Program

Version 7 – 16.09.2019

(subject to change)

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Maps

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Erich-Thienhaus-Institut
and Concert Hall
Sommertheater
LWL Freilichtmuseum
Im Weissen Ross
Talstraße
Hornsche Straße
Pestalozzistraße
Friesenstraße
Frankenstraße
Brückenstraße
Grünental
Waldweg
Kröppelfeld
Detmold-Nord
Berliner Allee
Detmold-Süd
Rosenstraße
Alter Postweg
Nachtigallenweg
Mozartstraße
Papenbergweg
Neustadt
Wiembecke
Paderborner Straße
MÜNSTERLÄNDER GRÄFTENHOF
WESTHELLWEG-HOF
PADERBORNER DORF
SAUERLÄNDER DORF
Am Südhang
Friedrich-Pieper-Straße
Friedrichshöhe
Paderborner Straße
HEILIGENKIRCHEN
Berlebecke
Heiligenkirchen
Unterer Weg
Obere Schanze
Am Weinberg
Schützenthal
Hiddesen
Amselweg
Detmold-Süd
Friedrich-Ebert-Straße
Cheruskerweg
Hünenweg
Maiweg
Katerallee
Im Kampe
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200 m
500 ft
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Overview

	FRIDAY, SEPTEMBER 13
15:00	**Workshop on Instrument Building** (7)
20:00	**Welcome Reception**

	SATURDAY, SEPTEMBER 14
	Posters and Demos (Saturday to Monday): 8
	Opening and Plenary
09:00	Welcome, Tribute & Introduction (Stärk, Marshall, Kob)
09:20	**Angster, Rucz, Miklos: 25 Years Applied Pipe Organ Research at Fraunhofer IBP in Stuttgart** (17)
	Acoustics of Wind Instruments and Organs: Flutes
10:00	Fabre, de la Cuadra: How do flute players adapt their control parameters to modifications of the flute bore? (17)
10:20	Arimoto: Experimental study on the temporal fluctuation of harmonics in flute sounds (17)
10:40	Kimie, Natsubori, Yokoyama, Iida, Arimoto: Experimental Investigation for Effects of Jet Angle on the Harmonic Structure in the Flute (18)
11:00	Break/P1-P2, D1
	Directivity of Musical Instruments: String ensembles
12:00	de Francisco, Kob, Rivest, Traube: ODESSA - Orchestral Distribution Effects in Sound, Space and Acoustics: an interdisciplinary symphonic recording for the study of orchestral sound blending (18)
12:20	Ioannou, Kob: Investigation of the Blending of Sound in a String Ensemble (18)
12:40	Saitis, Fritz, Scavone: Sounds Like Melted Chocolate: How Musicians Conceptualize Violin Sound Richness (19)
	Directivity of Musical Instruments: Sound fields
13:00	Petersen, Rosser: External sound field simulations and measurements of woodwind resonators (19)
13:20	Kob, Baskind: Impact of free field inhomogenity on directivity measurements due to the measurement set-up (19)
13:40	Dalmont, Maugeais: Piano strings with reduced inharmonicity (20)
14:00	Break/P3-P4, D2
	Design and Playing: Fingering and articulation
15:00	Adachi: Physical principle of pitch bent by cross-fingering (20)
15:20	Jiolat, Le Carrou, D'Alessandro: A parametric study of finger motions when playing the clavichord : towards characterization of expressive control (20)
15:40	Woolley, Campbell, Carlyle: Factors affecting transients in rapid articulation on a bass crumhorn (21)

	Design and Playing: Room acoustics
16:00	Pop, Osman, Knight: Music Practice Rooms: Ambitions, Limitations and Practical Acoustic Design (21)
16:20	Nishimiya, Tokuda, Yokota, Cho: Acoustical evaluation of differences in Sanshin's tone depending on shapes of SAO (21)
16:40	Break/P5-P8
	Acoustics of Wind Instruments and Organs: Pipe organs
18:00	Cottingham: The Khaen as a Miniature Pipe Organ (22)
18:20	Otcenasek, Dlask, Otcenasek: The air jet development in organ pipe tone attack caused by voicing adjustments (22)
18:40	Ollivier, Lechat, Dragna, Gluck: Distortion of acoustic shockwaves by U-shaped tube portions (22)
	Acoustics of Wind Instruments and Organs: Clarinet and single reeds
19:00	Takahashi, Goya, Goya, Tsutsumi, Kobayashi: Numerical study on the function of the register hole of the Clarinet (23)
19:20	Koiwaya, Iwagami, Kobayashi, Takahashi: Numerical study on unsteady fluid flow and acoustic field in the clarinet mouthpiece with the compressible LES (23)
19:40	Wang, Scavone: Computational Aeroacoustic Modeling of Single-Reed Mouthpiece Using Palabos (Live Stream) (23)
	Free Evening

	SUNDAY, SEPTEMBER 15
	Strings: Non-western instruments
09:00	Gupta, Dangarikar: Design, Construction, and Material of an Ancient Indian String Instrument (24)
09:20	Inanli, Altinsoy: Vibration Characteristics of Oud Soundboard (24)
09:40	Okada, Iwagami, Kobayashi, Takahashi: Numerical Simulation of Aerodynamics Sound in an Ocarina Model (24)
	Strings: Guitar and Harp modeling
10:00	Brauchler, Ziegler, Camargo, Eberhard: Experimental and Simulative Examination of the String-Soundboard Coupling in an Acoustic Guitar (25)
10:20	Caillon, Le Carrou, Chomette, Le Bomin: Modelling of Gabonese harps (25)
10:40	Break/P9-P12
	Virtual Prototyping of Musical Instruments: Design and player control
12:00	De la Cuadra, Ernoult, Fabre: Exploring dependency between instrument design and musician's control. (25)
12:20	Chatziioannou, Hofmann, Schmutzhard: A Real-Time Physical Model to Simulate Player Control in Woodwind Instruments (26)
12:40	Castera, Chabassier, Eernoult, Thibault, Tournemenne: The virtual workshop OpenWInD: Towards an optimal design tool of wind instruments for makers (26)
	Virtual Prototyping of Musical Instruments: Numerical exploration
13:00	Fréour, Masuda, Usa, Tominaga, Tohgi, Cochelin, Vergez: Numerical analysis and comparison of brass instruments by continuation (27)
13:20	Colinot, Guillemain, Doc, Vergez: Numerical synthesis applied to reed instruments: influence of the control parameter transients on the steady-state oscillation regime (27)
13:40	Taillard, Dalmont: Simulation of the nonlinear characteristic of the clarinet exciter and of the side holes (27)
14:00	Break/P13, D3

	Acoustics of Wind Instruments and Organs: Numerical improvements
15:00	Rucz, Angster, Miklós: Finite element simulation of radiation impedances with applications for musical instrument design (28)
15:20	Tabata, Kobayashi, Takahashi: Numerical study of Synchronization Phenomena of an Air-Jet Instrument using Finite-Difference Lattice Boltzmann Method (28)
15:40	Gilbert, Maugeais, Vergez: From the bifurcation diagrams to the ease of playing of reed musical instruments. A theoretical illustration of the Bouasse-Benade prescription (28)
16:00	Break
17:00	**Excursion and Dinner** (39)

	MONDAY, SEPTEMBER 16
	Reeds: Clarinet
09:00	Kemp, Wang, Scavone: Design of a mechanical player system for fatigue-life evaluation of woodwind reeds (29)
09:20	Pàmies-Vilà, Hofmann, Chatziioannou: The player-reed interaction during note transitions in the clarinet (29)
09:40	Almeida, Li, Inwood, Smith, Wolfe: Clarinet tonguing: the mechanism for transient production (Live Stream) (30)
	Mixed
10:00	Gupta, Sharma, Singh Gupta: Acoustics of Bifacial Indian Musical Drums with Composite Membranes (30)
10:20	Miura, Yasui: Acoustic measurement of Marimba, Xylophone and Xylorimba (30)
10:40	Amir, Bachar-Yakobi: Relating tone height and perceived pleasantness in the didgeridoo and bass trombone (31)
11:00	Break/P14, D4
	Modelling: Modelling techniques
12:00	Linke, Bader, Mores: The Impulse Pattern Formulation (IPF) as a nonlinear model of musical instruments (32)
12:20	Elie, Boutillon, Chabassier, Ege, Laulagnet, Trévisan, Cotté, Chauvat: MAESSTRO: a sound synthesis framework for Computer- Aided Design of piano soundboards (32)
12:40	Giordano, Thacker: Navier-Stokes-Based Physical Modeling of the Clarinet (32)
	Modelling: Modelling strings
13:00	Rau, Smith: Measurement and Modeling of a Resonator Guitar (33)
13:20	Toboonchuay, Park, Klongratog: Thai Fiddle Saw-u Modeled as a Helmholtz Resonator with Circular Membrane (33)
13:40	Coaldrake: Finite Element Modelling of Japanese Koto Strings (33)
14:00	Break/P15-P17
	Virtual Prototyping of Musical Instruments: Virtual instruments and data bases
15:00	Tahvanainen, Matsuda, Shinoda: Numerical simulation of the acoustic guitar for virtual prototyping (34)
15:20	Maestre, Scavone: Creating Virtual Acoustic Replicas of Real Violins (34)
15:40	Houde-Turcotte: Generation and Analysis of a Database of Geometrical and Acoustic Properties for the Modern Almenräder-Heckel System Bassoons (34)

	Virtual Prototyping of Musical Instruments: Instrument design
16:00	Beaton, Scavone: Optimization of Marimba Bar Geometry by 3D Finite Element Analysis (35)
16:20	Ernoult, Missoum, Guillemain, Vergez, Jousserand: How to include several acoustic characteristics in the design of woodwind instruments? (35)
16:40	Viala, Lämmlein, Placet, Cogan: Model-based quantification of the effect of wood modifications on the dynamics of the violin (35)
17:00	Break/P18-P21
	Instrument Building
18:00	Merchel, Olson, Altinsoy: Influence of tonewood parameters on the perceived sound quality of a steel-string acoustic guitar (36)
18:20	Fritz, Stoppani, Igartua, Rico, Arroitajauregi, Artola: The Bilbao project : How makers match backs and tops to produce particular sorts of violins (36)
18:40	Bader, Fischer, Münster, Kontopidis: Metamaterials in Musical Instruments (36)
	Timbre and Perception
19:00	Plath: Influence of Long-Term Playing on the Tonal Characteristics of a Concert Piano – an Observational Study (37)
19:20	Sulem, Bodner, Amir: Perception-based classification of Expressive Musical Terms: Toward a parametrization of musical expressiveness (37)
19:40	Fu, Fritz, Scavone: Perception of violin soundpost height differences (Live Stream) (38)
20:00	**Joint Music in Detmold Concert House** (40)

	TUESDAY, SEPTEMBER 17
09:00	**Measurement Session on Musical Instruments (ETI)**
13:00	**Farewell, Lunch bags**

Workshop on Friday, September 13

Workshop

Fr. 15:00 Workshop

Workshop on Instrument Building

Leonardo Fuks (Brasil), Lucas Heidemann (Germany), Yuri Landmann (The Netherlands) and Dustin Eddy (Germany)

The instrument building workshop will give the opportunity to build your own instrument. The instruments shall be played during the joint musical events. The workshop will be held in the basement of the conference venue: Sommertheater Detmold.

The workshop at ISMA 2019 is sponsored by:

Posters (Saturday to Monday)

Posters
Saturday to Monday, September 14-16, 2019
Location: Summer Theater, Foyer

Sa. 11:00 P1

Non-destructive measurement of the pressure waveform and the reflection coefficient in a flue organ pipe
Viktor Hruska, Pavel Dlask and Milan Gustar
Academy of Performing Arts in Prague
A multiple-microphone method employed for in-duct acoustics applications is adapted for a flue organ pipe geometry. In order to make the measurement non-destructive the microphones are replaced by a pressure probe synchronized with a reference signal. Limits of the method regarding the pipe geometry are verified by the numerical calculations employing the linearized Euler equations. Results based on the lossless model, the visco-thermal lossess and models regarding the convection and turbulence are compared and discussed. A framework for the reflection coefficient calculation is designed and tested.

Sa. 11:00 P2

High resolution 3D radiation measurements on the bassoon
Timo Grothe and Malte Kob
Detmold University of Music
Musical wind instruments with tone-holes have complex radiation patterns. Since openings act as sound sources, depending on their relative distance and phase soundwave superposition can lead to boosts or cancellations at different observation points. These phenomena are particularly prominent in the bassoon, as a multitude of differently sized tone-holes are distributed irregularly across a long, bent corpus. To extend our knowledge on pitch-related directivity patterns of such complex instruments the bassoon was chosen as a test case measurement object for a high resolution radiation measurement in 3D, using a repeatable, artificial excitation and a 2 axis turntable. We compare the radiation patterns of three different tonehole configurations, and discuss implications for simultaneous measurements with a microphone array.

Sa. 14:00 P3

On the use of reed-to-room transfer function in bassoon auralizations - a listening test
Timo Grothe, Stefanos Ioannou and Sebastià V. Amengual Garí
Hochschule für Musik Detmold
The sound of a bassoon in a room can be convincingly synthesized from a reed mouthpiece pressure measurement, if the transfer function between the reed and a room position is known. We present an experimental setup which allows to measure such ”reed-to-room” transfer functions, with a bassoon fixed in playing position on stage and a binaural microphone on a seat in a concert hall. With measured mouthpiece pressure signals from a musician playing the fixed bassoon on stage, the synthesis results from convolving source signals with transfer functions can be compared to the corresponding measurements. We demonstrate results in the form of a listening test to investigate the auditory quality of these auralizations.

Sa. 14:00 P4

Timbre and Duration of Attack Depend on the Amount of Reverberation

Tor Halmrast
Univ. Oslo and Statsbygg

The attack of a signal is of course best preserved if we hear the direct sound only, but that is not the case even in a small room. Musicians know how long reverberation masks the next onset, but more astonishing is the prolongation of the attack, also for a first note in a phrase.
The paper will present theory regarding how diffuse field reverberation influences the attack. The early response of a concert hall, is, however, seldom ”diffuse”, and it is shown that introducing early reflection can reduce the smoothening from the reverberation.
The paper shows measurements of attack from the Integrated Squared Step Response, for both real halls and simulations, and for signals of different lengths and for different musical instruments. Very short notes/clicks/xylophone gets almost no prolongation of the attack due to reverberation. Medium long notes get prolonged attack, which makes them sound somewhat less brilliant. For double bass arco etc. with long note on-set, the attack is also prolonged, but the timbre might be even smoother and more pleasant. Preserving the attack is important because listeners nowadays are used to recordings where any wanted amount of direct sound is mixed with a late, long smooth, non-correlated reverberation.

Sa. 17:00 P5

Analysis of reed vibrations and mouthpiece pressure in contemporary bass clarinet playing techniques

Peter Mallinger, Montserrat Pàmies-Vilà, Vasileios Chatziioannou and Alex Hofmann
Univ. Music and Performing Arts Vienna

While articulation on the B♭ clarinet has already been a subject of various studies, articulation on the bass clarinet has received less attention. Because of the increasing interest for using the bass clarinet, especially in contemporary music, this instrument is emerging from the shadow of the B♭ clarinet. In order to investigate articulation on the bass clarinet an experiment was carried out in an anechoic chamber at the University of Music and Performing Arts Vienna. A professional clarinetist was recorded performing different articulation techniques on a German bass clarinet under controlled performance conditions. Results show that the attack transients on the bass clarinet were about 0.085 s long in staccato articulation. In comparison, attack transients on the B♭ clarinet are 2 to 3 times shorter. This study especially focuses on the slap tonguing technique. Of particular interest is the reed displacement signal, which shows the movement of the reed. It has been observed that tones articulated with slap tonguing have a significantly shorter attack transient and are immediately entering the decay phase. Such measurements allow an in-depth analysis of player-instrument interactions with contemporary playing techniques and may support the refinement of physical model parameters but may also support music education.

Sa. 17:00 P6

Evaluating the role of the cutoff frequency on sound production of clarinet-like resonators using digital synthesis

Erik Alan Petersen, Philippe Guillemain and Jean Kergomard
Aix Marseille Univ, CNRS, Centrale Marseille, LMA, UMR 7031, Marseille

The impedance cutoff frequency due to the network of open toneholes is a well-known characteristic of woodwind instruments. Benade remarks that the frequency at which cutoff occurs is strongly related to the sound of an instrument and that it correlates to the adjectives musicians use to describe the character of a given instrument. However, it is not known how the cutoff frequency impacts the competition between the energy that facilitates the auto-oscillation of the reed and the energy that is radiated from the resonator. To evaluate the effects on sound production and radiation, simplified resonators with the same first impedance peak frequency, but different cutoff frequencies, are conceived and experimentally verified. It is found that both a rigorous geometrical and acoustic regularity result in a very strong cutoff behavior. Next, digital synthesis is used to simulate the pressure and velocity waveforms within the mouthpiece of resonators with different cutoff frequencies. Spectral characteristics of the resulting waveforms can be used to quantify how the cutoff frequency affects sound production.

Sa. 17:00 P7

Time-domain response measurement of the trumpet, and the room

Timo Grothe
Hochschule für Musik Detmold

The bell of a trumpet is a flaring horn which has two functions: on the one hand, it terminates the resonating bore and therefore controls the sound reflections traveling back to the mouthpiece. On the other hand, the bell controls the impedance match between the narrow downstream bore and the surrounding air in a room, and the radiation directivity. The cylindrical bore downstream of the mouthpiece can favor non- linear wave steepening: The ”brassiness” of the sound perceived in the room depends on the amplitude of the pressure peaks inside the mouthpiece. To investigate these phenomena sound pressure measurements have been performed on a trumpet, with sensors inside the mouthpiece, and at different distances from the bell using ”musical” excitation signals (generated by a trumpeter) and pulselike technical excitation signals, at various levels.

Sa. 17:00 P8

Study of the effect of acoustic sound bridges on wind instruments: Perceptual study with a panel of trumpet players

Jean-François Petiot
Ecole Centrale Nantes

The study of the quality of a musical instrument, as perceived by the musician, is a complex problem. Many subtle phenomena are involved and several devices, or materials, are proposed to musicians, with a noticeable commercial success for some of them. We are interested in a particular device: sound bridges for wind instruments (made of two plates, clipped at a joint of a wind instrument with a rubber band). The objective of the work is to study if audible differences, due to the presence of the sound bridges, can be highlighted during trumpet playing. An ABX test was carried out with a panel of 5 trumpet players with various levels (from professional to advanced amateur) and various use degrees of the bridges in their practice (from always to not user). After a training phase, musicians were blinded and asked to answer to several repetitions of the ABX test in free playing conditions. Results were analyzed with the binomial distribution and the Signal Detection Theory (SDT). In addition, several repetitions of different notes were recorded with and without the bridges. A spectral analysis was carried out to test whether or not a significant effect of the acoustic bridges can be highlighted.

Su. 11:00 P9

Relation between subjective evaluation for proficiency, expression or technique and acoustic feature on violin performance

Madoka Okemoto and Masanobu Miura
Hachinohe Institute of Technology

Studies of proficiency estimation for musical performance have been intensively conducted in the field of performance science.In most of the studies, feature parameters are calculated from sound of performance to estimate performance proficiency. However, most cases in such studies estimated only proficiency score, not for expressiveness or technique, that are considered as important for proficiency estimation. Therefore, this report tries to clarify a relation between effective acoustic parameters and scores of proficiency, expression or technique on violin performance. Moreover, most important parameters of each scores are discussed. Firstly, five professional violin players gave scores for proficiency, expressiveness and technique to 100 performances for simple major scale starting from 261Hz or C3 with vibrato. Then, a set of 98 parameters are calculated from the 100 performances. By using the parameters, scores for proficiency, expressiveness, and technique are estimated using liner regression with relative weights for each parameter, so that we confirmed the most effective parameters. As a result, most important parameters on each score are: FM vibrato parameters on proficiency, strength on attack for each note on expressiveness, and smoothness on consecutive two notes on technique. At the conference, authors will explain this result in detail on their presentation.

Su. 11:00 P10

Acoustical analysis of stringed instruments without touch

Heidi von Rüden[a] and Anton Schlesinger[b]
[a] *Musikinstrumenten-Museum SIM PK;* [b] *Beuth Hochschule für Technik*

At an abstracted level, the stringed instrument consists of a box with a neck and fastened strings. The parameter of the resonator, the material and construction features determine the sound. Therefore the acoustic measurement of instruments plays a prime role in conservation, for functional analysis and digital archiving.

In this contribution an acoustical, contact-free measurement method for quantifying the transfer function of stringed instruments is presented. The method assesses the sounding body and its periphery by means of a standard acoustical impulse response measurement (AIR) in an anechoic room. As a test signal a logarithmic sweep is employed that offers a high signal to noise ratio and the ability to separate potential harmonic distortion of the electronic signal chain from the impulse response of the instrument. The measurement is compared to the hammer probe, which is the current gold standard method.

AIR is an ideal tool for functional analysis, long term monitoring of instruments as well as quality control. Instruments are not subjected to mechanical stress and do not have to be prepared for play. The sonification of the impulse response allows for aural assessment and may complement as well as standardize the description of digital objects in archives.

Su. 11:00 P11

Non-contact measurement of bow force and friction force in bowed string instruments using a camera

Ryodai Izaki, Naoto Wakatsuki, Koichi Mizutani and Keiichi Zempo
University of Tsukuba

Visualizing the mechanical parameters given by the player to the instrument may help to improve the performance technique. Thus, the methods to measure parameters that have less influence on musical performance are required. In this research, we proposed a non-contact measurement method of bow force and friction force using an ordinary camera (not high speed). By using an ordinary camera instead of a high-speed camera, we can obtain the average position of the strings from the blurred image. The process consists of the following 3 steps: (1) Taking the video of illuminated strings with a camera. (2) The position of the strings is calculated from the center of gravity illuminated part. (3) String displacement from a neutral position is converted into bow force and friction force using the relation between position and force in a string. In addition, this method is possible to visualize the bow force and frictional force with real-time, so a player can check it there. We confirmed the validity of the proposed method by a verification experiment.

Su. 11:00 P12

How the Directivity of Bundengan Affects Its Musical Performance

Indraswari Kusumaningtyas[a], Raymond Christianto[a], Gea O. F. Parikesit[a], Rosie H. Cook[b], Muhammad S. Abdulloh[c], Luqmanul Chakim[c], Mulyani Moelya[d], Nicole A. Tse[e], Margaret J. Kartomi[f] and G. R. Lono Lastoro Simatupang[a]
[a] *Universitas Gadjah Mada, Indonesia;* [b] *Cheng Shiu University, Taiwan;* [c] *Woohoo Artspace, Indonesia;* [d] *SMPN 2 Selomerto;* [e] *University of Melbourne;* [f] *Monash University, Australia*

The bundengan is a traditional musical instrument from Indonesia that has a half-dome structure, and uses clipped strings and long, thin bamboo plates to generate metal-like and drum-like sounds, respectively. In our previous study, we have unraveled the physics of the clipped strings. However, the interaction between the strings and the half-dome resonator has been largely unknown. In this study, we investigate this interaction, particularly by measuring the directivity of the bundengan as the string vibrations are amplified by the resonator. We performed two sets of measurements, where the instrument was played by traditional and contemporary artists, respectively. This quantitative data complement our interviews with, and qualitative observations on, the artists to provide a comprehensive insight on how the directivity affects the musical performance of the bundengan. Our results open new possibilities for the sustainability of this endangered instrument, as the quantitative analysis allows the makers and players to further enhance the instrument's musical performance.

Su. 14:00 P13

Non-Linearities of the mechano-electrical tonegenerator of the Hammond Organ

Malte Münster and Florian Pfeifle
Institute of Systematic Musicology, University of Hamburg

The Hammond Organ with its electro-magnetic generator, still a standard instrument in the western music world. This organ still fullfills the musicians' demand for assertiveness and a distinctive sonic identity with intuitive control of some arbitrary parameters.
Bequeathed a heritage of some hundreds of thousands of tonewheel organs to the world, most of them still in service since the original manufacturer went out of business. The worldwide organ scene is still vivid.
A description of the tone production mechanism is presented based on measurements taken on different instruments, like Model A and T-Models and includes high-speed camera measurement and tracking of the generator and key mechanisms as well as oscilloscope recordings of the amplifier chain. Some properties emerge due to the interaction of the mechanical motion of interaction with the magnetic H-field.
Some non-linear effects like leakage between wheels, changes in the complexion of harmonics and at least amplifier distortion areexamined. A FEM model of the respective geometry showing good accordance with the proposed effects. A simplified FDM-model is written and a more complex physical model having a special regard to the geometry and electronic parts of the sound production mechanism.

Su. 14:00 P14

Proposal of a human-instrument interaction model and its basic examination using electromyogram

Ryo Itoigawa
University of Tsukuba, Japan

In the production of musical instruments, prototypes are evaluated by professional performers. It is empirically known that evaluation of musical instruments differs depending on the evaluator. However, the mechanism how human evaluates a musical instrument is not revealed. In this research, we newly proposed a human-instrument interaction model when a person evaluates a musical instrument to reveal its mechanism. For a basic study of the model, we measured human muscle activity and verified its trend when controlling the plucking parameters for the guitar. In the experiment, 5 subjects were asked to play a simple task with a plectrum under control the plucking position and dynamics. Subjects consist 4 experienced amateurs and 1 beginner. EMG of four muscles considered to be involved in the plucking motion using a plectrum and audio from the front magnetic pickup were measured simultaneously. As a result, the muscle activity due to the difference in the position has a large difference for each subject, and no specific trend was observed. The muscle activity due to the difference in the dynamics was found to have a certain tendency among subjects, such as muscle activity also increases and decreases with the increase and decrease of plucking dynamics.

Su. 14:00 P15

The ObieAlto project: looking for correlations between perceptual properties and constructional data

Claudia Fritz, Valérian Fraisse and Danièle Dubois
Institut d'Alembert - LAM, Sorbonne Université / CNRS

While the outline geometry differs slightly between violins, it can vary considerably between violas, which are less standardised. During the 2016 Oberlin workshop (organised by the Violin Society of America), a group of instrument makers have collectively designed the so-called ObieAlto outline. 25 violas were then built following this model, but without any other constraint. They were gathered and mounted with the same set of strings at the 2017 workshop. Two short excerpts (respectively in the low and high registers) were recorded by a professional player in a recording studio. The recordings were used in two listening tests, based on a free categorisation task : participants (20 makers and 10 violists) had to evaluate the similarities and differences between the instruments. Statistical and linguistic analyses showed a large variability between the participants but groups of instruments sharing relatively consensual features could be identified. Very few direct relationships between these perceptual features and physical parameters (constructional data but as well audio descriptors calculated on the recordings and vibro- acoustical measurements) could be observed, showing that the multiplicity of the parameters available during the building process allow instrument makers to obtain a certain set of perceptual properties with very different strategies.

Su. 14:00 P16

Tuning of membranophone based on visualization of membrane vibration mode

Eri Zempo, Naoto Wakatsuki, Koichi Mizutani and Yuka Maeda
University of Tsukuba

Tuning of membranophones is important to design timbre, while it is difficult for inexperienced players, due to the insufficient ability for judgment of pitch difference. In this paper, we propose tuning scheme for membranophones, substituting visual information for auditory information. First, vibration modes shape of the head membrane are visualized, based on the measurement of sound pressure on the head membrane by a circular microphone array, and we estimate the tension distribution of the head membrane, especially unbalance in tightness of the pair of rods on oppositional position, make the nodal line of the (1,1) vibration mode change. Second, we propose a tuning scheme for membranophones based on information on the state of the nodal lines of the mode shapes, visualized based on the microphone measurements, and the difference of eigenfrequencies between the orthogonal modes. We show that the proposed scheme is helpful to make the head tension uniform, as the results of experiments using the vibration of tom-tom with only one side head stretched as an example of actual membranophones. We expect this scheme to train the tuning ability for inexperienced players.

Su. 14:00 P17

Damping of waves at the walls of a conical tube

Cornelis Johannes Nederveen[a], Timo Grothe[b] and Johannes Baumgart[c]
[a] *Pijnacker;* [b] *Hochschule für Musik Detmold;* [c] *Dresden*

Resonators of reed wind instruments are tubular ducts with one open and one closed end. The ratio of pressure response to flow excitation at the closed end is the input impedance. Resonance frequencies of the duct are near to peaks in the impedance spectrum. Damping due to visco-thermal effects at the walls influences the frequency and the magnitude of the impedance-spectrum peaks, which influence intonation, playing behaviour and timbre. For cylindrical instruments theory to account for wall losses is available and experimentally confirmed. The wave equation in a conical tube while accounting for dissipative effects at the walls appears to be complicated. Four approximative solutions are compared: (1) Nederveen (1969) presented an approximate analytical solution while neglecting some higher order terms. (2) a transmission line method mimicking the conical pipe as a series of short conical (or cylindrical) pipes, (3) directly solving the equation with a Runge-Kutta procedure, (4) applying a finite difference method. For a ”simplified bassoon” (a perfect cone of 3000 mm length, input diameter 4.2 mm, output diameter 46.9 mm) the four methods give different results. Measurements are planned, but the narrow tube entrance and smoothness requirements make a high accuracy difficult. Suggestions are welcome.

Mo. 11:00 P18

Temporal Acuity - Flamenco Guitar versus Classical Spanish Guitar

Robert Mores
HAW Hamburg

Other than classical Spanish guitars, flamenco guitars are capable of projecting rapid beat sequences in pronounced clarity. This relates to what musicians call a fast guitar. This ask for fast attack but also for some kind of damping in between beats, which may follow each other densely by some ten milliseconds in a rasgueado. Temporal features are investigated across guitars of both types to understand whether the flamenco guitar differs from the classical guitar in these aspects. The full data set contains impulse responses for more than 60 valuable reference guitars. Attack and decay are extracted from bridge impulse responses and from playing open strings. Additionally, a simple measure represents the speed of sound development across the soundboard. This measure is derived from multi-point impulse responses taken along the soundboard. Populations of both types of guitars strongly overlap in these temporal maps and the physics seem to provide only part of the answer. Flamenco guitars tend to be faster in the treble range when monitored by means of specific temporal loudness. While there is only little done on modeling phase-dependent sound perception, auditory physiology may provide the other part of the answer.

Measurement-Based Comparison of Marimba Bar Modal Behaviour

Douglas Beaton and Gary Scavone
Computational acoustic modeling laboratory, CIRMMT, McGill University

A marimba bar's modal behaviour is governed by the shape of its ëundercut'. Manufacturers typically shape these undercuts to tune up to three modes for specified frequencies. With only three or fewer partials to tune, numerous bar geometries may yield the desired results. Different manufacturers will employ different techniques to arrive at suitable bar geometries. This diversity in tuning approaches, coupled with the natural variability of wood, results in a multitude of undercut shapes. Two bars may produce the same musical note despite plainly visible differences in undercut geometry. This work uses experimental modal analysis to investigate the variability of marimba bar modal behaviour. Measurements are performed on numerous bars of the same note. Geometric data, including overall dimensions and mass, are recorded for each bar. Several manufacturers are represented in the resulting data set, including Yamaha, Musser and Marimba One.

Variability of the tuned and untuned modal frequencies are of primary interest. Untuned torsional modes may compromise bar performance if their frequencies are near those of the tuned modes. The proximity of these untuned mode frequencies to those of the tuned modes is therefore also investigated. Results are presented comparing bar performance both between brands and within a brand.

Substitution of spruce tonewood with composite materials tailored using numerical models: an application to archtop guitars

Romain Viala[a], Claudia Fritz[b], Vincent Placet[a], Emmanuel Foltete[a] and Scott Cogan[a]
[a] *Univ. Bourgogne Franche-comté, FEMTO-ST institute;* [b] *Institut d'Alembert - LAM, Sorbonne Université / CNRS*

Stringed instrument making traditionally requires selected wooden materials, called tonewood. Numerous species are used, especially spruce and maple for domestic species and rosewood, ebony, mahogany and pernambuco for tropical ones. Nowadays, the shortage of sufficiently large trees as well as the impact of climate change has led to current and future supply issues. Multilateral treaties to protect endangered wood species are now including several of the above mentioned species, and may include more in the future. In parallel, during the last decade, composite materials made with natural fibres have increasingly been studied and used. The bio-based composites associate fibres from annually renewable sources and bulk wood cores with epoxy resin to create materials that exhibit adjustable mechanical properties. The long-term objective of this work is to demonstrate that such materials can be tailored to mimic the vibro-acoustical behaviour of tonewoods and seen as a sustainable solution. In this study, numerical models of stringed instruments are used to optimize the architecture of bio-based composites to copy the dynamic behaviour of a spruce archtop guitar soundboard. The dynamic response of the manufactured composite parts are measured and compared to the model predictions in order to validate the model-based recipes of composites.

Feasibility Study of Computational Environment for Assisting Musical Instrument Manufacturing

Guilherme Orelli Paiva, Rodolfo Thomazelli, Guilherme Nishino Fontebasso and Lucas Neves Egidio
Turbonius R&D

The musical instruments manufacturing requires several project demands related to the instrument structural capacity and to the desired aesthetic and sound attributes. Although technologies to support these projects have been available for at least two decades, most of what has been done is the empirical reproduction of consolidated models, which hinders innovations since it is often based on trial and error methods. Computational tools, therefore, are useful because they may provide a certain prediction level of the instrument structural behavior and its sound, leading to time and costs reduction in the instrument project. In this context, the Urutau project is emerging as a computational enviroment for assisting musical instrument manufacturers. This work presents a preliminary architecture of the Urutau enviroment as well as an objective validation study of its simulation tools. Initially, a simplified monochord is built and its corresponding CAD model is obtained. A finite element modal analysis is then performed and results are compared with experimental data. A physical modelling based on a modal approach associated with a finite-difference solution is used to generate a set of monochord synthesized sounds which are compared objectively to real sounds.

Demonstrations

Sa. 11:00 D1

A Liquid Sloshing Vibrato Mechanism for the Symbaline; an Active Wine Glass Instrument

Lior Arbel[a], Yoav Y. Schechner[a] and Noam Amir[b]
[a] *Technion - Israel Institute of Technology;* [b] *Tel Aviv University*

The Symbaline is an active instrument consisting of water tuned wine glasses excited by electromagnets. Its timbre is characterized by steady overtones and a smooth attack-decay envelope. In this presentation we describe an electromechanical system for adding vibrato to the Symbaline's sound. The system consists of a pendulum with a magnetic bob, submerged inside the liquid in the wine glass. Infra-sound signals are sent to an electromagnet external to the glass, generating a magnetic field which puts the pendulum into oscillation. As a result of the pendulum's movement the liquid in the glass sloshes and the water level fluctuates in a periodic manner. Audio frequency signals are sent to the same electromagnet, in parallel, inducing vibrations in the wine glass itself, by exciting a small magnet on the glass's surface. While the glass is radiating sound, its resonance frequencies are altered by the changing water levels, resulting in frequency and intensity modulation.

Sa. 14:00 D2

Kora-Som: an interface that converts a player's beating heart into a real-time metronome

Leonardo Fuks[a], Gabriel Moura[a] and Frederico Jandre[b]
[a] *Rio de Janeiro Federal University;* [b] *Biomedical Engineering Program, Rio de Janeiro Federal University*

The heart beat is a central timing reference in life and in music. Several composers and players along history have mentioned the heart rate as a measure for the musical pulse. On the other hand, it is known that listening and playing music affects the heart beat frequency. besides other physiological signals. The purpose of this project consists of building a device that detects, measures and replicates a subject's heart beat and makes it available for musical research and performance. The Kora-Som system employs a commercial heart rate sensor, widely used in sports. The data from this meter are received and decoded by a remote sensor, connected to an arduino and a portable computer. A piece of software generates and plays sounds from wavetables, melodic sequences, midi files and other formats and protocols. A player may litterally play with his/her own heart, what opens a large range of composing and improvising fields. A whole musical group is able to play to/with a certain listener, such as a health patient, in a very touching and stimulating situation. All timing and performing data is recorded and made available for eventual processing and evaluation.

Su. 14:00 D3

A real-time feedback system for vocal tract tuning

Marie Jeanneteau, Noel Hanna, John Smith and Joe Wolfe
UNSW Sydney

The first resonance of the vocal tract (an impedance minimum when measured at the lips) is tuned by some singers: all of the sopranos we have studied, whether trained or not, tune R1 to fo over the range roughly C5 to C6; altos and tenors sometimes tune it to one of the lower harmonics in their upper range. Sopranos who practise the range substantially above about C6 tune the second resonance R2 to fo. The first purely acoustic impedance maximum is tuned by saxophonists and clarinettists under some conditions. This paper introduces a public version of software that can be used in a system to teach vocal tract tuning using a nearly real-time display and a graphical user interface. Our first use of it was to teach R2:fo tuning to sopranos. In a one-hour session, some subjects learned tuning over a limited range, but only with the interface running, while others did not learn tuning. One of the authors (MJ) spent several hours with the system and learned to extend her range of R2 variation and could use R2:fo tuning over from F5 to E6, with and without the visual feedback. Training resonance tuning on saxophone is also proposed.

Experimental setup for real-time control of a single-reed woodwind instrument model

Alex Hofmann[a], Sebastian Schmutzhard[b] and Vasileios Chatziioannou[a]
[a] *Univ. Music and Performing Arts Vienna;* [b] *Austrian Academy of Sciences*

This paper demonstrates an experimental setup for music acoustic experiments and contemporary music performance following a hybrid physical modelling approach. In this setup, a clarinet mouthpiece with a sensor-equipped reed is coupled to a virtual tube. A C++ implementation of a tube model is presented in the form of a Csound opcode which runs on the ultra low-latency audio platform Bela. The coupling is realised with an actuator that acts on the sensor-reed. The actuator is driven by the virtual pressure at the closed end of the tube model, whereas the sensor-reed signal is fed back to the model as volume flow. The experimenter can modify the parameters for length, radius, conicity, end-reflection and air density of the tube model, and is also given control over the coupling between reed and actuator in real time. This setup allows to explore acoustic phenomena that are usually either enclosed (reed-resonator coupling) or static (e.g. resonator shape) in conventional acoustic instruments and may also be useful for music acoustics training.

Plenary Lecture and Sessions on Saturday, September 14

Plenary Lecture
Saturday, September 14, 2019

Sa. 9:20 Woodwinds and Organs: Pipe Organ 25 year Culmination

25 Years Applied Pipe Organ Research at Fraunhofer IBP in Stuttgart
Judit Angster[a], Péter Rucz[b] and András Miklós[a]
[a] *Fraunhofer-Institut für Bauphysik;* [b] *Budapest University of Technology*
Throughout the world, musical instruments are deeply rooted in cultural traditions. They are part of our cultural heritage, and their preservation and further development deserves our utmost attention. For many years, the Fraunhofer Institute for Building Physics IBP has been engaged in the research of European musical instruments, the organ in particular. To preserve its sound, to give support in building instruments as well as to contribute to the further development by integrating modern technologies are the focus of the joint research with other research institutions and a multitude of European organ building enterprises.
In 25 years, 9 common European and several other research projects were carried out. Some examples of the topics will be mentioned like development of 1) different kinds of new wind systems, methods and software for the design, 2) design methods, tools and software with applying computer simulations for flue and reed organ pipes 3) innovative swell shutters, 4) design methods and comprehensive tools for matching the instrument on the acoustics of the room.
The procedure of research, way of communication with instrument builders, the method of demonstration and dissemination of the research results will be discussed.

Acoustics of Wind Instruments and Organs: Flutes
Chairs: J. Angster, B. Fabre

Sa. 10:00 Woodwinds and Organs: Flutes

How do flute players adapt their control parameters to modifications of the flute bore?
Benoit Fabre[a] and Patricio de la Cuadra[b]
[a] *LAM Sorbonne Universite France;* [b] *Pontificia Universidad Catolica de Chile*
Skilled players can adapt their control parameters according to the response of the instrument they are playing. In the case of the flute, lips and face position relative to the mouthpiece are the main adjustments used for a fine control of the pitch, while the detailed geometry of the flute bore determines the intonation profile of the instrument along its tessiture. In this paper we introduce and explain the idea of a negative bore in which we control subtle modifications of the intonation profile of the flute. Skilled players are then invited to play on different profiles of the same instrument while the geometrical and hydrodynamical control parameters are monitored.
The paper will discuss the adjustments observed in the control strategy of the players, as function of the intonation profiles measured.

Sa. 10:20 Woodwinds and Organs: Flutes

Experimental study on the temporal fluctuation of harmonics in flute sounds
Keita Arimoto
YAMAHA Corp, R&D
There are some studies on the temporal fluctuation of harmonics in flute sounds. However, it is still unclear whether it is due to the fluctuation coming from human player or the nature of the sounding mechanism. In this study, an experiment was conducted to investigate temporal fluctuations purely due to the sounding mechanism of the flute. For this purpose, an artificial blowing system was built in order to yield flute sounds by a constant air flow as well as by adjusting the angle, offset, length and velocity of the jet. The temporal fluctuation for a harmonic component was computed by a standard deviation for a series of instantaneous harmonic amplitudes obtained from short-time audio analysis. The result shows that the temporal fluctuation increases as the average harmonic amplitude decreases, and vice versa. The effect of the temporal fluctuation on perceptual impression was finally confirmed by a synthesis experiment where flute sounds were re-synthesized with controlling the amount of the temporal fluctuation.

Experimental Investigation for Effects of Jet Angle on the Harmonic Structure in the Flute
Onogi Kimie[a], Ai Natsubori[a], Hiroshi Yokoyama[a], Akiyoshi Iida[a] and Keita Arimoto[b]
[a] *Toyohashi University of Technology;* [b] *YAMAHA Corp, R&D*
To clarify the effects of jet angle on the radiated sound from the flute, the radiated sound and jet fluctuations were experimentally investigated. An artificial blowing device with an artificial oral cavity was used to change the jet angle and the geometric jet offset (the relative height of the vertical line of the cavity exit center from the edge) independently. The actual jet offset (the relative height of the jet fluctuation center from the edge) was estimated based on the velocity profile measured by a hot-wire anemometer. Under the condition that the geometric jet offset is zero, the actual jet offset changed with the jet angle. Also, the sound of the second/third mode radiated more/less intensely with larger actual jet offset, while the radiated sound of the first mode remained almost the same level. These results indicate that the variation of the jet angle affects the actual jet offset, which affects the harmonic structure.

Directivity of Musical Instruments: String ensembles
Chair: J. Woodhouse, R. Mores

ODESSA – Orchestral Distribution Effects in Sound, Space and Acoustics: an interdisciplinary symphonic recording for the study of orchestral sound blending
Martha de Francisco[a], Malte Kob[b], Jean-François Rivest[c] and Caroline Traube[c]
[a] *McGill University, Montreal;* [b] *Detmold University of Music;* [c] *Université de Montréal*
ODESSA is a collaborative project between the Université de Montréal, McGill University and Detmold University of Music aiming to study orchestral blending effects, examining how instrumental sounds are sculpted by the conductor, the musicians and the hall acoustics and how the sound changes when heard and recorded from different perspectives. This project is realized in context of the ACTOR (Analysis, Creation, and Teaching of Orchestration) partnership, which involves a diverse international team of composers, music theorists, musicologists, computer and signal processing scientists, psychologists, acousticians, sound recordists and conductors. ACTOR's main goals are to develop a perceptually based theory of orchestration and to create new tools for music analysis, composition, teaching and mediation. Under the combined leadership of four researchers, the ODESSA project consists of a complex multitrack recording of the Orchestre de l'Université de Montréal performing excerpts from Tchaikovsky's Sixth Symphony, "Pathétique". More than 50 microphones are used in a combination of close microphone pick-up and ambient recording. Concurrently, the acoustical balance of the instruments is examined employing techniques such as 3D intensity probes and an acoustic camera. Excerpts of the recording of varying instrumental combinations are used as listening test stimuli with the purpose of investigating timbral blending effects.

Investigation of the Blending of Sound in a String Ensemble
Stefanos Ioannou and Malte Kob
Detmold University of Music
Ensemble sound is a topic where, to date, only little research has been conducted. A fundamental question that still needs to be answered is how many instruments of the same section are required for a group to blend together as an ensemble. As part of the ACTOR project, a violin phrase from Tchaikowsky's 6th Symphony has been recorded with one, two, three, four, six and ten violins using piezo microphones, spot microphones, a decca tree, room microphones, and a dummy head. Based upon these recordings a listening test was designed, in which participants had to (1) guess the number of violins and (2) state whether the recording sounds like an ensemble. Results reveal that a majority of listeners perceive an ensemble sound for a relatively low number of instruments whereas the number guess task fails for lagern numbers. The microphone location relative to the instruments is of major importance.

Sounds Like Melted Chocolate: How Musicians Conceptualize Violin Sound Richness
Charalampos Saitis[a,b], Claudia Fritz[c] and Gary Scavone[d]
[a] *Centre for Digital Music, Queen Mary University of London;* [b] *Chair of Acoustic and Haptic Engineering, TU Dresden;* [c] *Institut d'Alembert – LAM, Sorbonne Université / CNRS;* [d] *Computational acoustic modeling laboratory, CIRMMT, McGill University*
Results from a previous study on the perceptual evaluation of violins that involved playing-based semantic ratings showed that preference for a violin was strongly associated with its perceived sound richness. However, both preference and richness ratings varied widely between individual violinists, likely because musicians conceptualize the same attribute in different ways. To better understand how richness is conceptualized by violinists and how it contributes to the perceived quality of a violin, we analyzed free verbal descriptions collected during a carefully controlled playing task (involving 16 violinists) and in an online survey where no sound examples or other contextual information was present (involving 34 violinists). The analysis was based on a psycholinguistic method, whereby semantic categories are inferred from the verbal data itself through syntactic context and linguistic markers. The main sensory property related to violin sound richness was expressed through words such as full, round, and dense versus thin, weak, and small, referring to the perceived number of partials present in the sound. Another sensory property was expressed through words such as warm, velvety, and smooth versus strident, harsh, and tinny, alluding to spectral energy distribution cues. Haptic cues were also implicated in the conceptualization of violin sound richness.

Directivity of Musical Instruments: Sound fields
Chair: G. Scavone, T. Grothe

External sound field simulations and measurements of woodwind resonators
Erik Alan Petersen and Romane Rosser
Aix Marseille Univ, CNRS, Centrale Marseille, LMA, UMR 7031, Marseille
The input impedance is a useful quantity to characterize the acoustic response of woodwind instruments and is efficiently simulated using the Transfer Matrix Method (TMM). However, the TMM does not calculate intermediate variables that are convenient for simulating the external sound field. Recent work by Lefebvre et al proposes the Transfer Matrix Method with external Interactions (TMMI) which accounts for the mutual radiation impedance of toneholes radiating into the same space and uses the acoustic flow through each aperture as the reference variable. Treating the flow through each tonehole as a source in a linear array, it is possible to calculate the external sound field such as the waveforms at a given receiver location and directivity patterns. Additionally, the efficiency of a resonator can be calculated as the ratio of the power at the input of the resonator and the sum of the power radiating from each aperture. This is a useful step towards understanding the competition between the energy that is retained within a resonator and facilitates the auto-oscillation of the reed, and that which radiates from the resonator. This topic is explored through simulation and measurements using simplified cylindrical resonators.

Impact of free field inhomogenity on directivity measurements due to the measurement set-up Malte Kob[a] and Alexis Baskind[b]
[a] *Detmold University of Music;* [b] *alexis baskind music production*
Measurements in anechoic conditions are affected by the measurement set-up itself. The presence of grids, stands, turntables and the human body introduces reflections, diffraction, absorption and more changes to the ideally free field conditions. The impact of such equipment on directivity measurements is often neglected, and artefacts are are easily mis-interpreted as features of the source directivity. In an anechoic chamber several setups are compared with respect to changes in the measured directivity of a simplified musical instrument. The differences of the 1/r amplitude decay as well as the resulting directivities are presented and discussed.

Piano strings with reduced inharmonicity

Jean-Pierre Dalmont[a] and Sylvain Maugeais[b]
[a] *LAUM, Le Mans;* [b] *Laboratoire Manceau de Mathématiques – Le Mans Université*

The inharmonicity of the lower strings of straight pianos is still rather large especially for the first octave. Consequently, the timber of these strings can be sometimes awful and chords on the first octave highly dissonant. The idea of the present study is to show how this defect can be rectified by using an inhomogeneous winding on the whole string in order to minimize inharmonicity. The problem is solved by using an optimization procedure considering a non uniform linear density. Result show that the inharmonicity can be highly reduced. First results on a real string will be presented and discussed.

Design & Playing: Fingering & articulation Chairs: J.-P. Dalmond, G. Scavone

Physical principle of pitch bent by cross-fingering

Seiji Adachi
Fraunhofer Institute for Building Physics, Stuttgart

Cross-fingering is a technique of playing woodwind instruments in which one or more tone holes are closed below the first open hole. It usually yields a pitch lower than that played with normal fingering. However, pitch is raised in exceptional cases. Pitch flattening has been traditionally understood using the lattice tone hole theory. On the other hand, pitch sharpening has been scarcely explained except for pointing out the possibility for the open hole to act as a register hole. This talk proposes understanding these pitch bending phenomena in a unified manner with a model of two coupled mechanical oscillators. Bores above and below the open hole interact with each other by sharing the air in the open hole oscillating as a lumped mass. This mechanism is known in physics as avoided crossing or frequency repulsion. With an extended model having three degrees of freedom, pitch bending of the recorder played with cross-fingering in the second register can also be explained.

A parametric study of finger motions when playing the clavichord: towards characterization of expressive control

Jean-Théo Jiolat, Jean-Loïc le Carrou and Christophe D'Alessandro
Sorbonne Université, CNRS, Institut Jean Le Rond d'Alembert

The clavichord is considered to be the most demanding keyboard instrument in terms of finger control. This is because of its direct mechanisms: the key works as a lever. When the finger presses the key, the tangent (metal rod) on the key's extremity goes up and strike the string. And as long as the finger remains pressed on the key, the tangent remains in contact with the string, leading to string's tone variation. The loudness of the sound is proportional to the velocity of the key's displacement. Then there is a duality between loudness and pitch accuracy. This is the paradox of the clavichord. The objective of the study is to analyze experimentally the sounding consequences of the instrument with respect to the gestural strategies of the finger. To proceed, we use a robotic finger that can simulate different trajectories, either ideal trajectories (e.g. vertical or sliding motions) or actual trajectories performed by clavichord players. Players' trajectories are extracted by image processing of films made by a high-speed camera. Vibratory and acoustical measurements are performed, upon which relevant indicators are used to compare different configurations. The finger performing a circular motion reaches a good compromise between tone and loudness.

Factors affecting transients in rapid articulation on a bass crumhorn
Alan Woolley, Murray Campbell and Simon Carlyle
University of Edinburgh
The generation of a pitched note on a reed instrument involves a nonlinear acoustic coupling between the mechanical reed and the air column of the instrument. Once a stable regime of oscillation has been achieved the reed vibrates at the playing frequency, which is much lower than the reed natural frequency.
On windcapped instruments like the crumhorn a change in the playing frequency is initiated by opening or closing toneholes. This modifies the acoustic resonances frequencies of the air column, and the pressure feedback to the reed causes its vibration frequency to change. Factors affecting the transients during rapid pitch changes on a bass crumhorn have been investigated using high speed video recording of reed motion, laser-based position tracking of the reed tip vibration, and measurements of pressure upstream and downstream of the reed.

Design & Playing: Room and structure Chairs: T. Halmrast, M. Kob

Music Practice Rooms: Ambitions, Limitations and Practical Acoustic Design
Claudiu Pop[a], Riduan Osman[b] and Julia Knight[c]
[a] *The University of Sydney;* [b] *Northrop Consulting Engineers;* [c] *Resonate Consultants*
The acoustic design of music practice rooms is a well-researched and investigated topic. This study reviews critically the acoustic parameters generally accepted as desirable for these rooms and provides insight from a practitioners perspective. A series of music practice rooms are discussed and a holistic discussion is provided on the design challenges and successes as part of a multidisciplinary team of acousticians, architects, building services and structural engineers.

Acoustical evaluation of differences in Sanshin's tone depending on shapes of SAO Kojiro Nishimiya, Mao Tokuda, Yuki Yokota and Hideo Cho
Aoyama Gakuin University, Japan
Sanshin is an OKINAWA's traditional musical string instrument. Generally, the sound board is one of the main factors on the string instrument's tone from the acoustical points of view. Nevertheless, about Sanshin, the player and artisan have thought that Sao (Neck) has been the most important. Sanshin has many types of Sao and there have many arguments of the relationship between "Sao" and "Tone". However, the sound mechanism is still not clarified. Therefore, the purpose of this research is to elucidate the sound mechanism of Sanshin which include the influence of Sao. We measured the Sanshin's tone using different types of SAO with the same body, string, and bridge. As a result, we found the several differences in the tones. Especially the differences were confirmed in the frequency distributions and the attenuation rates. For the understanding of these behaviors, we focused about the change of the thickness and length of SAO, and the mass damping of the head of SAO. By the cutting works of one wood-Sanshin, we found that the thickness and length of SAO influence the frequency distributions and the mass damping influences the attenuation rate.

Acoustics of Wind Instruments and Organs: Pipe organs
Chairs: P. Rucz, V. Hruska

Sa. 18:00 Woodwinds and Organs: Pipe organs

The Khaen as a Miniature Pipe Organ
James Cottingham
Coe College, Cedar Rapids, Iowa
The khaen is a Southeast Asian mouth organ consisting of a number of free-reed pipes (commonly sixteen) mounted in a wooden wind chamber. From one point of view, it is possible to think of this instrument as an extremely small pipe organ: one with one rank of sixteen free-reed pipes. There have been a number of studies of the khaen in recent decades, often focusing on the coupling between a single reed and the pipe in which it is mounted. Yet music for the khaen, both traditional music and new music by current composers and players, almost always involves multiple notes sounding simultaneously. This paper summarizes some investigations involving the instrument as a whole, sometimes observing similarities and differences between the khaen and the pipe organ. A significant difference is the wind supply, which in the khaen is continually reversing direction. This certainly affects the musical playing style of the instrument, but may have other acoustical complications. Another area recently explored experimentally involves possible musical consequences of mode locking between pipes.

Sa. 18:20 Woodwinds and Organs: Pipe organs

The air jet development in organ pipe tone attack caused by voicing adjustments
Zdenek Otcenasek[a], Pavel Dlask[b] and Jan Otcenasek[a]
[a] *MARC HAMU Prague;* [b] *Academy of Performing Arts in Prague*
The contribution presents the results of a research on differences in development of air jet fluxes in labium of a rectangular organ flue pipe caused by different voicing adjustments. Air jets of tone starting transients were observed by laser PIV (particle image velocimetry) on a single transparent pipe with varied combinations of the upper lip height (cut-up), the flue slit area (breadth) and the windchest air pressure. Visualizations of the air jet velocity vectors will be linked to a development of sound pressure and descriptions of sound quality from a listening test.

Sa. 18:40 Woodwinds and Organs: Pipe organs

Distortion of acoustic shockwaves by U-shaped tube portions
Sebastien Ollivier[a], Thomas Lechat[b], Didier Dragna[b] and Arnaud Gluck[b]
[a] *Université de Lyon, Univ. Lyon 1, LMFA UMR CNRS 5509;* [b] *Université de Lyon, Ecole Centrale de Lyon*
Nonlinear propagation models for wave propagation in the resonator of brass instruments are generally based on a one-dimensional description. This description is made under the hypothesis that sound wave propagation does not depend on bends, and is the same for straight or curved resonators. However, brass instruments resonators are not straight, and the effects of bends have to be considered. Modal approaches have shown that the pressure field has no symmetry in curved ducts, both in linear and weakly nonlinear propagation. The present study addresses the question of the behavior of shockwaves in U-shaped tubes with geometries close to some parts of brass instruments resonators, For this purpose, both experiments and numerical simulations in time domain have been performed. The experiments are based on optical measurements requiring a square section of the U-shaped portion of the duct. The corresponding numerical simulations have been performed by solving the 2D Euler equations in curvilinear coordinates using a finite-difference time-domain approach. Results reveal the dynamics of shock propagation, the nonlinear interaction of shocks, and the distortion of the waveform.

Acoustics of Wind Instruments and Organs: Clarinet and single reeds
Chairs: J. Gilbert, P.-A. Taillard

Sa. 19:00 Woodwinds and Organs: Clarinet and single reeds

Numerical study on the function of the register hole of the Clarinet

Kin'Ya Takahashi[a], Kana Goya[a], Saya Goya[a], Genki Tsutsumi[a] and Taizo Kobayashi[b]
[a] *Kyushu Institute of Technology;* [b] *Kyushu University*

The function of the register hole of the Clarinet can be basically explained from the common property of two delay systems (J. Phys. Soc. Jpn, Vol.83, 124003 (2014)). Namely, if the strength of a short time delay is sufficiently small but non-negligible, the third harmonic is well sustained over a wide range of the short delay time. This fact indicates that the register hole with a small radius raise the pitch of the first register notes in a wide range more than an octave to the second register notes by a twelfth (19 semitones). However, the reflection function has many delay peaks even when only the register hole is opened. That is, the clarinet should be characterized as a multi-delay system. In this paper, we focus on the effect of a very short time delay, which characterizes the reflection from the discontinuity in the mouthpiece. We numerically found that the function of register hole survives even for such a three delay system including the reflection from the mouthpiece.

Sa. 19:20 Woodwinds and Organs: Clarinet and single reeds

Numerical study on unsteady fluid flow and acoustic field in the clarinet mouthpiece with the compressible LES

Toshiaki Koiwaya[a], Sho Iwagami[a], Taizo Kobayashi[b] and Kin'ya Takahashi[a]
[a] *Kyushu Institute of Technology;* [b] *Kyushu University*

The sound generation in the clarinet mouthpiece is still an unsolved problem from the view point of aeroacoustic and has been studied theoretically, experimentally and numerically by many authors. Numerical simulations on the unsteady flow in the clarinet mouthpiece using LBM have been reported by several authors. In this paper, we numerically study unsteady fluid flow and acoustic field in the clarinet mouthpiece with compressible LES. We adopt 2D and 3D models and the 3D model has numerical grids more than one hundred and 50 million to reproduce detail behavior of air-jet motion, vortices and acoustic filed. In our models, the reed is fixed and an uniform flow is injected from the reed slit to study the behavior in the attack transient. The 2D and 3D models behave in different ways. For the 2D model, the injected jet is rolled up making long-lived rotors in the mouthpiece, while for the 3D model it is destabilized in a certain distance is broken into a lamp of turbulence. We also study the station that an alternating current is injected from the slit to reproduce the acoustic resonance.

Sa. 19:40 Live Stream: Woodwinds and Organs: Clarinet and single reeds

Computational Aeroacoustic Modeling of Single-Reed Mouthpiece Using Palabos

Song Wang and Gary Scavone
McGill University, Montreal, Computational acoustic modeling laboratory CIRMMT

The sound generation behavior of a single-reed instrument can be determined from its aeroacoustic characteristics. Computational aeroacoustics (CAA) modeling offers a mean to analyze the aeroacoustics behavior of such a system. The lattice Boltzmann method (LBM) models fluid on a mesoscopic level and has certain advantages over traditional Navier-Stokes approaches in solving CAA problems. In this study, we present results from an aeroacoustic analysis of a 2D single-reed mouthpiece system using an open- source, parallelized lattice Boltzmann solver called Palabos. A variety of functionalities and components are investigated, including the parallelization, the grid refinement, the moving boundary, and the non-reflecting boundary condition, which demonstrates the versatility of Palabos. Different mouthpiece geometries are tested with both static and moving reeds. The nonlinear characteristics of the mouthpiece-reed system derived from this study are then compared with the theoretical quasi-static flow model.

Sessions on Sunday, September 15

Strings: Non-western instruments
Chairs: R. Mores, J.-P. Dalmont

Su. 9:00 Strings: Non-western instruments

Design, Construction, and Material of an Ancient Indian String Instrument
Anurag Gupta and Chaitali Dangarikar
Indian Institute of Technology Kanpur
Ekatantri Vina is a one-stringed fretless tubular zither from ancient India whose descriptions and representations are variously found in musicological texts and sculptures, respectively, between 10th and 15th century AD. The present work is a first of its kind attempt to study these sources to understand the precise structural and material nature of the Vina. In particular, we use the five Sanskrit texts where Ekatantri Vina is unambiguously described, and prepare accurate computed aided models of various parts of the Vina as well as describe their assembly. We also compare how the construction and the material of the Vina differed between various texts which span five centuries. Our work is motivated, on one hand, from an aim to establish historicity of certain unique design features of the present day Indian stringed instruments and, on the other hand, to initiate a systematic study towards reconstruction of ancient Indian instruments. Our investigations also provide grounds for further study in acoustics, mechanics, and materials, all in the context of ancient Indian science.

Su. 9:20 Strings: Non-western instruments

Vibration Characteristics of Oud Soundboard
Sinan Inanli and M. Ercan Altinsoy
TU Dresden
Oud is a plucked musical instrument played in many countries. This historical musical instrument involves many structural parts effecting its acoustics and sound quality. This study aims at investigating the vibration characteristics of an oud soundboard for free-free and fixed (at its edges and no back cavity) boundary conditions. Also as a final step, the soundboard-air cavity coupled modes were measured by assembling the soundboard and body together. Frequency response function (FRF) measurements were carried out by experimental modal analysis technique to reveal the dynamic behaviour (mode frequencies, mode shapes and damping coefficients) of the soundboard which has a conventional seven parallel strutting configuration.

Su. 9:40 Strings: Non-western instruments

Numerical Simulation of Aerodynamics Sound in an Ocarina Model
Hiroaki Okada[a], Sho Iwagami[a], Taizo Kobayashi[b] and Kin'Ya Takahashi[a]
[a]*Kyushu Institute of Technology;* [b]*Kyushu University*
The body of an ocarina is regarded as a Helmholtz resonator. Thus, we can expect differences in sounding mechanism between ocarinas and other air-jet instruments with a resonance pipe. Furthermore, ocarinas are driven by cross blowing like transverse flutes so that the driving mechanism with an air-jet should be different from that for vertical flues like a recorder. In this paper, we numerically explore the sounding mechanism of an ocarina from the view point of aeroacoustics with compressible fluid simulation. We adopt compressible LES as a numerical scheme of compressible fluid, which simultaneously reproduces fluid and acoustic fields and with which we can investigate the interaction between the fluid and acoustic fields near the mouth opening. Our 3D model has numerical grids more than one hundred and 50 million to reproduce detail behavior of air-jet motion, vortices and acoustic filed near the mouth opening. We numerically observed an acoustic oscillation with the Helmholtz resonance frequency in the body together with the detail structure of fluid field.

Strings: Guitar, modeling, and modes
Chairs: R. Mores, J.-P. Dalmont

Su. 10:00 Strings: Guitar, modeling, and modes

Experimental and Simulative Examination of the String-Soundboard Coupling in an Acoustic Guitar
Alexander Brauchler[a], Pascal Ziegler[a], Sabina Benatti Camargo[b] and Peter Eberhard[a]
[a] *ITM University of Stuttgart;* [b] *Sapienza University of Rome*
The acoustic guitar is a popular string instrument in which the sound results from a coupled mechanical process. The oscillation of the plucked strings is transferred through the bridge to the body which acts as an amplifier to radiate the sound of the guitar. In this contribution, the vibration of a guitar and the coupling between the strings and the guitar body is examined experimentally and by means of numerical simulation. An experimental setup not only capable of determining eigenmodes and eigenfrequencies but also demonstrating the transient coupling between the strings and the body is presented. This capability is achieved with a plucking mechanism that allows realistic and reproducible plucks of a single string and synchronized measurements of multiple plucks at different positions of the guitar body using a scanning laser Doppler vibrometer. Besides the experimental setup, a finite element model of the guitar is developed. The numerical model consists of the strings, the body, and the neck of the guitar. Furthermore, the struts reinforcing the soundboard and the back of the guitar are included. A comparison between the numerical model and the experimental measurements is conducted with particular focus on the transient coupling between the strings and the soundboard.

Su. 10:20 Strings: Guitar, modeling, and modes

Modelling of Gabonese harps
Antoine Caillon[a], Jean-Loïc Le Carrou[a], Baptiste Chomette[a] and Sylvie Le Bomin[b]
[a] *Sorbonne Université, CNRS, Institut Jean Le Rond d'Alembert;* [b] *Muséum National d'Histoire Naturelle, CNRS, éco-anthropologie et ethnobiologie*
Traditional instruments handed down from generation to generation, Gabonese harps have various shapes, often anthropomorphic, that depending on the population and the region concerned. Nevertheless, harps are all composed of eight strings, each wrapped up on one side to a tuning peg fixed on the neck and at the other side linked to a wooden tailpiece. It is often nailed to both ends of the resonance box, under the soundboard made of animal skin. In order to study the evolution of these instruments within the framework of a multidisciplinary project, an acoustic modelling of the instrument is undertaken. The main objective of this modelling is to understand and highlight maker's elements that predominate in their sound. For this purpose, the Udwadia- Kalaba formulation is used to model vibrating systems coupled together by mechanical constraints. In particular, this formulation can take into account geometrical non-linearities of strings induced by their high-amplitude excitation. Model parameters were first extracted from an instrument at our disposal. Then, time-domain simulations were confronted to experimental data. Finally, a parametrical study showed that the low string tension and modal behaviour of the tailpiece are of great importance in the characteristic sound of the instrument.

Virtual Prototyping of Musical Instruments: Design and player control
Chairs: V. Fréour, M. Jousserand

Su. 12:00 Virtual Prototyping: Design and player control

Exploring dependency between instrument design and musician's control.
Patricio de la Cuadra[a], Augustin Ernoult[b] and Benoit Fabre[c]
[a] *Pontificia Universidad Catolica de Chile;* [b] *Aix Marseille Univ, CNRS, Centrale Marseille, LMA, UMR 7031, Marseille;* [c] *LAM Sorbonne Universite France*
In flute-like instruments the pitch of the notes produced depend on the instrument geometry as well as on the control the musician exerts on it. Thus, a particular flute design requires from the musician a specific strategy to obtain a set of notes "in tune" with a certain cultural intonation agreement. The control parameters available in most flutes include the jet speed and the opening of one end of the flute, normally adjusted by the proximity from the lips to the labium.
In this paper we explore the relationship between the design of the instrument and the control exerted by the musician, proposing algorithms to automatically design the bore geometry and position and size of the toneholes for different musicians control strategies.

A Real-Time Physical Model to Simulate Player Control in Woodwind Instruments

Vasileios Chatziioannou[a], Alex Hofmann[a] and Sebastian Schmutzhard[b]
[a] *Univ. Music and Performing Arts Vienna;* [b] *Austrian Academy of Sciences*

The interaction between woodwind players and their instruments is a key aspect of expressive music performance. Therefore, recent studies have focused on understanding how the actions of the players affect sound generation. Based on experimental results obtained using both human performers and an artificial blowing machine, this paper presents a numerical model that, taking the players' actions into account, may synthesise expressive woodwind instrument sounds. Implemented in C++ the model allows real-time performance on a standard desktop computer, thus enabling the user to modify the model parameters in a live performance scenario. Apart from varying parameters related to the embouchure of the player and the effective length of the resonator (i.e. mimicking modifications that could take place in real playing) this model also allows virtual modifications that would not be possible to realize in the physical world, such as a cone gradually morphing into a cylinder and vice versa. Besides parameters related to the excitation mechanism and the geometry of the instrument, the user is able to modify the properties of the air inside the instrument and the magnitude of the viscothermal losses.

The virtual workshop OpenWInD: Towards an optimal design tool of wind instruments for makers

Guillaume Castera, Juliette Chabassier, Augustin Eernoult, Alexis Thibault and Robin Tournemenne
Inria team Magique 3D, 200 avenue de la vieille tour, 33400 Talence, France.

Our project develops an optimisation software (OpenWind) for wind instrument making. The approach is based on a strong interaction with makers and musicians, aiming at computing quantities and defining interesting criteria that should be optimized, from their point of view. Entry impedance is a well studied acoustical quantity that characterizes the linear response of the pipe. However, makers and musicians mostly rely on sounds produced in a musical framework in order to assess an instrument. These sounds can be modeled as a coupling between the pipe (resonator) and an embouchure (oscillator, as a reed for instance). We will present energy based time domain models and simulations where a reed embouchure is coupled with a linear pipe. State-of-the-art numerical techniques are used for the pipe discretization (finite elements for one-dimension Telegrapher's equations). Realistic radiation impedances are formulated in the time domain and an energy based model is derived along with a stable numerical scheme. Pipe junctions are also accounted for, by the means of extended Kirchhoff conditions that are shown to exhibit an inappropriate energy behavior in the time domain. A reed is coupled with the instrument and an energy-based time discretization is derived. Explicit and efficient algorithms are derived for the computation of the scheme's unknowns. Sounds can be heard while the pressure and flow inside the instrument can be observed during the note evolution.

Virtual Prototyping of Musical Instruments: Numerical exploration
Chairs: V. Fréour, M. Jousserand

Su. 13:00 Virtual Prototyping: Numerical exploration

Numerical analysis and comparison of brass instruments by continuation
Vincent Fréour[a], Hideyuki Masuda[a], Satoshi Usa[a], Eiji Tominaga[a], Yutaka Tohgi[a], Bruno Cochelin[b] and Christophe Vergez[b]
[a] *YAMAHA;* [b] *Aix Marseille Univ, CNRS, Centrale Marseille, LMA, UMR 7031, Marseille*
Brass instrument design has long been relying on empirical know-how, build up over the years by the craftsmen. Some relationships between the air-column geometry, the intonation and some attributes of sound color have been formalized through this process by the makers. However, many properties of the instrument, related to timbre, dynamic range, playability, etc. are still very difficult to correlate to the design. Alongside these issues and important questions for the craftsmen, the knowledge in the acoustics of musical instruments has extensively improved in the last decades, benefiting especially from cutting edge engineering methods for the analysis of dynamic systems. In this presentation, we will detail some applications of stability analysis and continuation (Asymptotic Numerical Method), to physical models of trumpets. This approach aims to clarify differences between instruments on the basis of calculated performance descriptors. On a longer term, our goal is to include these technologies in the development of new instruments, by providing some virtual performance analyzers for the design of brass instruments.

Su. 13:20 Virtual Prototyping: Numerical exploration

Numerical synthesis applied to reed instruments: influence of the control parameter transients on the steady-state oscillation regime
Tom Colinot[a], Philippe Guillemain[b], Jean-Baptiste Doc[c] and Christophe Vergez[b]
[a] *LMA Marseille;* [b] *Aix Marseille Univ, CNRS, Centrale Marseille, LMA;* [c] *Laboratoire de Mécanique des Structures et des Systèmes Couplés, CNAM, Paris*
Physical models of self-oscillating musical instruments include strongly nonlinear elements and delayed terms, leading to a great variety of produced sounds. For example, the same fingering on a wind instrument can produce oscillating regimes at several different fundamental frequencies as well as quasi-periodic regimes. The emergence of these regimes is conditioned mostly by the value of control parameters, representing the action of the musician, such as blowing pressure or lip force on the reed. As a strongly non-linear delayed system, a wind instrument model may converge to different stable regimes depending on the initial conditions and the transient of the control parameters. For the second point, an example would be the speed with which the blowing pressure reaches its final value. In this work, we show that depending on the way the blowing pressure increases to its final value, the steady regime may be oscillating or non oscillating, or correspond to the first or second register. Such considerations are useful when trying to predict the playability of an instrument using numerical simulations.

Su. 13:40 Virtual Prototyping: Numerical exploration

Simulation of the nonlinear characteristic of the clarinet exciter and of the side holes Pierre-André Taillard and Jean-Pierre Dalmont
LAUM, Le Mans
At the last ISMA, a method for measuring the nonlinear characteristic and the static mechanical behaviour of the clarinet exciter (reed + mouthpiece + lip of the player) was presented. Here, we show how this measured behaviour can be integrated in a real time simulation using a waveguide clarinet model, including nonlinear losses at the toneholes. The clear separation of the aeraulic (nonlinear characteristic) and mechanical (static bending of the reed against the mouthpiece lay, like a stiffening spring) aspects allows a straightforward, piecewise simulation of the dynamic behaviour, apparently without any numerical stability problem. For the simulation of the instrument, at a low sound level, the proposed empirical tonehole model tends towards the linear radiation impedance, whereas at high level, nonlinear losses dominate. They are modelled by Bernoulli's law with turbulent flow (as for the exciter). Taking nonlinear losses into account is crucial for a credible simulation of the instrument, especially in the second regime. The model allows to realistically predict the playing frequency and the timbre of the instrument according to the two main objective factors characterizing clarinet reeds: stiffness and opening at rest (without lip pressure). This allows a virtual prototyping of the clarinet exciter and resonator.

Acoustics of Wind Instruments and Organs: Numerical improvements
Chairs: B. Fabre, V. Fréour

Su. 15:00 Woodwinds and Organs: Numerical improvements

Finite element simulation of radiation impedances with applications for musical instrument design
Péter Rucz[a], Judit Angster[b] and András Miklós[b]
[a] *Budapest University of Technology;* [b] *Fraunhofer-Institut für Bauphysik*
Creating a musical instrument often involves designing acoustical resonators. The natural frequency and the quality factor of the resonator are affected by the radiation impedance to a significant extent. Therefore attaining as much a priori knowledge as possible on the radiation characteristics is desirable. On the other hand, for the sake of efficiency, radiation characteristics are most often reduced to a sole frequency dependent radiation impedance function. A finite element approach for the calculation of self and mutual radiation impedances was introduced recently [Rucz, JASA 143(4) 2449-2459], which is suitable for these purposes.
In this contribution, the methodology is applied and extended with different applications in musical instrument design. In particular, the radiation from the mouth regions of organ pipes and recorders are examined. The geometrical parameters having the most significant effect on the radiation characteristics are analyzed and the results are compared to previously published data. As another example, finite element simulations of Helmholtz resonators of a mallet percussion instrument are introduced. In this case, the length correction effect of the sound bars partially covering the opening of the resonators is studied. Finally, the effect of viscous losses on the quality of the natural resonance is investigated.

Su. 15:20 Woodwinds and Organs: Numerical improvements

Numerical study of Synchronization Phenomena of an Air-Jet Instrument using Finite-Difference Lattice Boltzmann Method
Ryoya Tabata[a], Taizo Kobayashi[b] and Kin'Ya Takahashi[a]
[a] *Kyushu Institute of Technology;* [b] *Kyushu University*
Coupled Van der Pol oscillators are often used for the studying of synchronization mechanism among flue organ pipes. However, recent studies have suggested that the effect of near-field interaction between the air-jet motion and the acoustic field plays an important role in the mechanism of synchronization. In this study, we focus on the synchronization between an air-jet instrument and external sound source. We numerically explore the synchronization mechanism using a finite-difference lattice Boltzmann method (FDLBM) as a direct aeroacoustic simulation scheme in two dimensions. We succeed in reproducing the frequency-locking phenomenon between the monopole sound source and air-jet instrument in the stationary state. Numerical simulations are conducted on a GPU cluster to explore the large parameter space. Transient behavior towards the frequency-locking phenomenon was observed, and the results demonstrate that the external sound source strongly affects the air-jet oscillation and the phase relationship of the sound pressure inside the resonator.

Su. 15:40 Woodwinds and Organs: Numerical improvements

From the bifurcation diagrams to the ease of playing of reed musical instruments. A theoretical illustration of the Bouasse-Benade prescription?
Joël Gilbert[a], Sylvain Maugeais[b] and Christophe Vergez[c]
[a] *Laboratoire d'Acoustique de l'Université du Mans – UMR 6613 CNRS;* [b] *Laboratoire Manceau de Mathématiques – Le Mans Université;* [c] *Aix Marseille Univ, CNRS, Centrale Marseille, LMA*
Reed musical instruments can be described in terms of conceptually separate linear and nonlinear mechanisms: a localized nonlinear element (the valve effect due to the reed) excites a linear, passive acoustical multimode element (the musical instrument usually represented in the frequency domain by its input impedance). The linear element in turn influences the operation of the nonlinear element. The reed musical instruments are self-sustained oscillators. They generate an oscillating acoustical pressure (the note played) from a static overpressure in the player's mouth (the blowing pressure).
A reed instrument having N acoustical modes can be described as a 2N dimensional autonomous nonlinear dynamical system. A reed-like instrument having two quasi-harmonic resonances, represented by a 4 dimensional dynamical system, is studied using the continuation and bifurcation software AUTO. Bifurcation diagrams are explored with respect to the blowing pressure, with focus on amplitude and frequency evolutions along the different solution branches. Some of the results are interpreted in terms of the ease of playing of the reed instrument. They can be interpreted as a theoretical illustration of the Bouasse-Benade prescription.

Sessions on Monday, September 16

Reeds: Clarinet
Chairs: K. Takahashi, P.-A. Taillard

Mo. 9:00 Reeds

Design of a mechanical player system for fatigue-life evaluation of woodwind reeds
Connor Kemp, Song Wang and Gary Scavone
McGill University, Montreal, Computational acoustic modeling laboratory, CIRMMT
Research into the vibrational properties of woodwind reeds, and potential synthetic replacements, requires the consideration of several factors. To date, analysis of pertinent properties of natural cane reeds has mostly been limited to reeds in their initial ”unplayed” state. One important mechanical aspect of reed-life and durability that should be considered is fatigue behaviour. Fatigue is concerned with the degradation of mechanical stiffness over the lifespan of a reed and is important for understanding changing vibrational behaviour. It is also likely that reed properties reach a steady-state after initial playing, but before they begin to significantly degrade, with mechanical properties (elastic, damping) during this period being most important for synthetic material development. Here an artificial player system is developed and used to evaluate the long-term mechanical behaviour of cane reeds. Reeds are ”played” on the system with control over playing time, input pressure and playing frequency. In this way, the dependency of mechanical fatigue on frequency is evaluated. During the study, reeds are also tested under static bending conditions to characterise mechanical degradation rates. Results will aid in understanding the importance of playing time and frequency on reed lifespan, properties, degradation and potentially lead to comparisons with current synthetic reeds.

Mo. 9:20 Reeds

The player-reed interaction during note transitions in the clarinet
Montserrat Pàmies-Vilà, Alex Hofmann and Vasileios Chatziioannou
Univ. Music and Performing Arts Vienna
When playing woodwind instruments, most of the player’s control over the instrument takes place inside the player’s mouth. Blowing pressure, tonguing strategies, embouchure and vocal tract configuration are modified during playing to perform expressively. Aiming at analysing the player’s actions at the note transitions, an experiment with eleven clarinet players was carried out. The mouth pressure, the mouthpiece pressure and the reed oscillation were recorded in order to track blowing and tonguing actions and to identify vocal tract adjustments. The influence of the player’s actions on the sound was quantified by considering the note attack and release transients. The results showed in which manner the players adapt tonguing and blowing actions according to the articulation style (legato, portato, staccato), the tempo and the dynamics of the music. The tonguing technique in portato articulation was consistent among players, whereas different techniques were observed for staccato articulation. The influence of the vocal tract on the attack transients was proven to be non-negligible and it was dependent on the clarinet register. Particularly at high pitches, some players showed vocal tract adjustments that supported shorter attack transients.

Live Stream: Reeds

Mo. 9:40 Live Stream: Reeds

Clarinet tonguing: the mechanism for transient production
André Almeida, Weicong Li, Lauren Inwood, John Smith and Joe Wolfe
UNSW Sydney
Players coordinate tongue release and variation in blowing pressure to produce a range of desired initial transients, e.g. for accents and sforzando, players use higher pressures at release to give higher rise rates in the exponential phase. The mechanisms were studied with high-speed video and acoustic measurements on human and artificial players of clarinets and simpler models. The initial mechanical energy of the reed due to deformation and release by the tongue is quickly lost in damping by the lip. The varying aperture as the reed moves towards equilibrium produces proportional variations in flow and pressure via a mechanism resembling the water hammer in hydraulics. Superposition of this signal with returning reflections from the bore give complicated wave shapes with variable harmonic content. When the reed gain more than compensates for losses, a nearly exponential phase follows until the last few oscillations before saturation. Maximal exponential decay rates (in tongue-stopped staccato notes) agree with losses measured in the bore impedance spectrum. Including estimates of the negative reed resistance explains semi- quantitatively the rise rates for initial transients. Different rates for higher harmonics contribute to different wave shapes and spectral envelopes, which are illustrated and modelled here.

Mixed
Chairs: R. Bader, J. Gilbert

Mo. 10:00 Mixed

Acoustics of Bifacial Indian Musical Drums with Composite Membranes
Anurag Gupta, Vishal Sharma and Shakti Singh Gupta
Indian Institute of Technology Kanpur
We are interested in a certain class of bifacial Indian drums, such as dholak, pakhawaj, and mrdangam, which consist of composite circular membranes stretched over an enclosed air cavity on both sides of an axisymmetric wooden shell. There is a large variety of such drums in Indian music which differ from each other in shapes and sizes of the shell and in the nature of the composite membranes. These drums produce sounds which have a definite pitch and hence can be qualified as musical in nature. Whereas, the effect of the composite nature of the membrane is well studied in the context of the monofacial Indian drum tabla, the acoustical implications of the coupling between two composite membranes (of different material and geometric properties) through an air cavity remains unexplored. The purpose of this work is to study this acoustical problem using a finite element method based numerical methodology. The aim is to solve the coupled structural acoustic boundary-value-problem for the enclosed air pressure and the membrane vibration. In our detailed investigation, we will study the effect of cavity size and shape, as well as the properties of the composite membranes, on the acoustics of the bifacial drums.

Mo. 10:20 Mixed

Acoustic measurement of Marimba, Xylophone and Xylorimba
Masanobu Miura[a] and Nozomiko Yasui[b]
[a] *Hachinohe Institute of Technology;* [b] *Graduate School of Science and Engineering, Saitama Univ.*
A set of wooden-keyboard percussion instruments, namely xylophone, marimba and xylorimba are acoustically compared. Since the size of xylophone and marimba has not had a standard size, their size and tone have a variety among them. More concretely, an American company Deagan produced the xylorimba between 1920- 1930, which was played by a xylophone player Yoichi Hiraoka, and then conveyed to Japan. The timber of xylophone is felt as to have the features of both marimba and xylophone. The acoustic feature is, however, not measured until now. A professional marimba player cooperated in our experiment. She is asked to play a single note C4 with a consistent hard mallet. The power spectrum of recorded acoustic signal is evaluated in terms of salient peaks on the recorded sound. Although the salient peaks on marimba and xylophone are almost well-known shapse, the one on the xylorimba has a distinct feature, which has 1) consonant peaks to F0, such as 2oct and 3oct+perfect 5th and 2) dissonant peaks to F0, such as 3oct major 2 degree (detuned to +1 and +22 cents). Therefore, the xylorimba is acoustically confirmed as to have both xylophone and marimba's features.

Relating tone height and perceived pleasantness in the didgeridoo and bass trombone

Noam Amir and Yasmin Bachar-Yakobi
Tel Aviv University

The motivation for this study came from the informal observation that didgeridoo tones seem to sound pleasant only over a span of less than an octave, while brass wind instruments of various types are found to be useful and pleasant over a much wider range. We therefore set out to explore the relationship between tone height and its perceived pleasantness and compare these evaluations both on a set of didgeridoos and on a bass trombone playing identical notes over a range slightly larger than one octave. Twenty listeners compared recordings of short tones from G1 to B2, played both on a bass trombone and a set of tubular didgeridoos, by proficient players. The listeners were asked to rate each note on a sliding scale from ”very pleasant” to ”very unpleasant”. Results showed that overall, the didgeridoo tones were found to be significantly more pleasant than the trombone tones. Surpisingly, the trombone tones were found to be more pleasant as tone height increased, while no correlation between tone height and pleasantness was found for the didgeridoo.

Modelling: Modelling techniques
Chairs: J. Chabassier, V. Chatziioannou

Mo. 12:00 Modelling: Techniques

The Impulse Pattern Formulation (IPF) as a nonlinear model of musical instruments
Simon Linke[a,b], Rolf Bader[b] and Robert Mores[a]
[a] *Hamburg University of Applied Sciences;* [b] *Institute of Systematic Musicology, University of Hamburg*
The Impulse Pattern Formulation (IPF) is a top-down method proposed previously (Bader, R.: Nonlinearities and Synchronization in Musical Acoustics and Music Psychology, 2013) which assumes musical instruments to work with impulses which are produced at a generator, travel through the instrument, are reflected at various positions, are exponentially damped and finally trigger or at least interact with succeeding impulses produced by the generator. The underlying recursive equation relates every new system state to previous values and their logarithm. Adding more system components increases the number of reflection points, thus the number of terms in the argument of the logarithmic function increases. Like other nonlinear equations, the IPF can produce stable states but also bifurcation and divergency and fully captures transitions between regular periodicity at nominal pitch, bifurcation scenarios, and noise. Applying the IPF on musical Instruments, the nonlinear behavior like transients or multiphonics can be described, which would be very complicated or impossible using well-established methods such as modal analysis or finite element models. Furthermore, the IPF is used for sound synthesis which follows the fundamental principles of real musical instruments and, due to the simple mathematical description of the IPF, needs a very limited amount of input parameters.

Mo. 12:20 Modelling: Techniques

MAESSTRO: a sound synthesis framework for Computer-Aided Design of piano soundboards
Benjamin Elie[a], Xavier Boutillon[b], Juliette Chabassier[c], Kerem Ege[d], Bernard Laulagnet[d], Benjamin Trévisan[d], Benjamin Cotté[a] and Nicolas Chauvat[e]
[a] *ENSTA-ParisTech;* [b] *Laboratory of Solid Mechanics, École Polytechnique;* [c] *Inria;* [d] *Univ Lyon, INSA-Lyon, Laboratoire Vibrations Acoustique, LVA;* [e] *Logilab*
The design of pianos is mainly based on empirical knowledge due to the lack of a tool that could predict sound changes induced by changes of the geometry and/or the mechanical properties of the soundboard. We present the framework of a program for the Computer-Aided Design of piano soundboards that is intended to bridge that gap by giving piano makers a tool to synthesize tones of virtual pianos. The sound synthesis is solely based on physical models of the instrument in playing situation. The calculation of the sound is split in several modules: computation of the modal basis of the stiffened soundboard, computation of the string dynamics, simulation of the soundboard dynamics in reaction to the string excitation, and calculation of the sound radiation. Reference tests of sound synthesis of real pianos as well as sound synthesis of modified pianos are used to assess our main objective, namely to reflect faithfully structural modifications in the produced sound, and thus to make this tool helpful for both piano makers and researchers of the musical acoustics community.

Mo. 12:40 Modelling: Techniques

Navier-Stokes-Based Physical Modeling of the Clarinet
Nicholas J. Giordano and Jared W. Thacker
Auburn University, USA
Direct numerical solutions of the Navier-Stokes equations have been used to model the recorder, trumpet, and clarinet. This first-principles approach to calculating the air flow through a wind instrument allows the investigation of a number issues that are difficult or impossible to address with more approximate modeling. The power of this kind of model is illustrated in studies of (1) how the labium position in a recorder affects the tonal properties, (2) qualitative failure of the Bernoulli equation in calculations of the pressure near the lips of a trumpet player, and (3) the dynamics of a clarinet reed.
Work supported by NSF grant PHY1513273.

Modelling: Modelling strings
Chairs: J. Chabassier, V. Chatziioannou

Mo. 13:00 Modelling: Strings

Measurement and Modeling of a Resonator Guitar
Mark Rau and Julius Smith
Center for Computer Research in Music and Acoustics (CCRMA), Stanford University
Resonator guitars are acoustic instruments which have one or more spun metal cones embedded in the top plate, with the strings driving the cone directly through a bridge. They were originally designed to be louder than traditional acoustic guitars and are often played with a metal slide. The vibrational characteristics of resonator guitars having a single inverted-cone are studied as the basis for a synthesis model. The small-signal input admittance is obtained using an impact hammer and laser Doppler vibrometer. As well, sinusoidal sweeps are made using a modal shaker at various driving amplitude levels. The shaker measurements show that some of the modes exhibit nonlinear characteristics which can be modeled using the Duffing equation. These measurements can serve as a basis for a digital waveguide model of the resonator guitar.

Mo. 13:20 Modelling: Strings

Thai Fiddle Saw-u Modeled as a Helmholtz Resonator with Circular Membrane
Kajornpop Toboonchuay[a], Munhum Park[b] and Bhanupol Klongratog[a]
[a] *Physics, King Mongkut's Institute of Technology Ladkrabang;* [b] *Inst. of Music, Sci. and Eng., King Mongkut's Institute of Technology Ladkrabang*
Saw-u is a Thai low-pitched vertical fiddle, of which two strings are bowed to vibrate, via a bridge, a sheet of goatskin or cowhide stretched over a cavity with sound holes. This instrument is similar to Cambodian Tro-u, but distinguished from Chinese Yehu or Korean Haegeum in that animal skin is used for the interface to the bridge (rather than wood in the latter two). In the current study, the unique structure of the instrument body was investigated by establishing a mathematical model where the cavity was assumed to behave as a Helmholtz resonator interacting with a circular membrane. Two coupled equations governing the motions of the membrane and that of the air mass in the soundhole were solved based on simple assumptions. The results showed that the resonance frequencies associated with the circular modes of the membrane were shifted under the influence of the Helmholtz resonator, whereas that of the resonator would remain unchanged. Moreover, it was found that an additional circular mode may be observed near the Helmholtz resonance frequency, which may significantly influence the sound quality by reinforcing the resonance. The application of the current findings to the analysis of similar structures will also be discussed.

Mo. 13:40 Modelling: Strings

Finite Element Modelling of Japanese Koto Strings
Kimi Coaldrake
The University of Adelaide
The development of a high resolution finite element model of the Japanese koto has been previously reported. The koto is a plucked zither made of paulownia wood and 1.83m in length. Its 13 strings are made of polyester fibre and supported by 13 moveable bridges approximately 6cm high. A functional representation of each string was included in the high resolution model by using a wave form that entered the koto sounding body at a signal point where the bridge would be located for the standard (hirajōshi) tuning. Correlation between spectra generated in the model and spectra of an actual instrument as played provided initial observations of string behavior. This study aims to improve the fidelity of the spectral response by directly coupling the string to the resonating body. A beam model and a truss model with the dimensions of a professional string that is pre-tensioned to yield a close approximation of strings on an actual instrument are studied. The nature of the boundary conditions at either end of the string is discussed. Simulation results from the two models as compared to notes played on the koto used as the basis of the finite element modeling are reported.

Virtual Prototyping of Musical Instruments: Virtual instruments and data bases
Chairs: V. Fréour, M. Jousserand

Mo. 15:00 Virtual Prototyping: Virtual instruments and data bases

Numerical simulation of the acoustic guitar for virtual prototyping
Henna Tahvanainen, Hideto Matsuda and Ryo Shinoda
Yamaha Corporation
This research presents numerical simulation tools used in the research of acoustic guitars in the industrial context. The focus is on describing a virtual prototyping environment that has been successfully used in product development. The main challenge is achieving an acceptable agreement between simulation and measurement of a random guitar taken in the production line. To this end, detailed geometrical modeling and averaged materials parameters values measured from the production line are used. Simulation and measurement results are compared in terms of mode frequencies, frequency responses, and radiation efficiency.

Mo. 15:20 Virtual Prototyping: Virtual instruments and data bases

Creating Virtual Acoustic Replicas of Real Violins
Esteban Maestre and Gary Scavone
McGill University, Montreal, Computational acoustic modeling laboratory, CIRMMT
In the context of preserving historical musical instruments as interactive digital acoustic artifacts that can be played and heard in real time, we provide an overview of our recent progress on measuring, modeling, and virtually recreating the sound radiation characteristics of real acoustic violins. Our approach is based on measuring the directivity of an acoustic violin and constructing an efficient digital filter model that can be used for real-time processing of a whitened version of the electrical signal coming from a silent violin as played by a musician. In a low reverberation chamber, we use a microphone array to characterize the radiativity transfer function of a real violin by exciting the bridge with an impact hammer and measuring the acoustic pressure at 4320 points on a sphere surrounding the instrument. From the real violin measurements, we design a mutable state-space digital filter that allows to obtain the sound pressure radiated in any direction. We characterize the silent violin transfer function by exciting the bridge with an impact hammer and measuring the electrical signal at its output. From the silent violin measurement, we design a recursive parallel filter that allows to whiten the electrical signal and digitally recover the force signal.

Mo. 15:40 Virtual Prototyping: Virtual instruments and data bases

Generation and Analysis of a Database of Geometrical and Acoustic Properties for the Modern Almenräder-Heckel System Bassoons
Vincent Houde-Turcotte
Université de Montréal
The bassoon is one of the orchestral instruments that still requires further research in the field of musical acoustics and data on the instrument's design is scarce. The main objective of this project is to provide a database of geometrical and acoustical properties measured on a large number of bassoons. Different types of data are included such as bore measurements obtained with a new automated measuring tool, tone hole positions/sizes/heights, impedance and sound pressure measurement with an artificial mouth and verbal description of the instrument's timbral qualities and playability by the owners. Measurements are entered on the PAFI (Plateforme d'aide à la facture instrumentale), which will be available to all users. The theoretical digital model proposed by the platform can be refined on the basis of the comparison with the measurements. The long-term goals is to trace the evolution of the Almenräder-Heckel bassoon over the last century and also to propose a new design to instrument makers corresponding of an optimal middle ground between the different versions of this instrument, such as the long tone holes of the wing joint, which cause many acoustical issues while being essential to obtain the timbre desired nowadays by players worldwide.

Virtual Prototyping of Musical Instruments: Instrument design
Chairs: V. Fréour, M. Jousserand

Mo. 16:00 Virtual Prototyping: Instrument design

Optimization of Marimba Bar Geometry by 3D Finite Element Analysis
Douglas Beaton and Gary Scavone
McGill University, Montreal, Computational acoustic modeling laboratory, CIRMMT
The natural frequencies of marimba bars are tuned by removing material from the bottom of the bar. Three partials are typically tuned, though less are tuned for higher notes. With only three or fewer partials to tune, many different bar geometries may produce the desired frequencies. As a result, bar geometries can show significant variation between brands, with each manufacturer employing their own tuning approach, honed over many years of experience.
This work uses 3D finite element analysis to investigate tuning marimba bar geometry, with an aim to inform manufacturing methods. Optimization techniques, including genetic algorithms, are employed to evaluate and improve bar geometries. The preferred geometries tune the desired frequencies, while also scoring well on secondary evaluation criteria. These secondary criteria include: separating the frequencies of torsional modes from those of the tuned modes, prioritizing symmetry, and producing shapes similar to professional marimba bars.
Models are developed using the open-source finite element program Calculix. Optimization routines are written in Python. The programs are interfaced to coordinate model execution. Functions are created to identify mode shapes based on displaced geometry. These functions provide resilience against any modal reordering, allowing the optimization routines to run unsupervised over significant changes in geometry.

Mo. 16:20 Virtual Prototyping: Instrument design

How to include several acoustic characteristics in the design of woodwind instruments?
Augustin Ernoult[a], Samy Missoum[b], Philippe Guillemain[a], Christophe Vergez[a] and Michael Jousserand[c]
[a] *Aix Marseille Univ, CNRS, Centrale Marseille, LMA;* [b] *Aerospace and Mechanical Engineering Department, University of Arizona;* [c] *Buffet Crampon*
When manufacturers design woodwind instruments, they must simultaneously adjust multiple aspects of the resonator response. The same resonator is used to play several notes by opening or closing tone-holes, and, for some instruments, the same fingering is used to play several registers. From an acoustic point of view, it means that several characteristics of the input impedance must be simultaneously adjusted: at least the first two resonance frequencies of each fingering. The acoustic models can predict the input impedance from the geometry of an instrument with good confidence. This suggests the possibility to solve the inverse problem through optimization algorithm: obtain the geometry having the desired input impedance. However, this inverse problem necessitates the optimization of several acoustic characteristics by modifying dozens geometric parameters (radius and position of the tone holes, chimney height, etc). A specific strategy is therefore necessary to solve this problem. A collaboration between manufacturers from Buffet Crampon and acousticians led to the development of an optimization tool to aid in the design of new woodwind instruments. The strategy adopted in this tool will be presented and applied to an illustrative problem: the construction of a pentatonic clarinet.

Mo. 16:40 Virtual Prototyping: Instrument design

Model-based quantification of the effect of wood modifications on the dynamics of the violin
Romain Viala[a], Sarah Lämmlein[b], Vincent Placet[a] and Scott Cogan[c]
[a] *Univ. Bourgogne Franche-comté, FEMTO-ST institute;* [b] *Swiss Federal Laboratories for Materials Science and Technology;* [c] *CNRS, FEMTO-ST institute*
The building of musical instruments is traditionally based on craftsmanship and selection of materials. Instrument makers generally attribute a dominant role to the material properties in regard with the acoustics of the musical instruments. Numerous methods are studied by both researchers and instrument makers to modify the physical and mechanical properties of tonewoods. The density, elastic and damping parameters are of particular interest. Wood properties can be modified through chemical treatments, fungi attacks, or climatic artificial aging and results can already be found for spruce, maple and ebony woods. Meanwhile, these methods increase the cost of wood preparation and the objective assessment of the impact of these wood modifications on the perception of musical instruments and especially the improvement of their ”quality” remains a subject to discussion. Physics-based models of musical instruments are now able to simulate their complex vibroacoustical behaviour. A numerical model is used to investigate the impact of wood property modifications on the dynamics of a violin while taking into account irreducible uncertainties in the material properties. The aim is to establish a threshold for wood treatments that will insure an observable impact on the dynamic behaviors of interest above and beyond the irreducible material variability.

Instrument Building
Chairs: J. Smith, L. Fuks

Mo. 18:00 Instrument Building

Influence of tonewood parameters on the perceived sound quality of a steel-string acoustic guitar
Sebastian Merchel[a], David Olson[b] and M. Ercan Altinsoy[a]
[a] *TU Dresden;* [b] *Pacific Rim Tonewoods*
Wood is one of the preferred materials for building stringed music instruments. Because wood is a naturally grown resource, there is large variability regarding material properties. Therefore, luthiers select their tonewoods carefully. In this project, listening tests were performed to investigate whether the objective testing of physical parameters of the tonewood help to make an appreciable impact on the sonic quality of the resulting instrument. Nine steel string guitars of the same model were produced by the Taylor Guitar Company, with strict control of all production parameters. The guitars varied only in two parameters: the density and the modulus of elasticity of the soundboard and bracewood, both made of Sitka spruce. The variability was representative of the range of the spruce wood currently produced by Pacific Rim Tonewoods, a supplier of tonewood to the acoustic guitar market. A short music sequence was used for pairwise preference evaluation in a double-blind listening test. The results suggest that, for this particular model (the Taylor 814ce Grand Auditorium), low density and stiffness of the guitar top have a positive impact on the overall preference. More generally, the results underscore the importance of integrating the design with physical characteristics of the component wood.

Mo. 18:20 Instrument Building

The Bilbao project : How makers match backs and tops to produce particular sorts of violins
Claudia Fritz[a], George Stoppani[b], Unai Igartua[c], Roberto Jardón Rico[d], Ander Arroitajauregi[c] and Luis Artola[c]
[a] *Institut d'Alembert – LAM, Sorbonne Université / CNRS;* [b] *George Stoppani violin making studio, Manchester;* [c] *BELE, Conservatorio de Musica – Juan Crisostomo de Arriaga, Bilbao;* [d] *Jardón Rico Luthier, Aviles*
The Bilbao project aims at answering this question by relating intrinsic characteristics of the materials (wood density and stiffness) and some geometric characteristics of the violin's constituent parts (thicknesses of the plates) with the tonal qualities of the complete violins. To this end, six instruments were carefully built : three instruments with normal backs, each paired with a pliant (thin), normal, or resistant (thick) top ; similarly, three with normal tops, each paired with a pliant, normal, or resistant back. The two examples of normal top paired with normal back serve as a control. Wood for tops and backs were closely matched in density and sound speeds - all tops and backs from the same trees. Greater control was achieved by having all plates and scrolls cut by CNC routers. The outside surface was not changed during the experiment, as the graduation was performed entirely on the inside surface. In addition, structural measurements were taken at many steps during the building process and the instruments were then assessed during playing and listening tests. These six instruments constitute therefore an unprecedented set of carefully controlled and documented violins, and offer an incredible opportunity for conducting various analyses and correlations.

Mo. 18:40 Instrument Building

Metamaterials in Musical Instruments
Rolf Bader, Jost Fischer, Malte Münster and Patrick Kontopidis
Institute of Systematic Musicology, University of Hamburg
Acoustic metamaterials are complex geometries leading to acoustic behavior not found in natural material, like negative stiffness or refraction, cloaking or spectral bandgaps. Indeed musical instruments are complex structures and some may already qualify as metamaterials. Still altering the instrument geometries and adding metamaterial behavior can increase the instruments sound variability and articulatory possibilities or lead to sounds not expected from mechanical instruments at all. The paper presents such examples. When modifying a frame drum by adding additional point masses forming a ring, the frame drum shows cloaking behavior when struck in the middle of the ring, where frequencies within a certain frequency band cannot leave the ring. This leads to a bandgap in the spectrum in the mid frequency range. Still when striking the drum outside the ring a normal drum sound is achieved. Therefore a drummer can produce sounds not known from drums before while with the same instrument can also play regular sounds. Other examples are modified guitar top plates with added point masses or waveguide structures.

Timbre and Perception
Chairs: J.F. Petiot, R. Mores

Mo. 19:00 Timbre & Perception

Influence of Long-Term Playing on the Tonal Characteristics of a Concert Piano – an Observational Study
Niko Plath
Institute of Systematic Musicology, University of Hamburg
Well-maintained pianos are said to ”mature” and to ”change to the better” over the first years. When auditioning concert pianos for purchase, technicians do often not choose the best sounding instrument but the one with the greatest potential for future development. The present work addresses the following questions: Are structural changes measurable on a piano after one year of operation in a concert house? Are these changes perceivable by listeners?
Measurements are performed on two occasions: First, on a brand new instrument prepared for sale. Second, on the same piano after having been played for one year in a concert hall. Single notes are recorded with dummy-head-microphones in player position in an anechoic chamber. An extended ABX listening test engaging approx. 100 players, tuners, and builders, addresses the questions whether a variation in tonal quality is audible and if so, what sound properties could lead to a perceived difference. Semantic sub-grouping allows for indication on the vocabulary listeners of varying expertise use to verbalize their sensation. The statements give hints on what could have changed over the year and are used as a basis for the analysis of corresponding physical properties and psychoacoustic parameters related to the described sensations.

Mo. 19:20 Timbre & Perception

Perception-based classification of Expressive Musical Terms: Toward a parametrization of musical expressiveness
Aviel Sulem[a], Ehud Bodner[a] and Noam Amir[b]
[a] *Bar-Ilan University, Israel;* [b] *Tel Aviv University*
Expressive Musical Terms (EMTs) are commonly used by composers as verbal descriptions of musical expressiveness that performers are requested to convey. In order to classify 55 EMTs covering a wide range of characters on the basis of their perception by performers, we conducted two experiments with the participation of 11 professional string players. They were asked (i) to organize the considered EMTs in a two- dimensional plane in such a way that proximity reflects similarity; (ii) to rate these EMTs in terms of valence, arousal, extraversion and neuroticism, on 7-level Likert scales. Using a minimization procedure, we found that a satisfactory partition requires these EMTs to be organized in four clusters (whose centers are associated with tenderness, happiness, anger and sadness) located in the four quarters of the valence-arousal plane of the Russell’s circumplex model of affect. An alternative representation is provided by the positive-negative activation parameters, introduced by Watson & Tellegen and corresponding to the coordinates along the diagonal directions of the valence-arousal plane. We obtained for these EMTs a significant correlation between positive activation and extraversion and between negative activation and neuroticism. This demonstrates that the expressed emotion is strongly related to the musical character of the performance.

Perception of violin soundpost height differences

Lei Fu[a], Claudia Fritz[b] and Gary Scavone[a]
[a] *Computational acoustic modeling laboratory, CIRMMT, McGill University, Montreal;* [b] *Institut d'Alembert – LAM, Sorbonne Université / CNRS*

This experiment explores how changes in soundpost height affect the perceptual qualities of the violin and whether there is a threshold of change below which players do not perceive differences. A violin installed with a height-adjustable carbon soundpost was employed. The experiment was designed as a sequence of playing tests. An experimenter was present to change the soundpost height. Thirteen professional violinists and six luthiers participated. The experiment involved two phases. During the first phase, subjects played and described their feelings about the violin with different soundpost settings in order to find their optimal soundpost height. During the second phase, the experimenter randomly increased, decreased or did not change the soundpost height in ten trials within a range of approximately $\pm$0.1 mm around their optimal height. Subjects were asked to play the violin for each trial and compare it with the previous setting, to decide whether they were the same or different. Initial results indicate that each subject's optimal soundpost height varies within an interquartile range of 0.3mm and the smallest height variation that could be recognized above chance level is about 0.04mm.

Logistics

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Special Event Details

- Excursion & Dinner – LWL Freilichtmuseum: Sunday, the 15th
  - Leaving early to arrive at the entrance of Freilichtmuseum on time at 5pm (15 min walk from Sommertheater)
  - Guided tour through open air museum including bird watching
  - "Im Weissen Ross" – dinner and jam session venue
    - Krummes Haus 1, 32760 Detmold
    - 50 Euro for dinner per person, including drinks
    - Jam session:
      - Combo instruments provided (drums, bass, PA, keys)
      - Bring solo instruments!
    - A bus shuttle is arranged to leave at 11 pm towards the Detmold city center.

— Joint Music Night – HfM Concert House: Monday, the 16th
  — Begins at 8pm
  — Bring your own instrument(s) – including your self made instruments from workshops!
  — Grand piano available
  — Encouraged to form a choir or performance groups on your own ahead of time
  — Meal provided free of charge

Travel Details – Leaving ISMA During ISMA, the public transport from Detmold is complicated due to construction works. This applies especially for destinations Bielefeld and Herford; travel to Paderborn is not affected. Here are some hints:

— To **Bielefeld** (ca. 60 min, change once)
  — The smoothest option will be to share a Taxi/Cab directly from the venue. It takes around 45-60 minutes and will cost around 90 Euro.
    — Gaby Assmann and a list at the registration desk will help to form carpools.
    — Detmold Taxi companies: +49 5321 28066; +49 5321 27747; +49 5321 4345
    — Bielefeld Taxi companies: +49 521 98896066; +49 521 44436; +49 521 97111
  — If you like "adventure", there are two options to go by public transport. Both involve a 20 minutes walk or 10 min bus trip to the Detmold train station.
  — From there, you have two options:
    — Option A Bus + Tram (longer travel, less prone to delays), runs hourly (06:05, 07:05, 08:05,..., 20:05)
      — Bus RE82 SEV from a dedicated bus stop in front of Detmold train station change at the second stop in "Bielefeld-Sieker" (50 min) to
      — Tram 2 towards "Altenhagen" – This tram departs directly at the bus stop and arrives 10 min/ 8 stops later at Bielefeld central station (subway). Plan a 6 minute walk from tram stop to the train tracks.
    — Option B Train + Bus (shortest travel, more prone to delays), runs hourly (05:59, 06:40, 06:40, 07:40,..., 19:40, 20:40, 22:41)
      — Train RE72 towards "Herford" and "Lage (Lippe)" from track 2, change at the next stop "Lage" (7 min) to
      — Bus RE82 SEV – This bus departs from the bust stop in front of the Lage train station building and arrives 40 min later at Bielefeld central train station (back entrance). Plan a 3 min walk from bus stop to the train tracks.

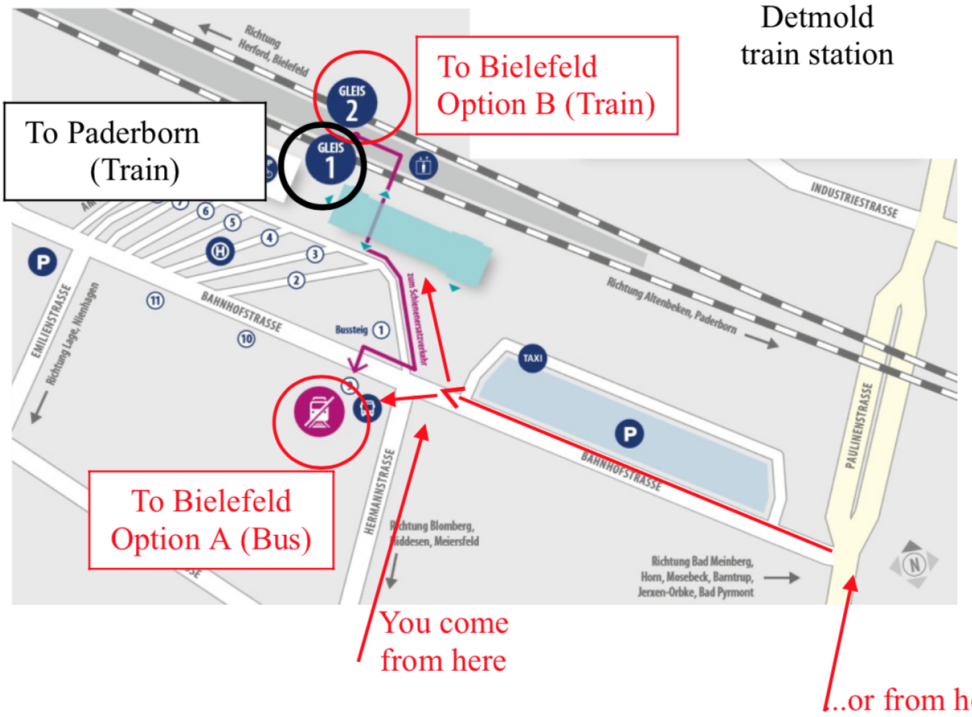
— Full plan for both Option B and A is found online at:
`https://www.baustellenfahrplan-owl.de/baustellen-wAssets/docs/re-82/P2342_RE82_375x315mm_Fahrplanaenderung_2019_web.pdf`.

— **Careful, delays!**
  — Especially option B is prone to delays: If you miss the bus in Lage, it can happen that you arrive one hour later in Bielefeld! Further, the bus trip from Lage is less convenient. In the Bus from Detmold (option A), you can enjoy a beautiful countryside.
  — *Please plan ample time* if you have to catch a connection in Bielefeld!
  — The quickest info on delays are are spread via this twitter channel:
`https://twitter.com/eurobahn_info`.

— To **Paderborn** (40 min, direct connection)
  — hourly (05:59, 06:02, 07:02, 08:02,..., 22:02)
  — Train RE72 "Paderborn" from track 1
  — Check your connection via this website
`https://www.bahn.com/en/view/index.shtml`.

— To **Herford** (50 to 90 min.; change twice)
  — Try to avoid this connection during ISMA.

Map of
Detmold
train station



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