music festival, Rutherford Appleton labs and California Academy of Sciences [1]. A parallel stream to this was my unconventional computing work with Bristol Photonics Lab on the use of unconventional musical computing to drive their “Quantum Computer on the Web” into states of entanglement, and the resulting naturally occurring sonification this process [2]. I will detail the first real-time use of controlled quantum dynamics in a public performance, which was at the Port Eliot Festival in 2016, using an adiabatic D-Wave 2X which reacted live to the singing of a Mezzo Soprano [3]. I will finish by highlighting my recent work that uses the IBM's online gate-based QC to generate melodies and the D-Wave 2X to harmonize them [4].

1. Kirke, A. et al. (2013) Cloud Chamber: A Performance with Real Time Two-Way Interaction Between Subatomic Particles & Violinist. *Leonardo*, 46(1); 2. Kirke, A. et al. (2015). A Hybrid Computer Case Study for Unconventional Virtual Computing. *Int. Journal of Unconv. Computing*, 11(3-4); 3. Kirke, A. et al. (2017). Experiments in Sound and Music Quantum Computing. In *Guide to Unconventional Computing for Music*. Springer; 4. Kirke, A. (2017) Musical excerpt from IBM 5Q on BBC Radio 4 Futureproofing, May, BBC UK.

Alexis Kirke is a composer and filmmaker well-known for his interdisciplinary practice. He is a member of the Plymouth University's Interdisciplinary Centre for Computer Music Research in the South-West of England, and is composer-in-residence for the Plymouth Marine Institute – the UK leader in Marine research and work on sustainability, marine pollution and conservation. Alexis has completed two PhDs, one in Arts and one in Technology. He has published articles on Algorithmic Composition and Performance. He has won an Outstanding Contribution Award at Media Innovation Awards 2016.

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Olof van Winden

Today'sArt
The Hague, The Netherlands

CREATIVITY AS HARD CAPITAL

In this paper I discuss the impact of technology on our lives and our culture and attempt to answer the question: Why do art, creativity, ethics, and philosophy become the main capital in this world where complexity prevails?

Olof van Winden is Director and founder of the Today'sArt festival in The Hague. Under his leadership, Today'sArt has expanded into an international network of festivals, projects and collaborations in Japan, South Korea, Mexico, Russia, the Middle East, Canada, the United States and many European countries. Van Winden was also the director of the Montevideo/Netherlands Media Arts Institute in Amsterdam. He has curated renowned exhibitions and events, including the Seoul Biennale (Media City Seoul, 2012), Detroit Electronic Music Festival (2002, 2003) and large scale exhibitions in Moscow in collaboration with the National Centre of Contemporary Arts and the Moscow Biennale. His visionary approach and inner urge to seek out new ideas are behind his drive to create a worldwide platform for facilitating artists in their creativity, and to bring this to global audiences of all backgrounds, cultures and interest, aiming to transform them through contemporary art forms. Known for his unconventional approach and expertise in media art, digital culture, creativity and innovation, he is regularly invited to speak at international conferences, to consult on creative projects, and to participate as a jury member/advisor for committees.

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Snežana Nešić

University for Music, Drama and Media
Hannover, Germany

PLANNING THE „QUANTUM MUSIC – #HANNOVER SESSION“ 2018

Five premiers of new commissioned compositions, conference and art installation in Sprengel Museum should take place in cooperation with Quantum-Music Project in winter 2018 in Hannover, Germany. Snežana Nešić, the leader of Ensembles "Ur.Werk" and "Incontri" and docent for composition and contemporary music on the Hannover University for Music, Drama and Media presents the program of the event and discusses the variety of creative approaches concerning the commissioned composers, as result of different philosophic and esthetical perceptions of quantum discourse.

Snezana Nešić studied accordion and composition in Kiev and Hanover, where she has been teaching New Music since 2007. She has composed on commissions from the Staatsoper Hannover, the Philharmonie Luxemburg and the Kammeroper Köln, among others. She has won numerous prizes as a composer and accordionist, among them the first Prize of the Molinari Quartet Composition Competition, and in 2015 her opera *The Rain Passed Over* was awarded a prize at the Festival *Oper'Actuel-Work in Progress*. She was a scholarship holder from the German Academy of Rome and was Artist in Residence in Montreal and in the Wilhem Kempff House in Positano. As an instrumentalist she won first prizes at many international competitions, such as the "International Accordion Days Klingenthal" and played as a soloist with numerous orchestras and ensembles, including the NDR Symphony Orchestra Hamburg and the Lower Saxony State Orchestra.

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**Institute of Musicology
Serbian Academy of Sciences and Arts
Belgrade**

Director: Katarina Tomašević

Institute of Musicology of the Serbian Academy of Sciences and Arts in Belgrade was founded in 1948 as the first institute of musicology in the former Yugoslavia. The Institute conducts study of history and theory of music and explorations in ethnomusicology and music aesthetics; studies have focused on the Serbian music and its links with music culture in the neighbouring and European countries. The Institute has its archive, phonoarchive, photographic collection, and a rich library. Beside scholarly research, the Institute has always been engaged in a spectrum of educational and cultural activities, targeting not only expert audience, but also a wider circle of public interested in the Serbian musical heritage and its position in the Balkan and European context.

Website: <http://www.music.sanu.ac.rs>



**Center for the Promotion of Science
Belgrade**

Director: Jovan Trifunović

Center for the Promotion of Science (CPN) is a government institution for promotion and popularization of science. The Center was founded on November 30, 2010 and it is more than just a public institution. The idea to create the Center emerged from the need to bring science closer to citizens in order to increase the general scientific literacy and assure the future technological progress in Serbia. The Center organizes promotions, lectures, workshops and panels all over Serbia. Its publishing activity includes the popular science magazine ELEMENTI and selected books on various popular science topics. It is also very active in the field of international cooperation and participates in many international projects. In the spring 2016, the Science Club network was established in 13 cities throughout Serbia. The last one was opened in Belgrade, in April 2017, in the center of Belgrade, 46 Kralja Petra Street. It is open for the whole scientific community in Serbia, for the people of all ages and its programs include all science disciplines.

Website: <http://www.cpn.rs>



**Quantum Music Project
2015–2018**



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

Quantum Music is a project with the aim to explore the connection between music and quantum physics. The project presents quantum physics and the quantum world to a wider audience and contributes to the creation of a new musical/scientific genre - Quantum Music.

Quantum Acoustics is the meeting point of two completely separate worlds: the world of everyday physics and the world of quantum physics reality. Bose-Einstein Condensate is the state of matter in which strange phenomena occur: quantum particles interact with gas molecules creating the miracle of sound. If a small, quantum ear could exist during these experiments, it would be capable of hearing some sensation — a quantum sound! This is the only point within the quantum physics wonder-space that interacts so directly with our reality.

Within this project we explore the possibilities of interactivity and creative communication between these two distant worlds.

Website: <http://quantummusic.org>

QUANTUM MUSIC

NOTES

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Међународна интердисциплинарна конференција

КВАНТНА МУЗИКА (И ИЗВАН ЊЕ)
МУЗИКА И НОВЕ ТЕХНОЛОГИЈЕ У XXI ВЕКУ

Српска академија наука и уметности
21-22. март 2018. године

Организатори:
Музиколошки институт САНУ
Београд

Центар за промоцију науке
Београд

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Дизајн:
Дејан Медић

Превод на енглески језик:
Зорица Симовић

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Део истраживања представљених на овој конференцији је резултат рада на пројекту ИДЕНТИТЕТИ СРПСКЕ МУЗИКЕ ОД ЛОКАЛНИХ ДО ГЛОБАЛНИХ ОКВИРА: ТРАДИЦИЈЕ, ПРОМЕНЕ, ИЗАЗОВИ (ОИ 177004) који финансира Министарство просвете, науке и технолошког развоја Републике Србије.

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MUSIC AND NEW TECHNOLOGIES IN THE 21ST CENTURY

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