MCM'24

18 – 21 JUNE
COIMBRA, PORTUGAL

9TH INTERNATIONAL CONGRESS ON MATHEMATICS AND COMPUTATION IN MUSIC

1 2 9 0 UNIVERSIDADE D COIMBRA

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Organization

CENTRE FOR INTERDISCIPLINARY STUDIES
CENTRE FOR INFORMATICS AND SYSTEMS
UNIVERSITY OF COIMBRA

Partnership

FACULTY OF ARTS AND HUMANITIES - UNIVERSITY OF COIMBRA
SOCIETY OF AND SOCIETY FOR MATHEMATICS AND COMPUTATION IN MUSIC

UIDB/00460/2020

MCM2024
WELCOME

We are delighted to welcome you to Coimbra for the 9th Biennial International Conference for Mathematics and Computation in Music (MCM 2024). During four exciting days (Jun 18-21), the conference provides a forum for scholars from around the world and through various disciplines to explore and debate practical or theoretical ideas, welcoming a scope of approaches to mathematical and computational music modeling, creation and application, and engaging fields within mathematics, informatics, engineering, cognition and music analysis, theory and performance, among others.

Organized by the Centre for Interdisciplinary Studies (CEIS20) and the Centre for Informatics and Systems (CISUC) of the University of Coimbra, in partnership with the Faculty of Arts and Humanities (FLUC), where the conference takes place, MCM 2024 is the flagship conference of the Society for Mathematics and Computation in Music (SMCM), and continues the biennial recurrence of meetings alternating sides of the Atlantic (Berlin 2007, New Haven 2009, Paris 2011, Montreal 2013, London 2015, Mexico City 2017, Madrid 2019, and Atlanta 2022).

The Program and e-Book of the conference can be dowloaded at https://www.uc.pt/ceis20/mcm24/. The Scientific Program Committee has organized the conference featuring 28 talks, 5 posters, 5 communication-performance talks, a 3-part workshop offered by Dmitri Tymoczko, and one tribute paper. The presentations were grouped around the following subjects: Mathematical Scale Theory and Tuning; Rhythm Analysis and Rhythm Generation; Categorical and Algebraic Approaches to Music; Quantum Music; Theory and Algorithms for Melodic/Harmonic Analysis and Generation; Geometric Approaches to Musical Algorithms and Microtonality; Fourier Analysis for Music; Similarity and Distance Measures for Music. In addition, the conference hosts two plenary talks: Norman Carey and David Clampitt present "35 Years of Well-Formed Scale Theory: Origins and Development" and William Sethares presents "The Many Tunings of Balinese Gamalean."

MCM 2024 also integrates three concerts in its program: a concert by MCM participants as composers and performers, a concert where Moreno Andreatta will perform a selection of his "Music and Maths" repertoire, and a concert of Coimbra Fado music by the group 'Quarteto de Coimbra' (Fábio Almeida, Tiago Rodrigues, Simão Mota, and Vasco Rodrigues).

In preparing this conference, we have benefitted from the enthusiastic participation of dozens of colleagues to put together the present Program. We are grateful for the guidance and leadership of the SMCM board, the rigorous work of the Editorial Committee for the Proceedings Springer Volume, and the enormously generous work of the reviewers of the Scientific Committee. And we thank the tireless and expert work of the Arrangements Committee of the Centre for Interdisciplinary Studies (CEIS20), the institutional partnership

of the Faculty of Arts and Humanities of the University of Coimbra, and the financial support of the Foundation for Science and Technology (under program: IUDB/00460/2020).

We wish you a stimulating conference.
Enjoy Coimbra!

June 2024

José Oliveira Martins
Omar Costa Hamido
Riccardo Wake
Amílcar Cardoso
Pedro Martins
Jônatas Manzolli

CONTENTS

2 **MCM2024 WELCOME**

10 **PROGRAMME**

20 **FLUC MAP**

22 **KEYNOTE SPEAKERS**

22 35 YEARS OF WELL-FORMED SCALE THEORY: ORIGINS AND DEVELOPMENT
23 THE MANY TUNINGS OF BALINESE GAMELAN

24 **PLENARY SESSION**

24 GENERAL MEETING OF THE SOCIETY OF MATHEMATICS AND COMPUTATION IN MUSIC GENERAL ASSEMBLY, SMCM

25 **COMMUNICATION-PERFORMANCES**

25 STAGES IN MY VUZA RHYTHMIC CANONS
26 OF ALL INTERVAL TETRACHORDS AND OCTATONIC SCALES
26 ADVANCED VISUALIZATION TECHNIQUES FOR MUSIC THEORY
27 SONIFICATION OF WIGNER FUNCTIONS: CASE STUDY OF INTENSE LIGHTMATTER INTERACTIONS
28 CONFIGURATIONS OF DISJOINT AUGMENTATION CANONS

30 **PANEL SESSIONS**

FOURIER ANALYSIS FOR MUSIC
30 1.1. FOURIER (COMMON-TONE) PHASE SPACES ARE IN TUNE WITH VARIATIONAL AUTOENCODERS' LATENT SPACE
31 1.2. DFT AND PERSISTENT HOMOLOGY FOR TOPOLOGICAL MUSICAL DATA ANALYSIS
32 1.3. FOURIER QUALIA WAVESCAPES: HIERARCHICAL ANALYSES OF SET CLASS QUALITY AND AMBIGUITY

RHYTHM ANALYSIS AND RHYTHM GENERATION
33 2.1. ON BRAZILIAN DRUM CLAVES AND GENERATING RHYTHM PATTERNS OUT OF THEM

33 2.2. EUCLIDEAN RHYTHM WITH PALINDROMIC RESTS
34 2.3. WHAT ARE "GOOD" RHYTHMS? GENERATING RHYTHMS BASED ON THE PROPERTIES SET OUT IN THE GEOMETRY OF MUSICAL RHYTHM

THEORY AND ALGORITHMS FOR MELODIC/HARMONIC ANALYSIS AND GENERATION
35 3.1. MODAL PITCH SPACE: A COMPUTATIONAL MODEL OF MELODIC PITCH ATTRACTION IN FOLK MUSIC
35 3.2. PERSISTENT HOMOLOGY AND HARMONIC ANALYSIS

CATEGORICAL AND ALGEBRAIC APPROACHES TO MUSIC
36 4.1. HIDDEN CATEGORIES: A NEW PERSPECTIVE ON LEWIN'S GENERALIZED INTERVAL SYSTEMS AND KLUMPENHOUWER NETWORKS
37 4.2. FINDING HOMOMETRIC MULTIPLETS
38 4.3. VOICE AND MATH: THE ART OF SINGING IN LIGHT OF MATHEMATICAL MUSIC THEORY
39 4.4. STRUCTURAL AND TRANSFORMATIONAL RELATIONS BETWEEN Z-RELATED HEXACHORDS

GEOMETRIC APPROACHES TO MUSICAL ALGORITHMS AND MICROTONALITY
40 5.1. ADVANCED POLYPHONIC MUSIC PATTERN MATCHING ALGORITHMS WITH TIMING INVARIANCES
41 5.2. TONNETZE AND TORI FOR THE 19-, 31-, AND 53-TONE EQUAL TEMPERAMENTS
41 5.3. A MODEL OF SCORES AS ABSTRACT SYNTACTIC TREES
42 5.4. I-SHAPED TILES IN THE TONNETZ

QUANTUM MUSIC
43 6.1. INTRO TO QUANTUM HARMONY: CHORDS IN SUPERPOSITION
43 6.2. QUANTUM MEMORY AND MATHEMATICAL GESTURES: TWO PERSPECTIVES ON VERDI AND WAGNER
44 6.3. QUANTUM TONALITY: A MATHEMUSICAL PLAYGROUND

MATHEMATICAL SCALE THEORY AND TUNING
45 7.1. QUARTER-TONE MUSIC: A TUNING SYSTEM ROOTED IN NATURAL HARMONIC SERIES
46 7.2. THE SANDWICH-LEMMA: THE RECURSIVE STRUCTURE OF SUPER-SYNTONIC AND SUPER-DIATONIC AUTOMORPHISMS
46 7.3. AN EXPLORATION OF THE DISCONTINUOUS-CONTINUOUS FUSION IN YUUNOHUI'TLAPOA FOR KEY- BOARD

SIMILARITY AND DISTANCE MEASURES FOR MUSIC
47 8.1. TOWARDS MEASURING THE DISTANCES OF CHORDS OF DIFFERENT CARDINALITIES
48 8.2. A FINGERPRINTING-BASED STRATEGY FOR MUSICAL GENRE SIMILARITY
48 8.3. ASSESSING THE COMPATIBILITY BETWEEN MUSICAL PERFORMANCE AND TUNING SYSTEM

51 WORKSHOP GRUPOIDS AND MUSIC
51 PART 01 & PART 02

52 CONCERTS
52 THE MUSIC OF MATHS
54 MEMBERS OF THE SOCIETY FOR MATHEMATICS AND COMPUTATION IN MUSIC
56 QUARTETO DE COIMBRA

59 A TRIBUTE TO YVES HELLEGOUARCH

60 POSTER SESSION
60 P1. EXPLORING MODE IDENTIFICATION IN IRISH FOLK MUSIC WITH UNSUPERVISED MACHINE LEARNING AND TEMPLATE-BASED TECHNIQUES
60 P2. MINING SIGNIFICANT SEQUENTIAL CONTRAST PATTERNS
60 P3. RECURRENCE RELATIONS RHYTHM
60 P4. BITS AND BEATS: COMPUTING RHYTHMIC INFORMATION AS BITWISE OPERATIONS OPTIMIZED FOR MACHINE LEARNING
60 P5. REGULAR TEMPERAMENT THEORY: EXPLORING THE LANDSCAPE BETWEEN JI AND ETS WITH LINEAR ALGEBRA

61 VIRTUAL EXHIBITION
61 MATHEMUSICAL VIRTUAL MUSEUM & PLANET VOICES INTERACTIVE VR AND PC EXHIBITION

62 USEFUL INFORMATION
62 COFFEE BREAKS

62 DAY 01 | JUNE 18TH
62 DAY 02 | JUNE 19TH
62 DAY 03 | JUNE 20TH
62 DAY 04 | JUNE 21ST
62 WELCOME RECEPTION | JUNE 18TH, 19H30
62 GALA DINNER | JUNE 20TH, 20H00
62 UC TOUR VISIT

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DAY 01

PROGRAMME

Tuesday June 18th — Theatre Paulo Quintela, FLUC

TIME	PROGRAMME
9h00	**CHECK-IN**
9h30	**OPENING SESSION** **João Ramalho Santos,** Vice-Rector for Research UC **Albano Figueiredo,** Director FLUC **Mariana Montiel,** President SMCM **Catarina Silva,** Vice-Director CISUC **José Oliveira Martins,** Scientific Coordinator CEIS20
10h00	**› KEYNOTE 01** **35 YEARS OF WELL-FORMED SCALE THEORY: ORIGINS AND DEVELOPMENT** **Norman Carey,** Graduate Center, City University of New York **David Clampitt,** School of Music, Ohio State University
11h00	**COFFEE BREAK**
	› PANEL SESSION 01 **FOURIER ANALYSIS FOR MUSIC**
11h30	**1.1. Fourier (Common-tone) Phase Spaces are in Tune with Variational Autoencoders' Latent Space** — Nádia Carvalho and Gilberto Bernardes
12h00	**1.2. DFT and Persistent Homology for Topological Musical Data Analysis** — Victoria Callet
12h30	**1.3. Fourier Qualia Wavescapes: Hierarchical Analyses of Set Class Quality and Ambiguity** — Samuel Pereira, Giovanni Affatato, Gilberto Bernardes and Fabian C. Moss

DAY 01 | TUESDAY JUNE 18TH — THEATRE PAULO QUINTELA, FLUC

TIME	PROGRAMME
13h00	**LUNCH BREAK**
14h30	**VIRTUAL EXHIBITION** (INSTITUTO DE PALEOGRAFIA, FLUC) **MatheMusical Virtual Museum & Planet Voices Interactive VR and PC exhibition** — Gilles Baroin
14h30	**POSTER SESSION** (ATRIUM OF THEATRE PAULO QUINTELA, FLUC) **P1. Exploring mode Identification in Irish folk music with unsupervised machine learning and template-based techniques** — Juan José Navarro-Cáceres, Nádia Carvalho, Gilberto Bernardes, Diego M. Jiménez-Bravo, and María Navarro-Cáceres **P2. Mining Significant Sequential Contrast Patterns** — Darell Conklin **P3. Recurrence relations rhythm** — Michael Cohen and Yasuyuki Kachi **P4. Bits and Beats: computing rhythmic information as bitwise operations optimized for Machine Learning** — Fernando Gualda **P5. Regular Temperament Theory: Exploring the Landscape between JI and ETs with Linear Algebra** — Dave Keenan and Douglas Blumeyer

DAY 01 | TUESDAY JUNE 18TH — THEATRE PAULO QUINTELA, FLUC

TIME	PROGRAMME
	› PANEL SESSION 02 **RHYTHM ANALYSIS AND RHYTHM GENERATION**
16h00	**2.1. On Brazilian Drum Claves and Generating Rhythm Patterns Out of Them** — Quan Duong, Kjell Lemström, and Olli Reijonen
16h30	**2.2. Euclidean Rhythm with Palindromic Rests** — Paraj Mukherjee
17h00	**2.3. What Are "Good" Rhythms? Generating Rhythms Based on the Properties Set Out in The Geometry of Musical Rhythm** — Paul Lascabettes and Isabelle Bloch
17h30	**COFFEE BREAK**
18h00	**› COMMUNICATION PERFORMANCE 01** **STAGES IN MY VUZA RHYTHMIC CANONS** Violeta Dinescu
18h30	**› CONCERT 01** **THE MUSIC OF MATHS** **Moreno Andreatta,** piano **Gilles Baroin,** video graphics
19h30	**WELCOME RECEPTION** **RESTAURANT O PAPA** R. Alexandre Herculano 37, 3000-019 Coimbra

DAY 02

PROGRAMME

Wednesday June 19th — Theatre Paulo Quintela, FLUC

TIME	PROGRAMME
9h30	**CHECK-IN (AND COFFEE)**
	› PANEL SESSION 03 **THEORY AND ALGORITHMS FOR MELODIC/HARMONIC ANALYSIS AND GENERATION**
10h00	**3.1. Towards measuring the distances of chords of different cardinalities** — Kristína Hurajová and Ondrej Hutník
10h30	**3.2. Persistent Homology and Harmonic Analysis** — Riccardo C. Gilblas
11h00	**COFFEE BREAK**
11h30	**3.3. Melody and Variation Generation Through KAM Theory** — Octavio A. Agustín-Aquino and Alicia Santiago-Santos
12h00	**3.4. Melodic Contour Generation with Spline Models of Cycles** — Matt Klassen and Paul Lanthier
12h30	**3.5. Piston Words** — Shawn Michael Westmoreland
13h00	**LUNCH BREAK**
14h30	› WORKSHOP **PART 01. GRUPOIDS AND MUSIC** Dmitri Tymoczko

DAY 02 | WEDNESDAY JUNE 19TH — THEATRE PAULO QUINTELA, FLUC

TIME	PROGRAMME
	› PANEL SESSION 04 **CATEGORICAL AND ALGEBRAIC APPROACHES TO MUSIC**
15h00	**4.1. Hidden Categories: A New Perspective on Lewin's Generalized Interval Systems and Klumpenhouwer Networks** — Alexandre Popoff and Moreno Andreatta
15h30	**4.2. Finding Homometric Multiplets** — Franck Jedrzejewski
16h00	**4.3. Voice and Math: The Art of Singing in Light of Mathematical Music Theory** — Juliana Castanho-Spector, Maria Mannone, Mariana Montiel and Francisco Gómez
16h30	**4.4. Structural and Transformational Relations Between Z-Related Hexachords** — Qiuwan Zhao
17h00	**COFFEE BREAK**
17h30	› KEYNOTE 02 **THE MANY TUNINGS OF BALINESE GAMELAN** William Sethares, University of Wisconsin - Madison
18h30	› COMMUNICATION PERFORMANCE 02 **OF ALL INTERVAL TETRACHORDS AND OCTATONIC SCALES** Emmanuel Amiot

DAY 02 | WEDNESDAY JUNE 19TH — THEATRE PAULO QUINTELA, FLUC

TIME	PROGRAMME
19h00	**› CONCERT 02** **MEMBERS OF THE SOCIETY FOR MATHEMATICS AND COMPUTATION IN MUSIC** **Sonata, Alban Berg** — **Emmanuel Amiot,** piano **Non leggemo più, Emmanuel Amiot** — **Juliana Castanho-Spector,** soprano — **Emmanuel Amiot,** piano **Not Marble, Jason Yust** — **Juliana Castanho-Spector,** soprano — **Norman Carey,** piano **Amarantha, Norman Carey** — **Marta Martins,** soprano — **Patrícia Silveira,** alto — **João Pereira,** tenor **O Don Fatale, Verdi** — **Juliana Castanho-Spector,** soprano — **Norman Carey,** piano **Sonatina in D major, Franz Schubert** — **David Clampitt,** violin — **Norman Carey,** piano

DAY 03

PROGRAMME

Thursday June 20th — Theatre Paulo Quintela, FLUC

TIME	PROGRAMME
9h30	**CHECK-IN**
	› PANEL SESSION 05 **GEOMETRIC APPROACHES TO MUSICAL ALGORITHMS AND MICROTONALITY**
10h00	**5.1. Advanced Polyphonic Music Pattern Matching Algorithms with Timing Invariances** — Antti Laaksonen and Kjell Lemström
10h30	**5.2. Tonnetze and Tori for the 19-, 31-, and 53-Tone Equal Temperaments** — Luis Nuño
11h00	**COFFEE BREAK**
11h30	**5.3. A Model of Scores as Abstract Syntactic Trees** — Gonzalo Romero-García, Carlos Agón, and Isabelle Bloch
12h00	**5.4. I-Shaped Tiles in the Tonnetz** — Michael Coury-Hall
12h30	**› WORKSHOP** **PART 02. GRUPOIDS AND MUSIC** Dmitri Tymoczko
13h00	**LUNCH BREAK**

DAY 03 | THURSDAY JUNE 20TH — THEATRE PAULO QUINTELA, FLUC

TIME	PROGRAMME
	› PANEL SESSION 06 **QUANTUM MUSIC**
14h30	**6.1. Intro to Quantum Harmony: Chords in Superposition** — Christopher Dobrian and Omar Costa Hamido
15h00	**6.2. Quantum Memory and Mathematical Gestures: two Perspectives on Verdi and Wagner** — Alberto Avitabile, Omar Costa Hamido, and Maria Mannone
15h30	**6.3. Quantum Tonality: A Mathemusical Playground** — Peter beim Graben and Thomas Noll
16h00	**UC GUIDED VISIT** (MEET AT LARGO DA PORTA FÉRREA)
18h00	› PLENARY SESSION (THEATRE PAULO QUINTELA, FLUC) **PLENARY MEETING OF THE SMCM** General Assembly, SMCM
19h00	› CONCERT 03 (THEATRE PAULO QUINTELA, FLUC) **FADO DE COIMBRA** **Quarteto de Coimbra** — Fábio Almeida, voice — Tiago Rodrigues and Simão Mota, Portuguese guitar — Vasco Rodrigues, guitar
20h00	**GALA DINNER** **RESTAURANT SAPIENTIA** R. José Falcão, 3000-062 Coimbra

DAY 04

PROGRAMME

Friday June 21st — Theatre Paulo Quintela, FLUC

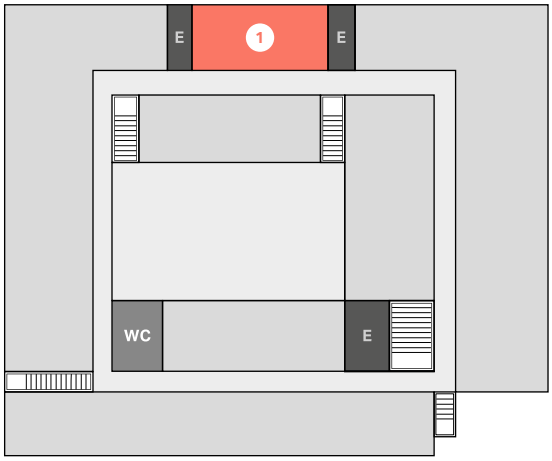
TIME	PROGRAMME
9h30	**CHECK-IN**
	› PANEL SESSION 07 **MATHEMATICAL SCALE THEORY AND TUNING**
10h00	**7.1. Quarter-Tone Music: A Tuning System Rooted in Natural Harmonic Series** — Aziz Ifzarne
10h30	**7.2. The Sandwich-Lemma: The Recursive Structure of Super-Syntonic and Super-Diatonic Automorphisms** — Thomas Noll, David Clampitt, and Mariana Montiel
11h00	**7.3. An Exploration of the Discontinuous-Continuous Fusion in Yuunohui'tlapoa for Key-board** — Julio Estrada
11h30	**COFFEE BREAK**
12h00	› COMMUNICATION PERFORMANCE 03 **ADVANCED VISUALIZATION TECHNIQUES FOR MUSIC THEORY** Gilles Baroin and Richard Cohn
12h30	› COMMUNICATION PERFORMANCE 04 **SONIFICATION OF WIGNER FUNCTIONS: CASE STUDY OF INTENSE LIGHT-MATTER INTERACTIONS** Reiko Yamada, Antoine Reserbat-Plantey, Eloy Piñol, and Maciej Lewenstein
13h00	**LUNCH BREAK**

DAY 04 | FRIDAY JUNE 21ST — THEATRE PAULO QUINTELA, FLUC

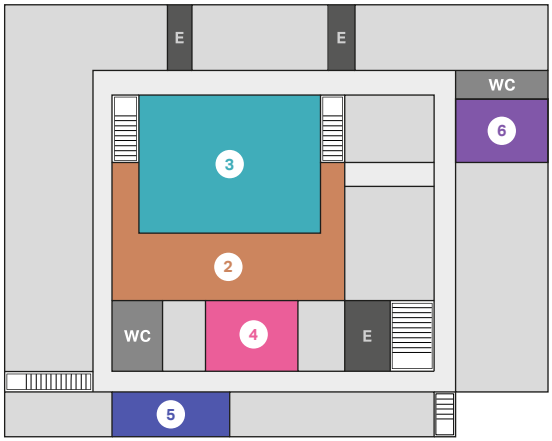
TIME	PROGRAMME
14h30	› WORKSHOP **PART 03. GRUPOIDS AND MUSIC** Dmitri Tymoczko
	› PANEL SESSION 08 **SIMILARITY AND DISTANCE MEASURES FOR MUSIC**
15h00	**8.1. Modal Pitch Space: A Computational Model of Melodic Pitch Attraction in Folk Music** — Gilberto Bernardes and Nádia Carvalho
15h30	**8.2. A fingerprinting-based strategy for musical genre similarity** — Aarón López-García
16h00	**8.3. Assessing the compatibility between musical performance and tuning system** — Brian Martínez-Rodríguez and Vicente Liern
16h30	› TRIBUTE **TRIBUTE TO YVES HELLEGOUARCZ** Franck Jedrzejewski
17h00	› COMMUNICATION PERFORMANCE 05 **CONFIGURATIONS OF DISJOINT AUGMENTATION CANONS** Jeremy Kastine
17h30	**CLOSING SESSION** Representatives of CEIS20, CISUC, SMCM

FLUC MAP

› 4TH FLOOR — FLUC



› 3RD FLOOR — FLUC



1 **ENTRANCE**

2 **ATRIUM AND REGISTRATION**
(Poster session)

3 **THEATRE PAULO QUINTELA**
(All the conferences)

4 **COFFEE BREAK**

5 **INSTITUTE OF PALEOGRAPHY**
(Virtual Exhibition)

6 **READING ROOM OF THE INSTITUTE OF ECONOMIC AND SOCIAL HISTORY**
(Music Rehearsal Room)

WC

E **ELEVATOR**

KEYNOTE SPEAKERS

PLENARY SESSION

COMMUNICATION-PERFORMANCES

PANEL SESSIONS

WORKSHOP GRUPOIDS AND MUSIC

CONCERTS

A TRIBUTE TO YVES HELLEGOUARCH

POSTER SESSION

VIRTUAL EXHIBITION

USEFUL INFORMATION

KEYNOTE SPEAKERS

› KEYNOTE 01

35 YEARS OF WELL-FORMED SCALE THEORY: ORIGINS AND DEVELOPMENT

Moderator: Thomas Noll

We present an anecdotal history of the studies that led to our first publication, the 1989 article "Aspects of Well-formed Scales" in Music Theory Spectrum, and give a brief introduction to the concepts. We explore the mathematics behind the concepts: continued fractions, distributions modulo 1, and symmetries of cyclic groups. Our precursor studies included the region notion, suppressed in the initial article, but developed in the context of the history of music theory in our 1996 Journal of Music Theory article, "Regions: A Theory of Tonal Spaces in Early Medieval Treatises."

The region concept was subsequently reinterpreted relative to central words in algebraic combinatorics on words, and was the point of departure for Carey's 2013 "Lambda Words" in Journal of Integer Sequences. We present the connection between our work and that of our principal precursor, John Clough, who with his co-author Gerald Myerson introduced Myhill's Property (MP). In our 1996 Perspectives of New Music article, "Self-similar Pitch Structures, Their Duals, and Rhythmic Analogues," we generalized MP and proved that it is equivalent to non-degenerate well-formedness. This article set the stage for the word-theoretical turn in well-formed scale theory, with an abstract scale (determined only by its cardinality N and a scale-step interval multiplicity g) represented by a circular word over a two-letter alphabet, and with examples of infinite words, later determined to be Sturmian words. It was another decade before the connections with algebraic combinatorics on words came to light, and were explored principally by Thomas Noll and Clampitt. We cover briefly the equivalence between Christoffel words and their conjugates on the one hand, and well-formed scales and their modes on the other.

Carey and Clampitt used the word theory perspective to re-prove Clough and Myerson's 1985 Cardinality Equals Variety theorem in a different mathematical context, in a special issue of Journal of Mathematics and Music, and in Theoretical Computer Science, both in 2018.

Keywords: *Well-formed scales, continued fractions, Stern-Brocot tree, Christoffel words, cyclic groups*

› **Norman Carey**
Norman Carey is the Executive Officer of the Music Department at the CUNY Graduate

Center in New York. He served on the music theory faculty of the Eastman School of Music and the piano faculty of Western Connecticut State University. As pianist, he appears on record with violist Emanuel Vardi performing the Brahms Sonatas, and drummer Elvin Jones in works of Fred Tompkins. His theoretical papers have focused on tonal analysis and scale theory, some of the latter of which, notably, are co-authored with David Clampitt. Carey is a founding member of the Society for Mathematics and Computation in Music.

› **David Clampitt**

David Clampitt is Professor-Emeritus of Music Theory at Ohio State University. He taught previously at Yale University and University of Chicago. He has published work in mathematical theory, history of music theory, and music analysis. The Society for Music Theory awarded him, together with Norman Carey, the Emerging Scholar Award in 1999, and together with Thomas Noll, the Outstanding Publication Award in 2013.

› KEYNOTE 02

THE MANY TUNINGS OF BALINESE GAMELAN

Moderator: Mariana Montiel

Gong kebyar is a widely performed style of bronze gamelan in Bali, Indonesia, that features a rich variety of tunings. Andrew Toth (1948-2007), a passionate researcher and enthusiast of Balinese music, collected tuning measurements of about 150 keys for each of 49 gamelan during his decades of fieldwork. His data, now preserved in the Wesleyan University Library, offers a valuable resource for studying the tuning practices and musical aesthetics of Balinese gamelan. In this talk, we present a novel way of accessing and analyzing Toth's data using an interactive computer program, a Max/MSP Patch called the "Gamelan Tuning Explorer."

This program allows users to listen to and manipulate the tuning data using sound, visualization, and adjustable parameters. We demonstrate how the Gamelan Tuning Explorer can reveal some of the key features of gamelan tuning, such as the ombak (the distinctive beating effect of two paired notes played in "unison""), the octave treatment (the degree of alignment or divergence between octaves), and the octave stretching or compression (the deviation from the equal-tempered octave). We hope that this program will enhance the understanding and appreciation of the diversity and complexity of Balinese gamelan tuning among scholars, musicians, and listeners.

Ongoing work with **Wayne Vitale**.

Keywords: *Gamelan, tuning, gong kebyar, ombak, octave*

› **William Sethares**

William Sethares received the Ph.D. degree in electrical engineering from Cornell University, and is currently Professor in the Department of Electrical and Computer Engineering at the University of Wisconsin in Madison. His research interests include adaptation and learning in audio, image and signal processing with special focus on the translation of qualitative models of perception into quantitative models. Dr. Sethares is the author of five books, including "Tuning, Timbre, Spectrum, Scale," and "Rhythm and Transforms," which apply perceptual models to the processing (and understanding) of sound.

PLENARY SESSION

GENERAL MEETING OF THE SOCIETY OF MATHEMATICS AND COMPUTATION IN MUSIC GENERAL ASSEMBLY, SMCM

COMMUNICATION-PERFORMANCES

› COMMUNICATION PERFORMANCE 01

STAGES IN MY VUZA RHYTHMIC CANONS

Several stages in understanding and using the Vuza rhythmic canon structure are enumerated. The starting idea was to compose Vuza canons of moments instead of Vuza canons of single notes. The next idea was to integrate such Vuza canons in more complex structures: polyphony of a Vuza canon and one or more melodies, polyphony of Vuza canons, polyphony of Vuza canons and other musical structures. Another stage was that of Vuza canons of attacks, allowing overlapping of voices, but not of attacks. This musical form is in the spirit of classical canons.

Chair: Jônatas Manzolli

› **Violeta Dinescu**

Romanian composer, now resident in Germany, of mostly stage, orchestral, chamber, choral, vocal, and piano works that have been performed throughout the world.

Prof. Dinescu graduated in mathematics and physics from Colegiul Național Gheorghe Lazăr in Bucharest in 1972, then pursued studies in composition, music pedagogy, and piano at Universitatea Națională de Muzică București from 1972 to 1978. During this time, she studied analysis with Ștefan Niculescu and composition with Myriam Marbe in 1977-78. She furthered her education in musicology in Heidelberg for two years. Her academic and professional excellence has been recognized with multiple awards, including four prizes from the Uniunea Compozitorilor și Muzicologilor din România (1975–76, 1980, 1983), Zweiter Preis in the GEDOK competition in Mannheim (1982), First Prize in Utah (1983), Terzo Premio in the G. B. Viotti competition in Vercelli (1983), and the Carl-Maria-von-Weber-Preis (1985). In 2017, she was inducted into the Europäische Akademie der Wissenschaften und Künste.

Prof. Dinescu has held numerous significant positions throughout her career. She has been a member of the executive board of directors of the International Alliance for Women in Music since 1985 and founded the Komponisten-Colloquium in Oldenburg in 1996, serving as its director since its inception. In 2000, she established the Archiv für Osteuropäische Musik in Oldenburg and has organized the annual symposia series Zwischen Zeiten since 2006. Her teaching career includes positions at the Școala de Muzică George Enescu in Bucharest (1978–82), the Hochschule für Kirchenmusik Heidelberg (1986–91), and the Hochschule für Musik und Darstellende Kunst in Frankfurt am Main (1989–92). She also lectured at the Hochschule für evangelische Kirchenmusik Bayreuth (1990–94) and

has been a Professor für Angewandte Komposition at the Carl von Ossietzky Universität Oldenburg since 1996. Prof. Dinescu has also given lectures internationally, including in South Africa and the USA.

› COMMUNICATION PERFORMANCE 02

OF ALL INTERVAL TETRACHORDS AND OCTATONIC SCALES

Serendipity is another name for method. When order appears unexpectedly in music, the explanation is so often mathematical. Here, a nice feature of a hand-made picture revolves about the Sylow subgroups of the affine group modulo 12 (and of its maximal normal subgroup T / I), explaining the surprise occurrence of octatonic scales when trying to organize al-interval tetrachords by common dyads.

Chair: Mariana Montiel

› **Emmanuel Amiot**

Emmanuel Amiot is a dedicated researcher in mathematics and music, specialized in algebra of musical objects. He penned a monography on musical applications of the Discrete Fourier transform, including homometry which happens precisely among all-interval tetrachords.

› COMMUNICATION PERFORMANCE 03

ADVANCED VISUALIZATION TECHNIQUES FOR MUSIC THEORY

Authors such as Hook, Tymozcko, and Cohn have used still imagery to model relation systematic pitch correlation and convey new analytical insights. Here we explore the pedagogical advantages of using industry-level graphic software to produce animations in a visual language to which many users are habituated.

This paper describes some of the technological resources and the advantages that they afford. It then presents fixed-image representations, and describes animated ones, of analyses of short cyclic progressions of harmonies in songs by Richard Rodgers (as performed by Ella Fitzgerald) and Nick Cave (as adapted and performed by Johnny Cash), as well as a passage of Schubert.

Chair: William Sethares

› **Gilles Baroin**

Gilles Baroin is a mathemusician, specialized in geometric visualization of musical structures and processes. Doctor-engineer, he is the designer of Planet-4D model used for visualizing musical systems and harmonic progressions in four dimensions. He regularly collaborates with artists, musicians and composers, and give scientific talks in international universities and conservatories (i.e Shangai, Montreal, London, Ljubljana, Moscow, Madrid, Tokyo, Baltimore, ...). Starting from the mere Newton chromatic circle, the Planet-4D Models can display continuous and discrete musical spaces, irregular temperaments, tonal, atonal and spectral music, and lately 24tone creations. Now developing for Virtual Reality, he is the creator of the first Mathemusical Virtual Museum that was premiered in the Museum of Design of Atlanta and guest at Kyoto's Virtual Learning Labs 2023. His last software creation, "Planet-Voices" is a new approach to generate chords and harmonic paths in real time in different geometrical spaces, by using "Voice Leading" technique. More on: www.mathemusic.net

› **Richard Cohn**

Richard Cohn received his PhD from the Eastman School of Music in 1987, with a dissertation on transpositional combination in atonal music, under the supervision of Robert D. Morris. Early articles focused on music of Bartók and Schenkerian theory. He taught in the Music Department at the University of Chicago from 1985, where he served as Department Chair from 1998 to 2001. In 2004, he founded Oxford Studies in Music Theory, which he edited for Oxford University Press for ten years. In 2005 he was appointed Battell Professor of the Theory of Music at Yale University. He is currently Executive Editor of the Journal of Music Theory.

› COMMUNICATION PERFORMANCE 04

SONIFICATION OF WIGNER FUNCTIONS: CASE STUDY OF INTENSE LIGHTMATTER INTERACTIONS

In quantum mechanics, the Wigner function ρW(r, p) serves as a phase-space representation, capturing information about both the position r and momentum p of a quantum system. The Wigner function facilitates the calculation of expectation values of observables, examination of quantum system dynamics, and analysis of coherence and correlations. Therefore, it might serve as a tool to express quantum systems intuitively, for example, by using sonification techniques. This paper summarizes the experimental strategies employed in a previous project and delineates a new approach based on its outcomes. Emphasizing the attribution of specific Wigner functions to their underlying quantum states, dynamics, and sources;

our proposed methodology seeks to refine the sonification and scoring process, aiming to enhance intuitive understanding and interpretation of quantum phenomena.

Chair: William Sethares

› **Eloy Piñol**
› **Maciej Lewenstei**
› **Antoine Reserbat-Planteye — Soprano Saxophon**

› **Reiko Yamada — Electronics**
Reiko Yamada is a composer and sound artist, originally from Hiroshima, Japan. She composes concert works, creates sound art installations and works with interdisciplinary collaborators. Her work explores the aesthetic concept of imperfection in a variety of contexts.

Yamada holds a D.Mus in composition from McGill University, and is a recipient of numerous prestigious awards and fellowships. She was a 2015-16 Fellow at the Radcliffe Institute for Advanced Study of Harvard University, the 2016-17 artist-in-residence at IEM (Institut für Elektronische Musik und Akustik), the 2018 Innovator-in-Residence at Colorado College, and 2020-21 S+T+ARTS resident artist. Her various projects have been commissioned and/or funded by New Music USA, the Canada Council for the Arts, IRCAM (the Institute for Research and Coordination in Acoustics/Music), CIRMMT (the Centre for Interdisciplinary Research in Music Media and Technology), the Conseil des arts et des lettres du Québec, Armitage Gone! Dance, the Zentrum für Orgelforschung der Kunstuniversität Graz and the European Commission among others. Her works have been presented in venues such as The Metropolitan Museum Breuer (New York). She is currently a postdoctoral researcher at ICFO (Institute for Photonic Sciences) and composer-in-residence at Phonos Foundation in Barcelona.

› **Omar Costa Hamido — Alto Saxophone**
OCH is a performer-composer-technologist working on music and quantum computing, telematics, multimedia, and improvisation. He is passionate about emerging technology, cinema, teaching, and performing new works. He earned his PhD at UC Irvine with his research Adventures in Quantumland (quantumland.art). He also earned his MA in Music Theory and Composition at ESMAE with his research on the relations between music and painting. In recent years, his work has been recognized with grants and awards from MSCA, Fulbright, FCT, Medici, Beall Center for Art+Technology, and IBM. omarcostahamido.com

› COMMUNICATION PERFORMANCE 05
CONFIGURATIONS OF DISJOINT AUGMENTATION CANONS

This paper introduces the concept of configurations of disjoint augmentation canons. A simple necessary and sufficient condition is given for the feasibility of any given 2-part n-note configuration.

Chair: Omar Costa Hamido

› **Jeremy Kastine**

PANEL SESSIONS

› PANEL SESSION 01

FOURIER ANALYSIS FOR MUSIC

Chair: Omar Costa Hamido

1.1. FOURIER (COMMON-TONE) PHASE SPACES ARE IN TUNE WITH VARIATIONAL AUTOENCODERS' LATENT SPACE

Expanding upon the potential of generative machine learning to create atemporal latent space representations of musical-theoretical and cognitive interest, we delve into their explainability by formulating and testing hypotheses on their alignment with DFT phase spaces from {0,1}^12 pitch classes and {0,1}^128 pitch distributions -- capturing common-tone tonal functional harmony and parsimonious voice-leading principles, respectively. We use 371 J.S. Bach chorales as a benchmark to train a Variational Autoencoder on a representative piano roll encoding. The Spearman rank correlation between the latent space and the two before-mentioned DFT phase spaces exhibits a robust rank association of approximately .65 +- .05 for pitch classes and .61+- .05 for pitch distributions, denoting an effective preservation of harmonic functional clusters per region and parsimonious voice-leading. Furthermore, our analysis prompts essential inquiries about the stylistic characteristics inferred from the rank deviations to the DFT phase space and the balance between the two DFT phase spaces.

Keywords: *Variational Autoencoders, Latent Space, Discrete Fourier Transform, Musical Harmony Analysis*

› **Nádia Carvalho**

Nádia Carvalho's musical journey began in 2005, leading her to complete a Bachelor's in Musical Composition at ESMAE in 2015. She also studied at the Royal School of Music in Stockholm. Concurrently, she pursued an Integrated Master's in Informatics and Computer Engineering at FEUP, focusing her dissertation on musical informatics. Engaging in the ERASMUS project Co-POEM, she collaborated with universities to modernize musical education through interactive games. Currently enrolled in the Digital Media Doctorate Program at FEUP, she continues to bridge the gap between music and technology in her academic research.

› **Gilberto Bernardes**

Gilberto Bernardes holds a Ph.D. in Digital Media from the University of Porto under the auspices of the University of Texas at Austin. He is an Assistant Professor at Universidade do Porto and a Senior Researcher at INESC TEC, where he leads the Sound and Music Computing Lab. With a prolific publication record of 90+ works, he maintains extensive international collaborations and oversees numerous Ph.D. and Master's candidates. He has been honored with nine awards, notably the Fraunhofer Portugal Prize, and has played pivotal roles in securing funding and participating in 12 research projects. Presently, Bernardes leads the Portuguese team in the EU-DIGIFOLK project. His research contributions encompass work in generative AI models, sound synthesis, music cognition, and the intersection of music and well-being.

1.2. DFT AND PERSISTENT HOMOLOGY FOR TOPOLOGICAL MUSICAL DATA ANALYSIS

There are several works that already exist in the context of persistent homology for Topological Musical Data Analysis, and we can cite Bergomi (2015) and Bigo and Andreatta (2019) among others: in each one of these works, the main problem is to find how we can associate a point cloud with a musical score, that is a set of points with a metric. This paper proposes to combine persistent homology with a symbolic representation of musical structures given by the Discrete Fourier Transform to answer this question: the points are the musical bars and the metric is given by the DFT in dimension two. We start with the mathematical background, and the main goal of this paper is thus to support the use of the DFT in this context, by extracting barcodes from artificially constructed scores based on Tonnetze, and then recovering topological features.

Keywords: *Filtered simplicial complex, Persistent homology, Barcodes, Discrete Fourier Transform, Topological Data Analysis, Musical analysis, Tonnetz*

› **Victoria Callet**

I have a PhD in mathematics and an agrégation in mathematics. I completed my thesis under the supervision of Moreno Andreatta and Pierre Guillot. I work at the Institut de Recherche Mathématiques Avancées in Strasbourg and teach mathematics at the Institut Nationale des Sciences Appliquées in the same city. My research interests include topological analysis of musical structures and automatic style classification using persistent homology and, more recently, Discrete Fourier Transform.

1.3. FOURIER QUALIA WAVESCAPES: HIERARCHICAL ANALYSES OF SET CLASS QUALITY AND AMBIGUITY

We introduce a novel perspective on set-class analysis combining the DFT magnitudes with the music visualisation technique of wavescapes. With such a combination, we create a visual representation of a piece's multidimensional qualia, where different colours indicate saliency in chromaticity, diadicity, triadicity, octatonicity, diatonicity, and whole-tone quality. At the centre of our methods are: 1) the formal definition of the Fourier Qualia Space (FQS), 2) its particular ordering of DFT coefficients that delineate regions linked to different musical aesthetics, and 3) the mapping of such regions into a coloured wavescape. Furthermore, we demonstrate the intrinsic capability of the FQS to express qualia ambiguity and map it into a synopsis wavescape. Finally, we showcase the application of our methods by presenting a few analytical remarks on Bach's Three-part Invention BWV 795, Debussy's Reflets dans l'eau, and Webern's Four Pieces for Violin and Piano, Op. 7, No. 1, unveiling increasingly ambiguous wavescapes.

Keywords: *Fourier Qualia Space, Wavescapes, Fourier transform, Music analysis, Harmonic qualities*

› **Samuel Pereira**
Samuel Pereira earned his degree in musical composition from the School of Music and Performing Arts (ESMAE), where he perfected his skills as a composer. He also holds a master's degree in Multimedia from the University of Porto, with a specialization in interactive music and sound design. Since October 2021, he has been a PhD scholarship holder with the Foundation for Science and Technology (FCT). His research focuses on analyzing musical syntax and harmonic motion in 20th century works, using advanced techniques from computational musicology.

› **Giovanni Affatato**
› **Gilberto Bernardes** (Biography on page 31)

› **Fabian C. Moss**
Fabian Moss is Assistant Professor for Digital Music Philology and Music Theory at Julius-Maximilians University Würzburg (JMU), Germany, and is also affiliated with the Zentrum für Philologie und Digitalität (ZPD). In his research, he bridges concepts and methodologies from the humanities and the sciences, and aims to understand music and its structure from an inherently interdisciplinary perspective, involving fields such as musicology and music theory, mathematics, music information retrieval, machine learning, music cognition, and

the digital humanities. One of my central interests lies in analyzing large digital corpora in order to better understand musical styles, especially from a historical viewpoint.

› PANEL SESSION 02

RHYTHM ANALYSIS AND RHYTHM GENERATION

Chair: Jônatas Manzolli

2.1. ON BRAZILIAN DRUM CLAVES AND GENERATING RHYTHM PATTERNS OUT OF THEM

Rhythmic patterns, or claves, are fundamental to many Latin American and Caribbean music styles. Clave rhythms are used as drum patterns to provide rhythmic frameworks and are often used as the basis for improvisation. This paper introduces the theory of Brazilian claves and how they can be understood in the Western music framework based on measures. This is the first systematic ethnomusicological model ever presented for the Brazilian clave system. Moreover, we present a simple but effective genetic algorithm that generates random Brazilian-style rhythms based on the clave theory introduced.

Keywords: *Brazilian Drum, Rhythm generation, Claves*

› **Quan Duong**

› **Kjell Lemström**
K. Lemström received his Ph.D. in Computer Science in 2000 from the University of Helsinki, where he is now a Senior University Lecturer. His current research interests include algorithmics, music informatics and learning analytics.

› **Olli Reijonen**

2.2. EUCLIDEAN RHYTHM WITH PALINDROMIC RESTS

Through an inspection of the rhythms used in Indian Classical music, one can easily see how frequently Euclidean rhythms are used, especially the rhythms in which the rests have a palindromic structure. In this paper, we characterize this family of rhythms. We look at

the geometric properties of such rhythms using tools that are very frequently used in live performances of Indian Classical music. We show how operations can be defined on such rhythms to construct a larger family of rhythms. Towards the end of the paper, we show applications of these rhythms in contemporary Indian Classical music.

Keywords: *Euclidean rhythm, Indian Classical music, Erdős deep rhythm, Homometric rhythm, palindromes*

› **Paraj Mukherjee**
Paraj Mukherjee is currently pursuing his undergraduate degree in mathematics from Ramakrishna Mission Vidyamandira. His areas of interest are number theory, commutative algebra, logic, and the intersection of mathematics and music. Apart from mathematics, Paraj has a keen interest in playing various Indian classical instruments like the sarod and tabla.

2.3. WHAT ARE "GOOD" RHYTHMS? GENERATING RHYTHMS BASED ON THE PROPERTIES SET OUT IN THE GEOMETRY OF MUSICAL RHYTHM

We propose in this article to generate good rhythms from geometric properties. This approach is based on the work by Toussaint, who investigated the properties that make a "good" rhythm good in his book The Geometry of Musical Rhythm. To do this, he analyzed the shapes of polygons corresponding to certain rhythms to derive geometric properties of a good rhythm. In this article, we propose to quantify these properties using original mathematical formulas. This scores each rhythm against several properties to measure how good a rhythm is, resulting in the generation of rhythms with k onsets and n pulses.

Keywords: *Musical rhythm, Geometry of music, Generating music, Geometrical modeling of rhythms*

› **Paul Lascabettes**
Paul Lascabettes is a postdoctoral researcher at the University of Strasbourg. He obtained his PhD in November 2023 at Ircam in the Musical Representation team.

› **Isabelle Bloch**
Isabelle Bloch graduated from the Ecole des Mines de Paris, Paris, France, in 1986, and received the master degree from the University Paris 12 in 1987, the Ph.D. degree from the Ecole Nationale Supérieure des Télécommunications (Télécom Paris) in 1990, and the

Habilitation degree from University Paris 5 in 1995. She has been a Professor at Télécom Paris until 2020 and is now a Professor at Sorbonne Université. Her current research interests include 3D image understanding, mathematical morphology, fuzzy set theory, structural, graph-based, and knowledge-based object recognition, spatial reasoning, logics, symbolic, hybrid and explainable artificial intelligence, with applications in medical imaging, symbolic representations of music, and digital humanities.

› PANEL SESSION 03

THEORY AND ALGORITHMS FOR MELODIC/HARMONIC ANALYSIS AND GENERATION

Chair: Dmitri Tymoczko

3.1. MODAL PITCH SPACE: A COMPUTATIONAL MODEL OF MELODIC PITCH ATTRACTION IN FOLK MUSIC

We introduce a computational model that quantifies melodic pitch attraction in diatonic modal folk music, extending Lerdahl's Tonal Pitch Space. The model incorporates four melodic pitch indicators: vertical embedding distance, horizontal step distance, semitone interval distance, and relative stability. Empirical evaluation, spanning Dutch, Irish, and Spanish folk traditions across Ionian, Dorian, Mixolydian, and Aeolian modes, uncovers a robust linear relationship between melodic pitch transitions and the pitch attraction model infused with empirically derived knowledge. Indicator weights demonstrate cross-tradition generalizability, highlighting the significance of vertical embedding distance and relative stability. Semitone and horizontal step distances assume residual and null functions, respectively.

Keywords: *Modal, Pitch attraction, Folk music, Empirical*

› **Gilberto Bernardes** (Biography on page 31)
› **Nádia Carvalho** (Biography on page 30)

3.2. PERSISTENT HOMOLOGY AND HARMONIC ANALYSIS

In this paper, we apply persistent homology, one of the main tools in Topological Data Analysis, to the study of harmonic complexity of musical pieces. A directed weighted graph of chords

provides a flexible structure that allows to adapt the distances between chords to a training corpus and to retain the asymmetry of human perception of chord progressions. Each musical piece of the corpus is modeled as a sequence of chords, which is used to compute the persistent homology of the simplicial complexes obtained by the Dowker filtration. The values associated to persistence barcodes are then studied to link the geometric properties of the simplicial complexes to the harmonic characteristics of the musical pieces.

Keywords: *Persistent homology, digraph, dowker, harmony*

› **Riccardo C. Gilblas**
Master degree in Mathematics (Padua/Bordeaux) in 2020 with the Algant programme; focus on algebraic geometry. Master degree in piano performance (Padua) in 2021 at conservatory C. Pollini. PhD in Mathematics (Padua/Strasbourg) in 2024 with Moreno Andreatta and Luisa Fiorot as supervisors. PhD Thesis: "Periodic sequences and persistent homology applied to music - theoretical foundations and new results".

› PANEL SESSION 04

CATEGORICAL AND ALGEBRAIC APPROACHES TO MUSIC

Chair: David Campitt

4.1. HIDDEN CATEGORIES: A NEW PERSPECTIVE ON LEWIN'S GENERALIZED INTERVAL SYSTEMS AND KLUMPENHOUWER NETWORKS

In this work we provide a categorical formalization of several constructions found in transformational music theory. We first revisit David Lewin's construction of a Generalized Interval System (GIS) to show that even a subset of the GIS conditions already implies a sequence of functors between categories. When all the conditions in Lewin's definition are fullfilled, this sequence involves the category of elements for the group action implied by the GIS structure. By focusing on the role played by categories of elements in such a context, we reformulate previous definitions of transformational networks in a Cat-based diagrammatic perspective, and present a new definition of categorical transformational networks, or 'CT-Nets', in more general musical categories. We show how such an approach provides a bridge between algebraic, geometrical, and graph-theoretical approaches in transformational music analysis. We end with a discussion on the new perspectives opened by such a formalization of transformational theory, in particular with respect to Rel-based

transformational networks which occur in well-known music-theoretical constructions such as Douthett's and Steinbach's Cube Dance.

Keywords: *Transformational Music Theory, Generalized Interval System, Category Theory, Transformational, Networks, Cube Dance*

› **Alexandre Popoff**
Alexandre Popoff is currently a Data Scientist in machine learning for medical image processing. He holds a graduate-level engineering diploma from the French 'grande école' Ecole Supérieure de Physique et Chimie Industrielle and a Ph.D. in organic chemistry. As an independent researcher, he has explored the field of mathematics and music since 2010, focusing mainly on transformational music theory. His research explores the generalization of Lewin's group theoretical approach using category theory, and the formalization of analytical musical networks (Klumpenhouwer networks), as well as the computational aspects of transformational music theory, having developed a Python library ('opycleid') for such uses. Other research interests include the analysis of John Cage's indeterminate music (in particular the 'Number Pieces'), and film music analysis using transformational theory.

› **Moreno Andreatta**
Moreno Andreatta holds diplomas in mathematics from the University of Pavia, piano performance from the Novara Conservatory and computational musicology from the EHESS in Paris. CNRS Director of research in mathematics and music at IRMA (Institute of research in advanced mathematics), he is also associate researcher at the IRCAM Music Representation Team. He teaches currently formal models of pop music and improvisation within the bachelor degree in musicology and popular music of the university of Strasbourg as well as computational musicology within the ATIAM Master Program of Sorbonne University in Paris. Alongside his scientific activity, Moreno Andreatta has always cultivated his passion for improvisation and poetry-based song composition (with or without the use of mathematics). His first concept album, entitled “Un racconto” and signed by the collective Le Bateau Ivre, has been released in 2022 by the label “Storie di Note” (EGEA Music distribution). For a detailed description of the mathematically-driven musical activity, with online excerpts, see at: www.morenoandreatta.com.

4.2. FINDING HOMOMETRIC MULTIPLETS

In the article On Extended Z-triples (1981), David Lewin proved that Z-sets introduced by Allen Forte, which are neither transposed nor inverted forms and which have the same interval

vector are not necessarily pairs. In a N = 16 degrees equal temperament, he exhibited triples of pcsets which are Z-associated. In this paper, we give a general formula for all homometric triples of pentachords, and some new methods to construct homometric multiplet.

Keywords: *Z-Relation, Homometric Sets, Lewin, Forte*

› **Franck Jedrzejewski**
Franck Jedrzejewski is a researcher in mathematical physics at INSTN/CEA (Paris-Saclay University). He has also a PhD in music and musicology and in philosophy. In 2013, he was elected Director of program at College International de Philosophie (CIPh), an institute founded in 1983 by Jacques Derrida, François Châtelet, and Dominique Lecourt. He has published more than 20 books, most of them in French: Dictionnaire des musiques microtonales (Dictionary of Microtonal Music), Hétérotopies musicales (Modèles mathématiques de la musique), La musique dodécaphonique et sérielle : une nouvelle histoire, or in English Looking at Numbers with the composer Tom Johnson and A Compendium of Musical Mathematics. His research is highly transdisciplinary (music, philosophy, mathematics, and Polish and Russian avant-gardes).

4.3. VOICE AND MATH: THE ART OF SINGING IN LIGHT OF MATHEMATICAL MUSIC THEORY

Elements of a Vocal Gesture Theory, previously developed as an abstract approximation, have served as the basis for the present work in which the theoretical aspect of this development is refined to accommodate concrete realities that the singer confronts. In particular, the connection between musical thinking (symbolic gestures) and performance (concrete gestures) can be described by a mathematical approach. On the one hand, singers have to imagine the vocal effect they wish to obtain, and, on the other hand, they must carry out concrete physical inner movements of their larynx, vocal folds, etc., to achieve the desired effect. Mathematical Gesture Theory can provide a framework to help understand how such imaginary and embodied movements relate one to another, as well as how they are connected in the practice of singing. Additionally, voice pedagogy, in general, is tremendously subjective and, as in all creative processes, what works for one singer does not necessarily

Keywords: *gesture theory, voice physiology, belcanto*

› **Juliana Castanho-Spector**
Juliana Castanho-Spector is a classically-trained singer and voice teacher with over twenty

years of experience performing operatic works and art songs. She is currently a doctoral candidate in Music and its Science and Technology at UPM (Universidad Politécnica de Madrid).

› **Maria Mannone**
Maria Mannone achieved her MSc in Theoretical Physics at the University of Palermo (Italy, 2012), three MAs at the Music Conservatory of Palermo (Piano, 2008; Composition, 2009; Orchestral Conducting, 2012), her Master 2 in Acoustics, Signal Processing, and Computer Science applied to Music (ATIAM) at IRCAM - UPMC Paris VI Sorbonne (France, 2013), and her PhD in Composition at the University of Minnesota (USA, 2017). Her research concerns swarm robotics, quantum computing, complex networks, and mathematics-music. She is a researcher at CNR and PhD student in Physics (University of Potsdam). She is an improviser of the Female Laptop Orchestra.

› **Mariana Montiel**
Mariana Montiel is Associate Professor at Georgia State University and President of the Society for Mathematics and Computation in Music: http://www.smcm-net.info/ . Her research revolves around Mathematical Music Theory and frequently she carries out interdisciplinary work with music theorists, computer scientists, and physicists. Simultaneously she cultivates a research interest in pedagogical aspects and, in particular, in the use of abstract and symbolic representations, common to both disciplines, mathematics and music.

› **Francisco Gómez**
Dr. Gomez is a researcher and a mathematics professor at Universidad Politécnica de Madrid. He does research in mathematical music theory where he has contributed in topics such as Euclidean rhythms, melodic similarity, mathematical models of emotions in music, rhetorical patterns, and multi-octave scales, just to name his main topics. He is also interested in the pedagogy of mathematics through inquiry-based and emotion-based teaching methods. He also does outreach for mathematics.

4.4. STRUCTURAL AND TRANSFORMATIONAL RELATIONS BETWEEN Z-RELATED HEXACHORDS

This paper investigates the structural and transformational relationships between Z-related hexachords in Z_12. We demonstrate that subsets with prime forms [06] or [016] are crucial for defining the structure of complementary Z-related hexachords. We present a categorization of Z-related hexachords based on the discrete Fourier transform (DFT). The categorization aligns with the relative positions of the [06] subsets in the hexachord. Moreover, we introduce

the method of dyad expansion for interpreting the transformational relationships between Z-related hexachords.

Keywords: *Z-relation, interval content, set theory, transformational theory*

› **Qiuwan Zhao**
Qiuwan Zhao was born in Beijing, China. She is a rising senior at the Eastman School of Music, University of Rochester, studying Music Theory and Applied Mathematics with a minor in Computer Science. Her research interests include musical spaces, transformational theory, and the applications of computational methods in musical analysis. Beyond academics, Qiuwan has studied piano for 14 years and is currently a student of Tamari Gurevich.

› PANEL SESSION 05

GEOMETRIC APPROACHES TO MUSICAL ALGORITHMS AND MICROTONALITY

Chair: Riccardo Wanke

5.1. ADVANCED POLYPHONIC MUSIC PATTERN MATCHING ALGORITHMS WITH TIMING INVARIANCES

This paper considers polyphonic pattern matching in symbolically encoded music under transposition invariance. We show how, in two specific retrieval problems, the worst-case time complexities can be improved by an order of magnitude by applying a relatively straightforward algorithm design technique. Moreover, the technique applies to most of the previously best-known algorithms for the other cases of the problem category, giving comparable worst-case running times. In general, given two point sets, a musical work T and a pattern P, the task is to find possibly transposed occurrences of P in T. The occurrences may be full or partial, with or without time-warping or time-scaling. The technique uses a merge-like approach to incrementally build pattern occurrences using sorted lists of notes. The algorithms search for incomplete matches that are subsequently extended as far as possible.

Keywords: *Music pattern matching, Geometric algorithms, Timing invariances*

› **Antti Laaksonen**
Dr. Antti Laaksonen works as a university lecturer at the Department of Computer Science of

the University of Helsinki. He studies algorithms for efficiently processing symbolic musical data, including finding musical pattern occurrences and detecting repeating patterns.

› **Kjell Lemström** (Biography on page 33)

5.2. TONNETZE AND TORI FOR THE 19-, 31-, AND 53-TONE EQUAL TEMPERAMENTS

The Tonnetz has proved to be useful for analyzing some chromatic passages of the nineteenth century, as well as for composition. In most cases, it implements the ordinary 12-tone equal temperament or 12-TET. However, the consonances are only exactly matched in just intonation, which has infinite notes. Therefore, other finite tuning systems were developed to better approximate it, among them 19-, 31-, and 53 TET, which in turn gave rise to related new instruments. In this paper, the Tonnetze and tori for these tuning systems are developed, which are intended to be helpful when using them.

Keywords: *Tonnetz, 19-TET, 31-TET, 53-TET, Neo-Riemannian theory*

› **Luis Nuño**
Professor at the Polytechnic University of Valencia (Spain). Research lines: numerical methods in electromagnetics, electromagnetic compatibility, and mathematics and music. He participated in the last two Congresses of Mathematics and Computation in Music (MCM): Madrid 2019 and Atlanta 2022. In the last one, he presented his "Harmonic Wheel" at the Museum of Design Atlanta (MODA). He publishes scientific papers mainly in IEEE Transactions on Electromagnetic Compatibility and Journal of Mathematics and Music. He also composes music for guitar and has published 2 CD's.

5.3. A MODEL OF SCORES AS ABSTRACT SYNTACTIC TREES

This paper deals with the structure of a musical piece. The score is modeled as an Abstract Syntactic Tree (AST) to account for the hierarchy of its elements. Formal definitions of harmony, texture and instrumentation are proposed and constitute the main components of the model. Concatenation and parallelization operators are then proposed to combine these components and organize them in a tree structure. This approach is illustrated on some examples.

Keywords: *Harmony, Texture, Instrumentation, Abstract Syntactic Tree, Hierarchical score modeling*

› **Gonzalo Romero-García**
Gonzalo Romero-García is a mathematician, computer scientist and musician specialized in the use of mathematical models and computer programs for the analysis and generation of tonal music. He studied at Universidad Complutense de Madrid and the Real Conservatorio de Música de Madrid and earned his PhD at Sorbonne University on the use of mathematical morphology for analysis and generation of time-frequency representations of music. He is interested both in the signal and symbolic representations of music and uses spectrograms, MusicXML files, piano rolls and graphs as musical inputs.

› **Carlos Agón**
Carlos Agon is a professor of Computer Science at Sorbonne University and a researcher in Computer Music at IRCAM in Paris. He first studied computer science at the Universidad de los Andes in Bogota, Colombia. After obtaining his Ph.D. in computer science from the University of Paris VI in 1998, he received the HDR (Habilitation à diriger des recherches) in 2003 with a thesis on "Programming Languages for Computer-Aided Composition." He implemented the OpenMusic visual programming language, which has been used in the composition of several musical works. Currently, he is the director of the Doctoral School EDITE.

› **Isabelle Bloch** (Biography on page 34)

5.4. I-SHAPED TILES IN THE TONNETZ

An I -shaped tile proposed in this paper is used to construct an enharmonically conformed Tonnetz space that preserves more music-theoretic information related to tonality, arguably the original purpose of a Tonnetz, than the standard parallelogram tiles currently used in the literature. The resulting tiling is monohedral, monomorphic and enantiomorphic, giving music-theoretic meaning in particular to the non- horizontal tile boundaries that cross fifths-related regions.

Keywords: *Tiling, Diatonic, Myhill's Property Tonality*

› **Michael Coury-Hall**
M. A. (Mike) Coury-Hall works on Wall Street during the day and studies music, composition, and music theory in the evenings through the Juilliard Evening Division since 2010. He is Co-Chair of the SMT Mathematics of Music Interest Group since 2019. He has presented at the annual meetings for MTMW in 2021 and 2023 and the annual meetings for Society

for Music Theory in 2019, 2020, and 2023 (poster sessions) and 2021 (presentation). He is interested in the applications of mathematical models in music theory and analysis.

› PANEL SESSION 06

QUANTUM MUSIC

Chair: Nuno Trocado

6.1. INTRO TO QUANTUM HARMONY: CHORDS IN SUPERPOSITION

Correlations between quantum theory and music theory—specifically between principles of quantum computing and musical harmony—can lead to new understandings and new methodologies for music theorists and composers. The quantum principle of superposition is shown to be closely related to different interpretations of musical meaning. Superposition is implemented directly in the authors' simulations of quantum computing, as applied in the decision-making processes of computer-generated music composition.

Keywords: *Harmony, Quantum Theory, QAC, Superposition*

› **Christopher Dobrian**
Christopher Dobrian is Professor of Music and Informatics at the University of California, Irvine. A composer of instrumental and electronic music, he conducts research on the development of artificially intelligent interactive computer systems for the cognition, composition, and improvisation of music. He is the author of the original reference documentation and tutorials for the Max, MSP, and Jitter programming environments by Cycling '74. He holds a Ph.D. from the University of California, San Diego, where he studied composition with Joji Yuasa, Robert Erickson, Morton Feldman, and Bernard Rands, computer music with Richard Moore and George Lewis, and classical guitar with Celin and Pepe Romero.

› **Omar Costa Hamido** (Biography on page 28)

6.2. QUANTUM MEMORY AND MATHEMATICAL GESTURES: TWO PERSPECTIVES ON VERDI AND WAGNER

Concepts and methods from theoretical physics and abstract mathematics can inspire

new techniques to analyze the structure of musical compositions, seen as the unfolding of phenomena over time. Here, we consider an adaptation to music of a criterion to measure memory in quantum states (degree of non-Markovianity) and elements from the mathematical theory of musical gestures. We analyze salient features of two opera pieces, from Verdi's La forza del destino and Wagner's Tristan und Isolde, commenting the obtained results and the limits of these techniques.

Keywords: *non-Markovianity, category theory, opera, orchestra*

› **Alberto Avitabile**
Alberto Avitabile is a post-graduate student in mathematics from "La Sapienza" University of Rome, with a background in complex algebraic geometry and topology. As a music enthusiast, his thesis work introduced him to gesture theory and mathematical music theory. He is mainly interested in exploring the correlation between music and geometrical language, with the purpose of classifying musical objects using homological and homotopical techniques.

› **Omar Costa Hamido** (Biography on page 28)
› **Maria Mannone** (Biography on page 39)

6.3. QUANTUM TONALITY: A MATHEMUSICAL PLAYGROUND

Correlations between quantum theory and music theory specifically between principles of quantum computing and musical harmony can lead to new understandings and new methodologies for music theorists and composers.

The quantum principle of superposition is shown to be closely related to different interpretations of musical meaning. Superposition is implemented directly in the authors' simulations of quantum computing, as applied in the decision-making processes of computer-generated music composition.

Keywords: *Quantum Theory, Music Theory, Pitch Class Profiles*

› **Peter beim Graben**

› **Thomas Noll**
Born on January 5, 1961, in Germany, in 1985 graduated from the Hotel School Poppe&Neumann in Konstanz with the "Kuechenmeister" diploma. In 1988 complemented the education with Hotel Management Courses in Cornell University in Ithaca, USA. Having started his career

in the hospitality industry as a Chef in Comino Hotels in Malta, Thomas Noll has more than 30 years of experience in the hospitality industry, over 20 of which - in the position of a General Manager. The extensive international experience of Thomas Noll includes working in Malta, Antigua, Crete, Egypt, Kenya, Switzerland, Turkey, and for the last 11 years in Russia, managing luxury 5 star properties in St. Petersburg – a world recognized tourist capital. Thomas Noll is a father of three children – Samantha, 21 years old, and twins Nikolaj and Nicole, 4 years old. Samantha has successfully completed her stagiaire in the Adlon Hotel in Berlin, and at the Hotel de la Cite in Carcassonne, she also got an invaluable experience at the Tanit Design company in Paris. She has started her 4 years Bachelors Program at Ecoliere Lausanne in August 09– following her father's path in the hospitality career. Samantha is currently undergoing her stagiaire in the Mandarin Oriental London in Sales & Marketing. Thomas Noll, President of TN Hotels & More company since June 2011.

› PANEL SESSION 07

MATHEMATICAL SCALE THEORY AND TUNING

Chair: Norman Carey

7.1. QUARTER-TONE MUSIC: A TUNING SYSTEM ROOTED IN NATURAL HARMONIC SERIES

The objective of this work is to study quarter-tone music through the lens of harmonic series. The 11th harmonic (11/8), which corresponds to the major fourth interval, offers a remarkably precise approximation of the quarter tone. By employing the "circle of major fourths," we may encompass the complete spectrum of 24 notes and establish a tuning system of quarter-tones that is based on overtones. We analyze its distinct attributes and perform a detailed examination of its impact, specifically on maqam music. To solve issues specifically related to modulation, a non-octave tuning is proposed by dividing the major fourth interval into 11 quarter-tones.

Keywords: *Tuning system, harmonic series, microtonal music, quarter-tone*

› **Aziz Ifzarne**
Professor of Mathematics, and music composer, Sultan Moulay Slimane University, ENSA Khouribga, Morocco.

7.2. THE SANDWICH-LEMMA: THE RECURSIVE STRUCTURE OF SUPER-SYNTONIC AND SUPER-DIATONIC AUTOMORPHISMS

In the context of the transformational modeling of Pairwise Well-Formed (PWWF) modes, we study transformations on four letters a, b, c, d, which we call super-syntonic and super-diatonic morphisms. We show that the recursive "sandwich" construction of syntonic and diatonic morphisms can be lifted to the level of super-syntonic and super-diatonic morphisms. This result allows us to show that super-syntonic and super-diatonic morphisms, which are constructed this way, are automorphisms of the free group F4 with four generators.

Keywords: *PairwiseWell-Formed Scales, Kaleidoscope Transformations, Diatonic and Syntonic Modes, Sturmian Morphisms, Algebraic Combinatorics on Words*

› **Thomas Noll** (Biography on page 44)
› **David Clampitt** (Biography on page 23)
› **Mariana Montiel** (Biography on page 39)

7.3. AN EXPLORATION OF THE DISCONTINUOUS-CONTINUOUS FUSION IN YUUNOHUI'TLAPOA FOR KEY- BOARD

This work arises from the compositional and theoretical research on music scales through d1-theory, and on the continuum; it resorts to a terminology useful for composers, interpreters, or musicologists without mathematical training, as the author himself. The musical topic of the continuum emerged in the 20th century, introducing ideas like rhythm as frequency, microintervals, timbre, noise,glissandi, and spatialization. A unified study to comprehend the musical continuum as a global field needs to focus on a blend of components of rhythm (pulse, attack, microdurations) and sound (pitch, dynamics, color). This idea is understood as a macrotimbre. When these components in a continuous macrotimbre are intended to be asynchronous, the audible result is an amalgam of disruptions, interferences or crossings that are perceived as an elastic musical matter. By combining sequential pitch with continuous transitions of chords density, harmonic content, dynamics, and speed of pulse, such as yuunohui'tlapoa for a keyboard, asynchrony produces a discontinuous-continuous macrotimbre. The synthesis of this last is perceived as internal collisions of rhythm, melody, and harmony within a melo-harmonic texture or as a macro-timbre texture. The substantial differences between discontinuity and continuity in terms of calculation, memory, perception, or imagination, prompted the need for a distinct compositional approach to allow the notation of its constant spatial-temporal evolution, this being fulfilled by chronographic recording of rhythm and sound.

Keywords: *Continuum, Discontinuity, Macrotimbre, d1-theory*

› **Julio Estrada**

Born in Mexico City in 1943, Julio Estrada's family was exiled from Spain in 1941. A composer, theoretician, historian, pedagogue, and interpreter, he began his musical studies in Mexico (1953-65), where he studied composition with Julián Orbón. In Paris (1965-69) he studied with Nadia Boulanger, Messiaen and attended courses and lectures of Xenakis. In Germany he studied with Stockhausen (1968) and with Ligeti (1972). He earned a Ph. D. in Musicology at Strasbourg University (1990- 1994). In 1974 he became researcher in music at the Instituto de Estéticas, IIE/UNAM, where he was appointed as the Chair of a project on Mexican Music History and Head of MúSIIC, Música, Sistema Interactivo de Investigación y Composición, a musical system designed by himself. He is the first music scholar to be honored as member of the Science Academy of Mexico and by the Mexican Education Ministery as National Researcher [since 1984]. He created a Composition Seminar at UNAM, where he has been teaching Compositional Theory and Philosophy of Composition.

› PANEL SESSION 08

SIMILARITY AND DISTANCE MEASURES FOR MUSIC

› **Chair: Thomas Fiore**

8.1. TOWARDS MEASURING THE DISTANCES OF CHORDS OF DIFFERENT CARDINALITIES

Music can be represented by a sequence of chords. The transition between the individual chords is naturally of great importance due to the induced musical tension or the created cadence. We summarize several known and less known approaches for comparing two chords of the same as well as different cardinality and calculating their distances in the corresponding chord spaces, which are used to measure transitions between individual chords.

Keywords: *Chord space; voice leading; metric; pseudometric; topology*

› **Kristína Hurajová**

Kristína Hurajová is a second-year PhD. student of Applied Mathematics at Faculty of Science, Pavol Jozef Šafárik University in Košice. She graduated her second level university studies from the study programme of Mathematics and Biology in the field of study Teacher Training

and Education Science at the Pavol Jozef Šafárik University in Košice in 2022. At the same university, she obtained her bachelor´s degree in Mathematics and Biology in the field of study Interdisciplinary Study in 2020.

› **Ondrej Hutník**
Ondrej Hutník has received the M.Sc. degree in Mathematics and Informatics from Pavol Jozef Šafárik University in Košice (2003) and Ph.D. degree in Applied Mathematics from University of Žilina, Slovakia (2006). Since 2012 he has been an Associate Professor and from 2023 a Full Professor of Mathematics at the Faculty of Science of Pavol Jozef Šafárik University in Košice. He is the author or co-author of more than 70 refereed papers published in international journals and proceedings of international conferences. His research interests include measure and integration theory, time-frequency analysis, complex analysis and operator theory.

8.2. A FINGERPRINTING-BASED STRATEGY FOR MUSICAL GENRE SIMILARITY

Music information retrieval is a field that uses signal processing to create computer-assisted musical systems, including acoustic fingerprinting which extracts perceptual features from music samples. This paper introduces a method to measure musical genre similarity using audio fingerprints, specifically through class-representative fingerprints that aggregate genre-specific fingerprints. We propose a similarity index for these fingerprints and demonstrate its effectiveness using the GTZAN dataset. Our results confirm the method's utility in assessing similarity between genres, suggesting further research to expand its application to additional datasets.

Keywords: *Audio Fingerprinting; Music Information Retrieval; Stylometry; Musical genre*

› **Aarón López-García**
PhD in Mathematics for the Universitat de València with a specialization in Statistics and Operations Research

8.3. ASSESSING THE COMPATIBILITY BETWEEN MUSICAL PERFORMANCE AND TUNING SYSTEM

This paper we propose a novel method, based on a fuzzy approach, for assessing the compatibility of a set of experimentally measured notes with any theoretical tuning system.

Through the exposition of three illustrative experiments, we demonstrate the potential of this method, where we calculate the average tuning distance between the music performance and the theoretical values, revealing insights into the suitability of different tuning systems for specific musical contexts, as well as the nuanced adjustments made by the musicians in response to varying musical scenarios.

Keywords: *Tuning, Performance, Fuzzy, Compatibility*

› **Brian Martínez-Rodríguez**

Brian Martínez-Rodríguez is an Associate Professor at the International University of La Rioja in the Master of Musical Research, as well as in the Music degree program, and Professor of Musical Technology, composer, physicist, cultural manager, and researcher focused on computer-assisted musical composition and new trends in music, as well as their relationship with new technologies. His research areas include artificial musical creativity, automated classification and recommendation systems for musical styles, or models for generating artificial empathy. He studied Physical Sciences at the University of Valencia and later obtained a Superior Degree in Music, specializing in Composition, at the Joaquín Rodrigo Superior Conservatory of Music in Valencia. He holds a Master's degree in Musical Research from the International University of La Rioja, a Master's degree in Advanced Artificial Intelligence from the National University of Distance Education, and a Doctorate in the Doctoral Program in Art: Production in Research from the Polytechnic University of Valencia. He has collaborated as research personnel at the Polytechnic University of Valencia. He has worked as a computer analyst and software architect in the private sector. For several years, he has been the manager and cultural manager of the Joven Orquesta Turina and is the artistic director of various music cycles. He is currently a member of the Latin GRAMMY Academy. As a composer, notable commissions have been made by instrumentalists such as Ronald Romm, John Manning, Paul Archibald, Jacques Mauguer, John Faieta, Piero Bonaguri, Viktoria Elisabeth Kaunzner, Daniel Sachs, or ensembles such as The Atlantic Brass Quintet, the Sidney Contemporary Orchestra, the Maimónides University Orchestra, the Concertante String Orchestra, the Stradivari Symphony Orchestra, or the Joven Orquesta Turina. He has received numerous awards, including the Valencia Crea Award 2014, the Juan Bautista Comes International Composition Award 2013, the first prize in the Horacio Salgán International Competition 2012, and the first prize in the II Isla Verde International Competition 2012. Currently, his works are being published by Barry Editorial and Ediciones Piles.

› **Vicente Liern**

Licenciado en Matemáticas y doctor en Física Teórica por la Universitat de València, inició su labor investigadora dentro de la Física Matemática, con el estudio del movimiento de

partículas elementales en el marco de la relatividad general. Posteriormente, su campo de investigación ha sido la optimización matemática bajo condiciones de incertidumbre, en modelos aplicados a la gestión de carteras, modelos de localización y la gestión de recursos humanos. En la actualidad trabaja en el diseño de sistemas de ayuda a la decisión para problemas de inversión socialmente responsable, impact investing y selección de personal. Su investigación, publicada en revistas nacionales e internacionales, ha sido financiada por varios proyectos de I+D de la Generalitat Valenciana y de los Ministerios de Ciencia y Tecnología y de Educación y Ciencia.

WORKSHOP GRUPOIDS AND MUSIC

PART 01 & PART 02

› **Dmitri Tymoczko**

Dmitri Tymoczko (b. 1969, Cambridge, Massachusetts) is a composer and music theorist who teaches at Princeton University. His book A Geometry of Music (Oxford) has been described as "a tour de force" (The Times Literary Supplement), a "monumental achievement" (Music Theory Online), and, potentially, a modern analogue to Schoenberg's Harmonielehre (The Musical Times). His two CDs, Beat Therapy ("far reaching yet utterly entertaining," Newmusicbox) and Crackpot Hymnal ("ebullient … polystylistic … kinetic … vividly orchestrated and vibrantly paced," Sequenza21), are available from Bridge Records. A third CD, Rube Goldberg Variations, will appear in 2017. The author of the first music-theory article ever published by Science magazine, he has received a Rhodes scholarship, a Guggenheim fellowship, and additional prizes from the American Academy of Arts and Letters, the Radcliffe Institute for Advanced Study, Tanglewood, the Society for Industrial and Applied Mathematics, and others. His music, which often draws on jazz and rock, has been performed and commissioned by groups including the Amernet Quartet, the Atlantic Brass Quintet, the Brentano Quartet, the Corigliano Quartet, Flexible Music, Gallicantus, the Gregg Smith Singers, the Illinois Modern Ensemble, Janus Trio, the Kitchener/Waterloo symphony, Network for New Music, Newspeak, Pacifica Quartet, Synergy Vocal Ensemble, Third Coast Percussion Quartet, and Ursula Oppens.

CONCERTS

› CONCERT 01

THE MUSIC OF MATHS

How to put the number π into music? Or the Fibonacci sequence (once it is reduced modulo n)? How to write permutational songs based on permutational poems? Or to write permutational poems leading to extra-minimalistic one-note music? How to compose pop songs with maximal harmonic variety by using Hamiltonian cycles on different graph-theoretical musical spaces? The concert proposes a journey into some fascinating mathematical objects that have been taken as a starting point for a collection of songs composed by Moreno Andreatta that will be presented in a piano and voice performance accompanied by the graphical animations realized by Gilles Baroin.

SONG FOR Π

What is the melody of π? Or, at least, one of the possible melodies obtained by simply mapping the digits to the white keys of the piano? The multilingual song has been composed in March 2022 for the π-Day celebrations under the auspices of the International Mathematical Union and the support of IMAGINARY as an expression of the common hope to see back the peace flag in the world.

FIBONACCI WALTZ MOD 10

The unending and increasing Fibonacci sequence becomes stable and periodic once it is considered modulo 10. The corresponding melody, with Pisano period equal to 60, draws a highly symmetric path within the cyclic group of order 10 and has an intrinsic ternary character that can be naturally expressed as a waltz, like in this piano solo composition.

ANTES, DESPUÉS

This mathematical song is based on a permutational poem by the Argentinian poet Julio Cortázar (1914-1984). To each line (or verse) of each strophe of the poem is associated a melody and a harmony that stay invariant through the permutation process. This puts in question the teleological and directional character of a music composition where all melodies associated to the verses of the strophes can be permutated ad libitum.

UNA STORIA D'AMORE FINISCE UNA VOLTA SOLTANTO

A one-sentence song using only the D note but a lot of different chords containing this pitch. A very simple example of a minimalistic permutational song in which the meaning of the final text is the result of the permutational process that generated it. The song is also

available in French (after a translation by the writer and cartoonist Etienne Lécroart) but it will be performed in the original Italian version.

MON COEUR TU ES FOU

A song based on poem by the Iranian poet Forough Farrokhzad (1935-1967) who was also screenwriter, painter, and filmmaker. The poem, translated and sung in French, has been put into music by freely using the simplest Hamiltonian cycle in the Tonnetz corresponding to a zig-zag harmonic sequence passing through all possible major and minor chords.

A PART

A second song that makes use of the simplest Hamiltonian cycle in the Tonnetz (corresponding to Beethoven's zig-zag but this time in a minor key). After a text by the French contemporary poet Andrée Chedid (1920-2011).

APRILE

A "decadent" Hamiltonian Song based on a poem by Gabriele D'Annunzio (1863-1938). The song makes use of three different hamiltonian cycles without inner symmetries. The performance will be accompanied by an animation by Gilles Baroin.

LA SERA

After a poem by Mario Luzi (1914-2005), the song starts as a typical four chords pop song before entering, in the chorus, into a more suspended atmosphere thanks to the use of a particular Hamiltonian cycle on the Tonnetz enabling the modulation through all major and minor chords via a harmonic sequence with different degrees of inner symmetry. The live performance is accompanied by a graphic animation realized by Gilles Baroin.

AH!

A "semi-Hamiltonian" song, relaxing the mathematical constraints and allowing to visit several times a given chord. The song is based on a poem of the French contemporary poet and mathematician Jacques Roubaud, a member of the OuLiPo (Ouvroir de Littérature Potentielle, roughly translated as the Workshop of Potential Literature).

FRANGIFLUTTI

This song is based on a poem of the Italian poet Leonardo Mello and is contained in the CD Un racconto, signed by the group "Le Bateau Ivre" and edited by the label "Storie di note" (EGEA distribution). Several symmetries on the Tonnetz are used in order to control the modulation process in the song.

DOMENEDIO

The song explores Umberto Eco's concept of "opera aperta" (open artwork) and proposes to the performer to plan the instrumental part of the song according to the constraints that set the initial and final key (respectively F#m and Bm) and enables the use of only two transpositions (T -1 and T -3) in order to modulate through different minor keys. The song is based on a poem by Livio Andreatta written in regional dialect from north of Italy.

THE GUNNER HAMILTONIAN DREAM

The song is a mathematical harmonization of Roger Waters' celebrated "The Gunner's Dream" from the album The Final Cut (1983). Three different Hamiltonian paths on the space of major, minor and augmented chords are used that entirely cover the formal structure of the original song. The performance is accompanied by Gilles Baroin's graphic animation using the "Cube Dance" graph-theoretical representation by Jack Douthett's and Peter Steinbach as well as his own Hyper Sphere geometrical model.

› **Moreno Andreatta, composition and performance** (Biography on page 37)
› **Gilles Baroin, graphical animations** (Biography on page 27)

› CONCERT 02

MEMBERS OF THE SOCIETY FOR MATHEMATICS AND COMPUTATION IN MUSIC

SONATA, ALBAN BERG

› **Emmanuel Amiot, piano** (Biography on page 26)

NON LEGGEMO PIÙ, EMMANUEL AMIOT

› **Juliana Castanho-Spector, soprano** (Biography on page 38)
› **Emmanuel Amiot, piano** (Biography on page 26)

NOT MARBLE, JASON YUST

› **Juliana Castanho-Spector, soprano** (Biography on page 38)
› **Norman Carey, piano** (Biography on page 22)

AMARANTHA, NORMAN CAREY

› **Marta Martins, soprano**

Marta Martins, a soprano, holds a bachelor's degree in Singing from ESMAE (Porto, 2017), where she studied under Professor Rui Taveira, graduating with the highest honors. She also

earned her master's degree from the Hochschule für Musik und Tanz Köln (2022, Germany), under the tutelage of Christoph Prégardien.

Throughout her career, she has performed in Portugal, Spain, Sweden, Italy, and Germany. She has collaborated as a soloist with several orchestras including Orquestra XXI, Orquestra do Norte, Orchestra Kairos (Germany), Beethoven Orchester Bonn (Germany), Orquestra de Guimarães, and Orquestra do Algarve. Marta is a member of the ensembles Capítulo and Bando do Surunyo.

In February 2018, she won the Helena Sá e Costa Award in Porto. In 2019, she was accepted into the European Opera Academy program, attending "Conservatorio Luigi Cherubini" in Florence, and the "University of Arts" in Stockholm. That same year, she was a scholarship recipient from the Calouste Gulbenkian Foundation. In 2023, she won the 2nd prize in the "Concurso da Fundação Rotária Portuguesa" and was awarded for the best interpretation of an opera aria.

› **Patrícia Silveira, alto**

Patrícia Silveira (Coimbra, 1996) works primarily as an opera singer. Her versatile voice has led her to prestigious stages across Europe, exploring music from ancient to contemporary genres. She regularly collaborates with ensembles such as La Capella Nacional de Catalunya / Jordi Savall, O Bando de Surunyo, in a duo with harpist Rebeca Csalog, and pianist Ángel González. Patrícia was the recipient of the Ian Donald Wilson Memorial scholarship in 2023 and was a finalist in the Young Musicians Prize 20/2021. Recent highlights include the premiere of the opera π by João Pedro Oliveira, participation in the opera Ariadne auf Naxos by R. Strauss at Opernfest Berlin under the direction of Matthew Toogood, and performing as Cherubino and Marcellina in scenes from Mozart's The Marriage of Figaro with the Algarve Orchestra under the direction of Martim Sousa Tavares. She has also collaborated with Divino Sospiro, Le Concert des Nations, Orquestra do Norte, Orquestra de Guimarães, Orquestra Clássica do Centro, Taller Atlántico Contemporáneo, Holland Baroque, among others.

› **João Pereira, tenor**

Born in 2005, João Pereira is from Santo Tirso.

João started his musical studies in Escola de Música de São Martinho do Campo at the age of five. Lately he attended CCM (Centro de Cultura Musical) studying piano, where he persisted, aquiring the 8th grade in piano.

Simultaneously, João studied singing with professor Rui Silva during the last 3 years, being admitted in ESMAE (Escola Superior de Música e Artes do Espetáculo) in vocal studies, currently studying with professor Rui Taveira. João Pereira took part in some contests and masterclasses where he was awarded several times, increasing his musical experience.

O DON FATALE, VERDI

› **Juliana Castanho-Spector, soprano** (Biography on page 38)

› **Norman Carey, piano** (Biography on page 22)

SONATINA IN D MAJOR, FRANZ SCHUBERT

› **David Clampitt, violin** (Biography on page 23)

› **Norman Carey, piano** (Biography on page 22)

› CONCERT 03

QUARTETO DE COIMBRA

Roughly 100 years ago, a generation of brilliant musicians laid the aesthetic and musical foundations of Canção de Coimbra (Song of Coimbra). Heirs to a popular musical tradition, this generation knew how to elevate the wisdom and voices of the people, giving them a new guise and personal touch. This generation included numerous artists such as Armando Goes, Edmundo Bettencourt, António Menano, Paradela de Oliveira, Almeida d'Eça, Artur Paredes, Afonso de Sousa, and Flávio Rodrigues.

Beyond the aesthetic and musical revolutions of this generation, the lesson remained that to project the music of Coimbra into the future, it is necessary to study and work on its roots. Starting from this motto, in this concert, the Quartet of Coimbra, a group of young musicians, recovers the philosophy of this golden generation, interpreting themes and arrangements by the great names of the Canção de Coimbra.

The Quartet of Coimbra, formed in 2022, is a group of experienced musicians trained in Coimbra, who have engaged in an in-depth study and performance of the repertoire of the Canção de Coimbra. Besides working on the musical and cultural heritage of the city, the Quartet has presented original themes, trying to contribute to and continue this legacy.

FADOS E CANÇÕES

- **Fado Sepúlveda**
- **Fado das Saudades**
- **Campos de Flores**
- **Descantiga (original)**
- **Rua dos Jacarandás (original)**
- **Balada Sé Velha (original)**

PEÇAS DE GUITARRA PORTUGUESA

› **Artur Paredes**

- Mi menor
- Sol Maior
- Ré Menor
- Ré Maior
- Lá Menor

› **Carlos Paredes**

- Verdes Anos
- Canção
- Asas da Saudade
- Asas Sobre o Mundo
- Fado Moliceiro,
- Canto de Amor

› **Fábio Almeida, voice**

Born in Coimbra, he developed an interest in Canção de Coimbra during his teenage years by listening to broadcasts of the Monumental Serenades. He pursued his path in the academic milieu, joining the fado group Capas ao Luar from the Fado section of the Coimbra Academic Association, performing in various parts of the country. His study and work have been guided by references from great interpreters of Coimbra such as Armando and Luiz Goes, Edmundo Bettencourt, and Paradela de Oliveira.

› **Simão Mota, Portuguese guitar**

Born in Lisbon in 1998, he early on showed an interest in music, learning the guitar self-taught. In 2016, he moved to Coimbra to learn the Coimbra guitar with Master Jorge Gomes. He has participated in various performances, both in Portugal and abroad. His musical activity has been dedicated to the collection, study, and interpretation of various composers, as well as the composition of original themes. His repertoire includes composers like the Paredes family, António Brojo, António Portugal, and Francisco Martins.

› **Tiago Rodrigues, Portuguese guitar**

Born in Braga in 1995, he started his musical journey on the guitar at the age of 12, self-taught. In 2013, he enrolled in the Medicine course at the University of Coimbra. During his studies, he joined the fado group Ad Aeternum from the Fado section of the AAC as an accompanying guitarist, performing in various concerts across the country. In 2019, his passion for the work of Artur Paredes led him to dedicate himself exclusively to the Coimbra guitar and to

extensive work in collection, research, and study. Since then, he has focused on rediscovering and perfecting the techniques used by Artur Paredes.

› **Vasco Rodrigues, guitar**
Born in Coimbra in 2000, from an early age, influenced by his father, the music of Coimbra became part of his daily life. At 13, his passion for music led him to start his musical journey on the guitar. In 2019, he enrolled in the Human Resource Management course at the Miguel Torga Institute in Coimbra. That same year, he formed the fado group d'Anto from the Fado section of the AAC as an accompanying guitarist. In 2021, he started working with Simão Mota and Tiago Rodrigues, and since then, he has been exploring the vast repertoire of the Paredes family.

A TRIBUTE TO YVES HELLEGOUARCH

Chair: Omar Costa Hamido

Mathematician and cellist, Yves Hellegouarch was an honorary member of the Journal of mathematics and music. He passed away on February 5, 2022.The two notes we present here have never been published. The first is an unfinished lecture text on the relationship between mathematics and music. The second is a text written in English by Yves Hellegouarch. He asked me to help him edit it. He would have liked to publish it, the last witness of his passion for his instrument, the cello.

Keywords: *Hellegouarch, Tunings; Cello, Temperaments*

› **Wynne Hellegouarch**

› **Franck Jedrzejewski**
Franck Jedrzejewski is a researcher in mathematical physics at INSTN/CEA (Paris-Saclay University). He has also a PhD in music and musicology and in philosophy. In 2013, he was elected Director of program at College International de Philosophie (CIPh), an institute founded in 1983 by Jacques Derrida, François Châtelet, and Dominique Lecourt. He has published more than 20 books, most of them in French: Dictionnaire des musiques microtonales (Dictionary of Microtonal Music), Hétérotopies musicales (Modèles mathématiques de la musique), La musique dodécaphonique et sérielle : une nouvelle histoire, or in English Looking at Numbers with the composer Tom Johnson and A Compendium of Musical Mathematics. His research is highly transdisciplinary (music, philosophy, mathematics, and Polish and Russian avant-gardes).

POSTER SESSION

Chair: Francisco Gómez

Posters will be presented by authors on June 18, 14h30 at the Atrium of Theatre Paulo Quintela, and will run throughout the conference.

P1. EXPLORING MODE IDENTIFICATION IN IRISH FOLK MUSIC WITH UNSUPERVISED MACHINE LEARNING AND TEMPLATE-BASED TECHNIQUES
- **Juan José Navarro-Cáceres**
- **Nádia Carvalho**
- **Gilberto Bernardes**
- **Diego M. Jiménez-Bravo**
- **María Navarro-Cáceres**

P2. MINING SIGNIFICANT SEQUENTIAL CONTRAST PATTERNS
- **Darell Conklin**

P3. RECURRENCE RELATIONS RHYTHM
- **Michael Cohen**
- **Yasuyuki Kachi**

P4. BITS AND BEATS: COMPUTING RHYTHMIC INFORMATION AS BITWISE OPERATIONS OPTIMIZED FOR MACHINE LEARNING
- **Fernando Gualda**

P5. REGULAR TEMPERAMENT THEORY: EXPLORING THE LANDSCAPE BETWEEN JI AND ETS WITH LINEAR ALGEBRA
- **Dave Keenan**
- **Douglas Blumeyer**

VIRTUAL EXHIBITION

MATHEMUSICAL VIRTUAL MUSEUM & PLANET VOICES INTERACTIVE VR AND PC EXHIBITION

At the Institute of Paleography (FLUC).

› **Gilles Baroin** (Biography on page 27)

USEFUL INFORMATION

COFFEE BREAKS
At the open space on the 3th floor behind the Theatre Paulo Quintela (FLUC).

DAY 01 | JUNE 18TH
Morning: 11h00 — 11h30
Afternoon: 17h30 — 18h00

DAY 02 | JUNE 19TH
Morning: 11h00 — 11h30
Afternoon: 17h00 — 17h30

DAY 03 | JUNE 20TH
Morning: 11h00 — 11h30

DAY 04 | JUNE 21ST
Morning: 11h30 — 12h00

WELCOME RECEPTION | JUNE 18TH, 19H30
Require mandatory registration.

› **Restaurant O PAPA**
R. Alexandre Herculano 37, 3000-019 Coimbra

GALA DINNER | JUNE 20TH, 20H00
Require mandatory registration.

› **Restaurant SAPIENTIA**
R. José Falcão, 3000-062 Coimbra

UC TOUR VISIT
Registration is limited to 30 visitors.
Register and pay at the registration desk (Atrium and Registration).

TITLE The 9th Biennial International Conference for Mathematics and Computation in Music

COORDINATION José Oliveira Martins, Omar Costa Hamido, Riccardo Wanke, Pedro Martins, Amílcar Cardoso and Jônatas Manzolli

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IMPACT

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