

HYBRID DUO*

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ABSTRACT

As members of the LP Duo, for the past 14 years we have experimented with various possibilities of playing on two pianos. Our artistic curiosity and the desire to gain new knowledge and freedom led to our involvement with the *Quantum Music* project and the creation of a new instrument – the hybrid piano. In this paper we elaborate on our experience with using the new hybrid pianos within the *Quantum Music* project, but also discuss our ensemble as an artistic embodiment of duality, entanglement and other quantum phenomena. Hybrid piano is a combination of a traditional piano and digital synthesizer with analogue controls that allows different processing of acoustic and digital signals in real time and enables the pianists to continue to use concert pianos whilst equipping them with new colours and new, hitherto unexplored expressive possibilities.

KEYWORDS: Quantum Music, piano duo, hybrid piano, LP Duo, duality

INTRODUCTION – THE PATH TOWARDS THE HYBRID PIANO

As members of the LP Duo (Lončar / Pavlović), for the past 14 years we have experimented with various possibilities of playing on two pianos. In addition to the classical repertoire that we learned during the undergraduate and specialist studies at the Faculty of Music, University of Arts in Belgrade, and afterwards at Hochschule für Musik und Theater Rostock (Germany) where we completed Master and Konzert-

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examen (KEX) studies for piano duo, since the very beginning of our career we have been interested in contemporary art – performing works of contemporary composers, collaborating with artists from the domains of visual and applied arts (video art, film, photography, performance, dance, theatre), playing in ensembles and bands covering different genres (rock, popular, experimental music), as well as playing different types of synthesizers. Our artistic curiosity and the desire to gain new knowledge and freedom, and the gradual steps that we took over the years, led to the realization of the Quantum Music project and the creation of a new instrument – the hybrid piano, that will be discussed in this paper.

The Quantum Music Project was initiated by Dragan Novković, an engineer and acoustics specialists from Belgrade, and Vlatko Vedral, Professor of Quantum Physics at the University of Oxford.² The goal of the project was to present and illustrate basic characteristics of quantum physics, to examine the sound phenomena occurring in the quantum world by scientific-artistic methods, and to prepare a multimedia concert that would feature “new” music (quantum music), including works for the new instruments specially built for this project, the hybrid pianos (that will be described below).

Some of our previous project that gradually led to Quantum Music and the creation of the hybrid piano were: “LP Duo – Do You Love John Cage?“,³ “Karlheinz Stockhausen – *Mantra* for two pianos with ring modulators“,⁴ the concert performed on analogue synthesizers at the opening of the International Review of Composers,⁵ the concert for two pianos and analogue synthesizers performed at Studio 6 of Radio Belgrade,⁶ and the album *Mechanical Destruction*, recorded on analogue synthesizers.⁷ All these projects led to the idea to invent a hybrid piano, which we finally realised in collaboration with engineers Prof. Dr Dragan Novković and Darko Lazović. This new instrument actually “prepares” the classic piano and transforms it into an analogue-digital instrument through the use of MIDI technology. We discovered the first fundamental link for creating the hybrid piano when we studied John Cage’s work *Three Dances and A Book of Music* for two pianos. John Cage (1912–1992) was one of the first composers who experimented with the expansion of the piano sound, “getting inside” the interior of the instrument and placing various objects on and between

2 Quantum Music Official Trailer: <https://www.youtube.com/watch?v=yx6ozqjBwC>

3 Multimedia performance on the occasion of John Cage’s centenary in 2012, performed in Belgrade, Zagreb and Ljubljana.

4 Performed at the Belgrade festival of electronic music *Dispatch* and the Music Biennial in Zagreb, in 2010 and 2011 respectively.

5 Performed in Belgrade in 2013, at the Great Hall of Dom Omladine (Youth Centre).

6 The recording of this concert was broadcast several times on RTS 3, Serbian Broadcasting Corporation and it is available on Youtube: <https://www.youtube.com/watch?v=kekTyXQACrc>

7 LP (vinyl) *Mechanical Destruction*, Dansk Komponist Forening (in collaboration with New Art Center, Belgrade) and Phonofile Balkan, 2016, <https://www.discogs.com/LP-Duo-Mechanical-Destruction/release/9219152>; https://www.youtube.com/watch?v=mKxvO_aCwk8

piano strings (e.g. various types of screws, rubber bands, etc.). In this way, the piano becomes a kind of a new percussion ensemble, aurally resembling Indonesian *gamelan* orchestras. The performance on the prepared pianos requires from the pianists a completely new reflection on the interpretation of the pieces, because the pianists create the new sounds themselves by “preparing” the strings; in other words, the pianists actively participate in the change of sound of the standard piano. In turn, this translates to the additional innovations in the manner of playing, *touché*, dynamic range, articulation, as well as the overall alignment with the other piano.⁸ The piano thus becomes a new instrument, not just for performers but also for listeners, who can see two pianos on the stage, but hear completely different sounds coming from them.

The next in a series of experiences that paved the way for the creation of a new instrument was our preparation for the performance of Karlheinz Stockhausen’s *Mantra* (1970) for two pianos with ring modulators.⁹ This is the first piece for two pianos which actually “prepares” the piano by using electronic devices – ring modulators instead of screws and rubberbands. The musicians control ring modulators while playing amplified pianos, thus obtaining new sound layers by multiplying frequencies of certain tones.

Even before we founded LP Duo, as members of several popular and experimental groups¹⁰ the two of us often played analogue synthesizers.¹¹ After many years of using these specific instruments, we came up with the idea to commission and/or play the works by contemporary composers for a particular ensemble of analogue synthesizers.¹² This special experience has shown certain qualities and originality in the interpretation of new works by using the synthesis of sound and certain functions of analogue synthesizers such as filters, arpeggiators etc. Also, the introduction of selected works by contemporary composers in the context of live performance on analogue synthesizers – non-standard instruments for this kind of music, that were previously used primarily in popular music – provided the listeners with a specific new experience.¹³ The characteristics and possibilities of creating sound on analogue

8 See our performance of John Cage’s *Three Dances* (1st movement) here: <https://www.youtube.com/watch?v=RyNVJq6w-Ww> (Belgrade, Dom Omladine, 22 June 2012).

9 Ringmodulation is a signal processing function in electronics, the implementation of amplitude modulation or frequency mixing, performed by multiplying two signals, where one is a typical sine wave or another simple waveform.

10 These include Belgrade bands and groups Jarboli, Neočekivana sila, E-Play, Duboka Ilegala, Chinch, Prti Bee Gee.

11 Analogue synthesizer uses analogue loops and analogue signals to generate sound electronically. Analogue synthesizers are actually a collection of waveforms, noise generators, filters, ring modulators, oscillators, mixers and control devices packaged in a modular or integrated form.

12 The concert by LP Duo at the International Review of Composers in 2013, Belgrade, Dom Omladine.

13 For this concert we arranged works from our standard repertoire, but also premiered several new works, specifically written to be performed on analogue synthesizers.

synthesizers have shown excellent sound results in certain commissioned or arranged compositions (e.g. *Mechanical Destruction*), but the design of keyboards with fragile plastic keys was not suitable for performing musical material of this kind. Namely, analogue synthesizers were created for another type of music, and the technological development of these instruments was accompanied by the emergence of new music genres primarily in the domain of electronic popular music (although there were composers who arranged classical music pieces for analogue synthesizers, e.g. Isao Tomita). Especially problematic in performance are very fast, virtuoso parts, *legato* playing and leaps, due to the characteristics of keyboards and sound control. Also, the sound itself, though extremely rich and characteristic, becomes tiring after some time. Hence, it was very important for us to try to combine the acoustic sound of the piano with analogue and digital sounds. In the ensuing projects we “paired” two pianos with analogue synthesizers (two pianos and four analogue synthesizers, two for each pianist) and rearranges the existing repertoire for this “ensemble.” This practice has attracted excellent response from the audiences, confirmed by a number of successful concerts (Studio 6 Radio Belgrade, Opera Copenhagen, Music Biennale Zagreb). In this case, the combination of pianos and analogue synthesizers provides the wealth of sound colours; however, the pianists face the challenge of moving from the piano to the synthesizers and vice versa, because these instruments are played completely differently, which is primarily reflected in the dynamic differences of the keyboard (analogue synthesizers do not have any keyboard dynamics, therefore the control of sound parameters is quite difficult). The idea to invent a hybrid piano for the Quantum Music project was a natural extension of the experiences described above. This new instrument has enabled us to continue to use concert pianos and acoustic sounds, and simultaneously any other analogue or digital sound that can be “triggered” from the computer by pressing a piano digit.

HYBRID PIANO

Hybrid piano was designed and built for the Quantum Music project. The engineer Darko Lazović constructed this mechanism, assisted by Dragan Novković. The instrument is designed so that it can be easily inserted into any grand or upright piano. Hybrid piano is an acoustic combination of electronic and analogue technology – a combination of a traditional piano and digital synthesizer with analogue controls that allow different processing of acoustic and digital signals in real time. Similar mechanisms have already been developed, but what is innovative here is that the mechanism is designed to be completely portable and every pianist can easily place it in any piano in the shortest possible time (about 30 minutes) with a simple user manual.

The hybrid piano is made of 90 micro-controllers, one for each piano key, one for the main controller and one for turning the silencer mechanism on and off. Magnetic sensors with digital output are used to detect pressing and releasing the keys. The system consists of an electronic mechanical structure that is placed under or above the keyboard and the silencer that is placed on the frame of the mechanism of piano hammers. This structure converts movements of keyboards into MIDI commands

received by electronic instruments or computers. In order to make the pressure on the piano key converted into a MIDI command, it is necessary to have an electronic sensor below or above the key, which will detect the movement of the key. Pressing the keys moves the lever with constant magnets and when the magnet passes above the surface of the magnetic sensor at the digital output, an electric impulse is obtained by signaling the magnet passage through the sensor. The magnetic sensor technology allows greater dynamic accuracy, and unlike optical sensors, there are only a few cables and it has two-layer printing that makes the hybrid piano relatively cheap to produce. Also, it is possible to repair and change the mechanism of each key separately and there is no problem with the dust.

On a printed electronic plate, on which the digital magnetic sensor is located, there is also a small computer or micro-controller in the integrated circuits that monitors states on the digital outputs of magnetic sensors. By analyzing the change in the state of digital outputs of magnetic sensors, the micro-controller determines the intensity of the key, as well as the moment when it is released. When a micro-controller notices the movement of the key, it forms a MIDI command that is sent to electronic digital tone generators. Below or above each key there is one tile with a micro-controller; all 88 micro-controllers (the piano has 88 keys) “communicate” with each other. Namely, if they were all sending MIDI commands describing the movements of the keys at the exact same time, it would destroy the information. Hence micro-controllers “negotiate” between themselves when transmitting their MIDI commands, because this type of command is transmitted only on one line, and the same command can not send more micro-controllers’ information on the same line at the same time. In this way, each micro-controller can send a MIDI command over one line at a single-time interval.

MIDI commands sent from these 88 micro-controllers of the keyboards arrive to the main board with one larger micro-controller that performs received commands and then forwards them to digital electronic sound generators. With this architecture of the device, the micro-controller on the main board can, based on the information about the note, divide the keyboard into several parts, and we can play different “instruments” on separate channels. The listeners can hear both acoustic and digital sounds, and the final mix depends on the requirements of the performance; it can be controlled by the pianists themselves or the sound designer, depending of the setting of the whole system.

SOUNDS OF THE QUANTUM WORLD

The movement of atoms at “normal” temperatures can be considered completely chaotic, and each atom can be treated as a single system that interacts with atoms from its immediate environment. Contemporary physics treats particles, including atoms, as dual systems, possessing characteristics both of particles and waves at the same time, depending on the particular situation. When cooling the atoms, all movement slows down, and atoms begin to behave as waves more and more. By slowing motion, atoms oscillate with lower frequencies, resulting in an increase in their wave-

length. At one point during the cooling process all atoms pass through the so-called. transition phase, after which they share a common minimum energy state. After that moment, atoms can no longer be regarded as individual elements, but as one quantum system, which can be analyzed as a whole. It is this state of matter in which the unification of atoms into one structure comes to be called the Bose-Einstein condensate.¹⁴

Quantum physics experiments allow this kind of condensate to be excited by lasers, resulting in an expansion of mechanical waves in the structure of the condensate, which by definition is the basis of every sound formation. So, if our ears were sufficiently small, they could hear the sound of the quantum world; however, in reality, this is not possible. What *is* possible is that the results of such experiments, expressed in the form of a chart, a table and a formula, can be used to synthesize the sounds. This is exactly what we did with the Quantum Music project: results of the experiments and theoretical predictions related to the Bose-Einstein condensate were sent to audio engineers who generated individual sounds by using the additive synthesis methoded (Novković et al. 2018), and compiled them into a bank of quantum sounds. Only then, we received this newly-created sound material that we could further manipulate both in our interpretation of existing works and when creating new ones, using computer programs and digital software such as Virtual Studio Instruments (VST).

When preparing the multimedia performance that would showcase the new hybrid instruments and the new compositions, we began by writing the synopsis derived from Vlatko Vedral's lecture on Quantum Music.¹⁵ Afterwards, we wrote or arranged the pieces for two hybrid pianos that would enable us to reflect upon the various quantum phenomena and present them to the audiences in an accessible and artistically convincing way, whilst utilising the innovative expressive possibilities of the new instruments to the maximum.

QUANTUM MUSIC CONCERT – CHAPTERS

1. *Quantum Vacuum*

Two identical instruments, two pianos, represent two quantum particles and their relationship. Duality is one of the basic premises of quantum philosophy and the role of the piano duo in such a constellation helps with certain explanations of quantum postulates. For this chapter, we chose the composition *Rondo* by Chiel Meijering (b. 1954). It is a very fast piece and contains a lot of virtuosic elements. We did not want to disturb the atmosphere of this composition, so the quantum sounds that we chose were just an extension of the basic sound of the piano. Aside from newly synthesized quantum sounds, we also used the Spectrasonic Omnisphere MIDI software in all pieces that we performed. The quantum sound samples are used to underlie the harmonic contents of this composition.

14 For a thorough explanation of the behaviour of particles in the condensate and the particle-wave dychotomy see other articles in the present issue: Mølmer 2018; Garner 2018; Novković et al. 2018.

15 <https://www.youtube.com/watch?v=D4oW3lphcg>

2. Collapse

We wrote the piece *Ostinato for Leonid Šejka*¹⁶ for hybrid pianos and for this segment of the Quantum Music concert. The effect that the listeners can hear is an “arpeggiator” programmed in the Spectrasonic Omnisphere software. Also, when the piano key is pressed slow enough it is possible to completely avoid the piano sound. The sound of a synthesizer controlled both by a MIDI signal and a piano key has its own dynamic range, hence the problem of such “silent” playing was finding the right ratio of the pressed key in relation to the piano sound and the sound controlled by the hybrid mechanism. The middle section is an improvisation following the video on the front and back projections. The observer (shown as the human eye) in the back projection tries to “capture” or localize the particles projected on the front. Pianists follow this process through simple rhythmic improvisation in the first piano and simulation of quantum sounds in second piano. The acoustic piano sound is not present. The localization moments of the particles were fetched by the samples obtained from the quantum laboratory. Leonid Šejka’s surrealist paintings were an inspiration for composing this piece because they require a special focus to spot a detail.

3. Double Slit Experiment

The piece *Maquina III* by Antonio Correa (b. 1982) was originally written for two pianos. The prerecorded sound, played on analogue synthesizers, was programmed so that the sound changed its sources during the performance. What was constant was the acoustic piano sound that came from two speakers placed on the stage. The prerecorded sound was divided into several channels and played from different speakers; each channel had a programmed path. This “circulation” of sounds is meant to demonstrate the movement of photons.

4. Duality

The piece *Sustainable Development* by Ivan Božičević (b. 1961) was originally written for two pianos; we arranged it for hybrid pianos. It consists of several similar patterns based on the pentatonic scale that appear in one, and then in the other piano in different registers, which occasionally creates the impression of a “stereo” sound image. In both pianos, we used the samples obtained by generating the sound of simulations of the experiments that took place in the quantum laboratory. The fundamentals of these sounds are almost the same in both pianos, but what is “unpredictable” is how each one of these sounds develops in relation to the timing of the pressed key. Since these parameters were adjusted according to the “probability” principle, most of the controls of these sounds were left to improvisation.

5. Bose-Einstein Condensate

What we learned from quantum physicists is that they will never say that our world is separate from quantum world; but in order to be able to understand the quantum dimension, these worlds are often “separated” in theory. In this “chapter” w3 tried

16 Leonid Šejka (1932–1970) was a famous Serbian surrealist painter and architect of Russian descent, one of the founding members of the group Mediala.

way to illustrate the laboratory conditions in which these sounds were measured in a humorous; hence we “set” two tasks for the Bose-Einstein condensate while playing on hybrid pianos, and the BEC “responded” to us. The sounds that we received from the quantum lab were used in two ways: in the first task, the basic sound was arranged with changing the frequency and the pitch of the sound itself, whilst preserving all of its basic parameters. We “translated” the sound to get the well-tempered impression. In the second task, we did not modify the basic quantum sound that we got from the lab in any way. With the various modes of reproduction of these “answers” we wanted to show the possibilities for manipulation of quantum sounds. This is also possible to do “live” on the stage, in real time, but it is very expensive; however, we hope that in the second stage of the project, with a working title *Beyond Quantum Music*, we will have the opportunity to do this.

6. *Bioquantum*

This chapter explains (in visual and musical terms) that the two worlds that communicated in the previous chapter are not separated. Although they function very differently, they still constitute one whole. The projection shows the connection of quantum phenomena with photosynthesis, birds and nature. In the first section, the sound was programmed in such a way that, when the key is quickly and skillfully released, it is possible to hear only the piano. A longer hold of the key allows the extension of the basic tone. In the next section of this composition, the second piano uses the software sound of a synthesizer that resembles the legendary analogue-digital synthesizer Roland JUNO-60, with its distinctive “retro” sound.

7. *Entanglement*

In this chapter, pianists represent two particles in an entangled state. The first piano uses a pre-programmed MIDI sound; we tried to reimagine the sound of the legendary Minimoog synthesizer. Minimoog is monophonic, which means that when pressing more than one key, it can not register both, but only plays the one that is pressed last, or the one that is higher than the previous one. This was our little homage to analogue synthesizers and an attempt to produce the effect of a monophonic analogue synthesizer by using the hybrid piano.

The entanglement is a mysterious phenomenon in the quantum world. Particles that are located in two distant places in the universe have related characteristics. When one changes its state, the other at the same time reacts with an adequate change of complementary quantum properties (Cf. Mølmer 2018). In the chamber ensemble, musicians communicate through audible experiences, however one of the basic ways of communication is by maintaining visual contact. Namely, one of the musicians must always “give a sign” to begin the performance, or certain parts of the composition where extraordinary precision is necessary. In the middle part of the Entanglement Chapter, one member of the piano duo (Andrija Pavlović) comes to the other member (Sonja Lončar) and ties her eyes with a black ribbon, then returns to his piano and ties his own eyes as well, thus cancelling visual contact. The idea for this “dramatic” move came from the very concept of quantum physics; just like two entangled particles who can continue to communicate even when separated by millions of

light years, we wanted to abolish visual communication and rely only on what we hear. This concept seems very simple, but what happened every time when we performed this composition in this way (and while we were practicing it) was a completely new experience for us; the act of listening became the main focus and our communication on the abstract level was much more intense.

The last section of this composition is also extremely virtuosic and fast. Within this section, there is a small “break“ in which one of the pianists is expected to give a sign to the other to continue playing. When performing this piece blindfolded, it was not possible and our communication was completely left to the “entangled“ state in which we found ourselves. The break is long enough for us to lose the continuity of the basic “groove“ for a moment, so we had to rely on our intuitive communication that we built over the last fifteen years i.e. since we started playing together. Just like two particles in an entangled state, we remained connected through a pure aural experience and we both reacted to the changes in the state of our entangled pair.

8. Teleportation

The last chapter begins with the basic theme of the composition *G-Song* by Terry Riley (b. 1935). We arranged the basic theme for two pianos and repeated it three times. In the first repetition it is very similar to the original composition, in the second repetition it gradually accelerates and the arrangement becomes more complex, while in the third repetition its basic meter changes. The last repetition is interrupted by a prerecorded sound. With the first tones of this sound, the light suddenly goes off and the pianists disappear, “teleported“ from the scene, and appear on the screen. We composed this piece in the style of a modern popular genre called *retro-futurism*. Teleportation is the quantum phenomenon most common in popular culture and used in many films and TV series such as *Star Trek*. Although quantum teleportation does not have much in common with such popular interpretation, any other attempt to explain it to an audience with no previous knowledge in this field would be completely impossible.

The basic idea for this chapter was to point to the unstoppable changes that are taking place in relation to the ubiquitous presence of new technologies in our everyday lives and the rapid exchange of information. Someday soon quantum computers will completely change our perception of the world.

At the end of this multimedia concert, during the applause, we only bow as figures projected on the screen, whilst not being physically present. With this, we wanted to point out the general loneliness that plagues our planet; the exchange of information among people has intensified and accelerated by means of digital technologies, but the physical contact in these communications has been lost.

CONCLUSION

New technologies can be very inspiring and assist the further development of each ensemble. Hereby we do not just refer to new instruments – in this case, keyboard instruments (synthesizers, computers, hybrid pianos) that can provide endless possi-

bilities for the creative process of the piano duo – but also to the possibilities of digital connections, conquests of new sound territories, presentations of one’s work outside of a predetermined genre, in order to subtly educate the audiences and offer different views on art, life and the world as a whole. It is equally important for musicians to make an effort and try to find an adequate place for their ideas and artistic ideals in the cultural markets by using all the tools available to spread and share their ideas and knowledge with the audiences. Exiting the conventional spaces of performing classical and contemporary music and entering the domain of popular music and culture is indeed one of the good ways of achieving this. The artists’s ability to verbally explain and “defend” their art is equally important. If the artists, in this case the piano duo, manage to build successful careers, dedicate themselves to their brand and communicate it successfully to the audience (Cf. Medić 2014), they acquire the ability – but also a great responsibility – to attempt to educate and change the world for the better.

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Соња Лончар и Андрија Павловић

ХИБРИДНИ ДУО

(САЖЕТАК)

Београдски клавирски дуо Соња Лончар и Андрија Павловић (ЛП Дуо) већ четрнаест година експериментише са различитим могућностима свирања на два клавира. Поред класичног репертоара који је овај дуо прошао за време и након основних и специјалистичких студија на ФМУ у Београду а потом и на Високој школи за музику и позориште у Роштоку (Немачка), његови чланови су од самог почетка испољавали интересовање за савремену уметност, извођење дела композитора-савременика, бављење визуелним и примењеним уметностима (видео, филм, фотографија, музички перформанс, кореографије, позоришне представе), те свирање у ансамблима и музичким саставима различитих жанрова (рок, популарна, експериментална музика), као и свирање на различитим синтисајзерима. Њихов истраживачки дух и потреба за освајањем нових знања и слобода, као и сва наведена искуства, постепено су водила ка осмишљавању и реализацији пројекта *Квантна музика* и стварању новог инструмента – хибридног клавира. У овом раду чланови ЛП Дуа преносе своја искуства рада на пројекту *Квантна музика* и на развоју хибридног клавира, док у исто време свој ансамбл посматрају као отелотворење квантних феномена попут дуалности. Хибридни клавир је комбинација традиционалног клавира и дигиталног синтисајзера са аналогним контролама које омогућавају различито процесовање акустичких и дигиталних сигнала у реалном времену и омогућавају пијанистима да наставе да користе концертне клавире, али обogaћене новим бојама и досад незамисливим изражајним могућностима.

Кључне речи: квантна музика, клавирски дуо, хибридни клавир, ЛП Дуо, дуалност