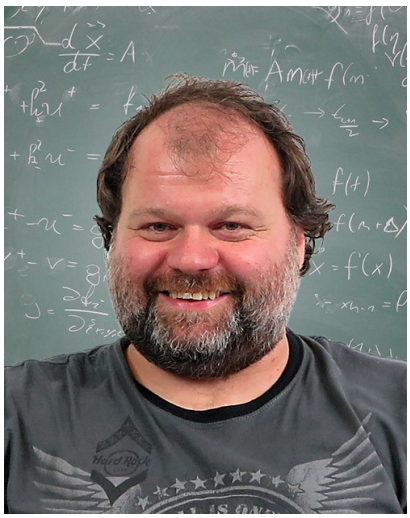
Peter Balazs

Director Acoustics Research Institute
Austrian Academy of Sciences
Wohllebengasse 12-14
1040 Wien
+43 1 51581 2510
orcid.org/0000-0003-4939-0831
Scopus Author ID: 8211873600
ResearcherID: E-3020-2010
peter.balazs@oeaw.ac.at
http://www.kfs.oeaw.ac.at/Balazs
http://www.balazs.at



Curriculum Vitae

Scientific Interests:

My vision is bridging (deep theoretical) mathematics to more applied scientific topics. I am passionately committed to **application-oriented mathematics for acoustics and signal-processing**. This allows the full usage of mathematical rigor and controllability of parameters for models and methods in the applied sciences on one hand. On the other hand this creates new mathematical topics and concepts, raises novel questions within mathematics that are interesting and inspiring per-se.

I am particularly interested in frame theory (discrete and continuous; in Hilbert and Banach spaces), operator theory (multipliers and the representation of operators) and time-frequency analysis (adaptive and adapted transforms; as well as phase-aware processing). My approaches are connected to numerical linear algebra (efficient open science implementations for frame representations; convex optimization), signal processing (inpainting, filter banks and denoising), numerical acoustics (BEM /FEM), mathematical physics (coherent states), psychoacoustics (adaptation of time-frequency representations to biological auditory systems), acoustical measurements and simulations (related to spatial hearing and vocal tracts), bioacoustics (methods of mice ultrasound vocalizations) and machine-learning (deep neural networks).

Education

2001	**MSc** in mathematics with distinction at Univ. Vienna. Thesis: "*Polynomials over Groups"*. Advisor. Prof. G. **Kowol**
2005	**PhD** in mathematics with distinction at Univ. Vienna. Thesis: "*Regular and irregular Gabor frame multipliers with application to psychoacoustical masking"*. Advisor: Prof. H. G. **Feichtinger**
2011	**Venia Legendi** (Habilitation) in mathematics at Univ. Vienna. Thesis: *"New Concepts in Frame Theory Motivated by Acoustical Applications"*

Awards

2003	*"Stipendium für kurzfristiges wissenschaftliches Arbeiten"* (grant of the University of Vienna for scientific work abroad)
2004	*"Top-Stipendium des Landes Niederösterreich"* (grant from Lower Austria for best students)
2005	*"Leistungs-Stipendium"* (University of Vienna; performance scholarships, recognition of extraordinary achievements of students)
2009	short-listed for the "*Best Paper Award 2008*" of the Austrian Academy of Sciences
2011	*"Anerkennungspreis für Wissenschaft durch das Land Niederösterreich"* (Recognition Award for Scientists from Lower Austria)

2011	**START-price** (see Funding ID)
2012	IEEE senior member grade

Professional Experience

1999 – 2002	**Software Developer** at the *Acoustics Research Institute* (ARI) (C++, MFC, XML)
2002 – 2005	**PhD research position** at ARI, the *Laboratoire d'Analyse Topologie et Probabilités* (LATP), Université de Provence, and the *Laboratoire de Mécanique et d'Acoustique* (LMA), CNRS Marseille, France, with the European Union Network HASSIP (Nov. 2003 – Apr. 2004)
Aug. 2005	**PostDoc research position** at *Unité de physique théorique et de physique mathématique (FYMA)*, UCL Louvain-la-Neuve, Belgium
2005 – 2008	**PostDoc research position** at ARI
March, Mai and June 2006	**PostDoc research position** at the LATP, Université de Provence and the LMA, CNRS Marseille, France, with the European Union Network HASSIP
2008 – 2012	**Senior research position** at ARI: founding head of work-group "Mathematics and Signal Processing in Acoustics"
2008 – 2017	Several months parental part-time leave for three kids.
2012 – 2017	Member of the board of the IDK (political body for the directors of institutes within the Austrian Academy of Sciences)
2012 – present	**Director** of ARI (research institute with currently 45 employees)

Supervision

In several third-party funding projects 11 PostDoc were employed and guided (F. Jaillet, M. Dörfler, D. Stoeva, T. Necciari, N. Holighaus, P. Søndergaard, D. Bayer, Z. Průša, G. Chardon, F. Huang, D. Abreu.).

The following final theses were finished under the supervision of P. Balazs:

2007	G. Toupin, *"Development of software applications for psychoacoustic experiments"*, Ecole Centrale Nantes (Master Thesis, co-advisor, finished 25.09.2007)
2006 – 2010	T. Necciari, *"Masquage Auditif Temps-Fréquence: mesures psychoacoustiques et application à l'analyse-synthèse de sons"*, Université de Provence, Marseille. (PhD, co-advisor and jury-member, *defense* 25.10.2010, passed with distinction)
2008 – 2011	M. Liuni, *"Adaptive Sound Analysis and Synthesis"*, University of Florence and IRCAM Paris (PhD, co-advisor, reviewer and jury member, *defense* 09.03.2012, passed with distinction)
2007 – 2016	N. Engelputzeder, *"Linear time-variant Systems and Gabor Riesz bases"*, University of Vienna (PhD, co-advisor, reviewer and jury member, *defense* 19.02.2016)
2013	M. Speckbacher. *"Time-frequency representation adapted to perception"*, Technische Universiät München (Master Thesis, supervisor, fninished 27.9.2013; passed with distinction)
2013 – 2014	N. Bachmann, *"Complete Bessel sequences"*, University of Vienna (advisor and jury member, passed with distinction 24.07.2014)
2014 - 2017	M. Speckbacher, *"Reproducing pairs and flexible time-frequency representations"*, University of Vienna (PhD, advisor, passed with distinction: 21.09.2017)
2011 - now	several internships ('stage'), reports and exams; Université Paris Diderot, Paris 7
2019	A. Nieto-Berezhinskaya, "*Analyse and reproduction of the Laurel Yanny acoustic Illusion*", University of Vienna (Bachelor; co-advisor: W. Kreuzer)

2019	A. Fleisch, "*Acoustic factors of looming perception*", University of Vienna (Bachelor; co-advisor: R. Baumgartner)
2019	A. Aigner, "*Anwenden eines unterbewussten absoluten Gehörs mit Hilfe von musikalisch einprägsamen Melodien*", University of Vienna (Bachelor; co-advisor: M. Hoeschele)
2016 - now	D. Reitschmidt, "*Adaptive functions of courtship ultrasonic vocalizations in male mice*", VetMedUni Vienna (2016 -) first advisor: D. Penn (co-advisor)
2016 - now	M. Marconi, "*Mechanisms of ultrasonic vocalizations in house mice*", VetMedUni Vienna (2016 -) first advisor: D. Penn (co-advisor)
2017 – now	S. Rajbamshi, ….
2019	D. Haider, …
2019-now	L. Köhldorfer, ….

Funding ID

All grants focus on the link between the mathematical frame theory, the signal processing algorithms, their implementations and the acoustical applications.

2005 – 2009	**Partner** JCJC project of the Agence Nationale de la Recherche "*senSons – Vers le sens des sons*" (project leader: S. Ystad, LMA, CNRS Marseille)
2006 – 2007	**Project leader** WTZ project (AMADEUS) "*Time-Frequency Representation and Perception"*, cooperation with the LMA, CNRS Marseille. (5.950,– Euro)
2008 – 2011	**Principal applicant and project leader** WWTF project for **High Potentials**: "*Frame Multipliers: Theory and Application in Acoustics (MulAC)"* (425.000,– Euro)
2010 – 2013	**Partner** PhD project "*Speech Intelligibility Enhancement Using Modern Envelope And Phase Manipulations*" funded by Oticon (project leader: P. Soendergaard, Technical University of Denmark)
2011 – 2013	**Project leader** WTZ project "*Shift Invariant Spaces and their applications to Audio Signal Processing"*, cooperation with the Department of Mathematics, University of Buenos Aires. (5.500,– Euro)
2011 – 2013	**Co-applicant** FWF **Lise-Meitner project** "*Time-Frequency Implementation of HRTF*" (principial applicant: D. Marelli, together with P. Majdak) (128.120,– Euro)
2011 – 2014	**Partner** ESF/EU project *"Support for incorporating research and development teams in international cooperation in the area of image and audio signal processing*" (project leader: Z. Sméka, Brno University of Technology) (2.000.000,– in total)
2012	**Co-applicant** ESI special semester "*Modern Methods of Time-Frequency Analysis*" (principal applicants: H. G. Feichtinger and K. Gröchenig) (86.400,– Euro in total)
2012 – 2018	**Principal applicant and project leader START** project "*Frames and Linear Operators for Acoustical Modelling and Parameter Estimation*" (FLAME) (1.197.970,– Euro)
2013 – 2014	**Co-applicant** WTZ project "*Novel methods of completing missing samples in audio signals"*, cooperation with NuHAG, Faculty of Mathematics, University of Vienna and . Brno University of Technology, Vysoké učení technické (project leader: Monika Dörfler) (5.600,– Euro in total)
2013 – 2014	**Co-applicant** WTZ project "*Frame Theory for Sound Processing and Acoustic Holophony"*, cooperation with Institute for Research and Coordination in Acoustics and Music (IRCAM), Paris, France (project leader: Diana Stoeva) (5.920,– Euro)
2013 – 2019	**Co-applicant** WWTF project "*Computational harmonic analysis of high-dimensional biomedical data"*(CHARMED), (project leader: Martin Ehler; call "Vienna Research Groups

	for Young Investigators Call 2012 Mathematics and ...") (1.500.000,– Euro in total)
2013 – 2016	**Co-applicant** FWF DACH project "*Adaptive Wavelet and Frame technique for acoustic BEM. Boundary Integral Operator Solution Techniques with Optimal Properties*" (BIOTOP); (project leader: Wolfgang Kreuzer; cooperative project with Germany and Switzerland) (340.651,50 Euro)
2014 – 2017	**Co-applicant** FWF-ANR project "*Perceptual optimization of time-frequency audio representations and coding*" (POTION) (project leader: Piotr Majdak; cooperative project with France) (237.174,– Euro)

2015 – 2016	**Project Leader** WTZ project (CZ 01/2015) "*Modern methods for the restoration of digital audio signals"*, cooperation with Brno University of Technology, Vysoké učení technické (5.812,– Euro)
2017 – 2021	**Co-Principal Investigator** WWTF project *"Infinite Dimensional Signal Processing Techniques for Acoustic Applications (INSIGHT)*", (principal investigator: Georg Tauböck; call: Mathematics and .... 2016) (623.200,– Euro)
2017 – 2020	**Co-applicant** FWF-GACR project *"Modern methods for the Restoration of lost information in digital signals – MERLIN"*, cooperation with Brno University of Technology, Vysoké učení technické (Project leader Nicki Holighaus) (338.218,65,– Euro)
2018 – 2020	**Project Leader** WTZ project (SRB 01/2015) "*ANACRES – Analysis and Acoustics Research"*, cooperation with Faculty of Sciences, University of Novi Sad (7.000,– Euro)

Major National and International Collaborations

In my experience a broad and reliable network of scientists is essential for an efficient research environment. My current network contains the following scientists:

H. G. **Feichtinger,** K. **Gröchenig** (Univ. Vienna)	Numerical harmonic analysis, Gabor theory.
J. P. **Antoine** (Univ. Cath. Louvain-la-Neuve)	Discrete and continuous frames, with connection to mathematical physics.
R. **Kronland-Martinet**, S. **Ystad** (LMA, CNRS Marseille)	Sound synthesis, signal processing and psychoacoustical masking.
B. **Torrésani** (LATP, Univ. Provence) P. **Søndergaard** (Oticon Denmark)	Practical time-frequency analysis, the Linear Time Frequency Analysis Toolbox (LTFAT) and psychoacoustical masking.
H. **Harbrecht** (Univ. Basel), S. **Dahlke** (Univ. Marburg)	Adaptive Wavelet and Frame techniques
A. **Röbel**, M. **Liuni**, M. **Noisternig** (IRCAM Paris)	Application of frame theory in Acoustics
A. **Arefijamaal** (Univ. Sabzevar), A. **Rahimi** (Univ. Maragheh)	Frame Theory

Invited Visits

September 2006	LATP, Université de Provence, Marseille, France
August 2007	LTS2, Signal Processing Institute, EPFL Lausanne, Switzerland
October 2007	Centre for Applied Hearing Research (CAHR), Technical University of Denmark
November 2007	FYMA, UCL Louvain-la-Neuve, Belgium
2008 – 2011	(several) LATP, Université de Provence and LMA, CNS, both Marseille; as well as FYMA, UCL Louvain-la-Neuve (within the MulAc project)
December 2011	Centre for Applied Hearing Research (CAHR) , Technical University of Denmark
February 2014	The Norbert Wiener Center, University of Maryland
November 2016	Research Group of Computational Mathematics, University Basel
April 2018	Mathematical Institute of Serbian Academy of Science and Arts; Department of Mathematics and Informatics, Faculty of Sciences, University of Novi Sad, Serbia

Workshop Organization / Special Sessions

2005	International workshop "*HASSIP workshop: Application Of Time Frequency Analysis In Acoustics*", at ARI
2007	Scientific exchange meeting: "*NuHAG meets ARI*"
2008 – 2011	5 international workshops within the **MulAC** project (see *http://www.kfs.oeaw.ac.at/mulac*)
2012 – 2014	Kickoff and midterm workshop of the FLAME project
2012	Workshop "*Time-frequency methods for the applied sciences*" within the "ESI12- Modern Methods of Time-Frequency Analysis II"-special semester.
2014	Special Session *"Dictionary-based processing of single- and multi-channel audio"* at ICASSP 2014 (together with A. Röbel, M. Liuni)
2016	International conference: "*Strobl16 – Time-Frequency Analysis and Related Topics*" (together with H.G. Feichtinger, K. Gröchenig and T. Strohmer)
2017	Special Session *"Spectral Estimation and Acoustics"* at SAMPTA2017 – Sampling Theory and Applications, 12th International Conference (together with L.D. Abreu); technical committee.
2017	Special Session "*Modern Mathematical Methods for Signal Processing in Audio and Acoustics*" at 13th International Conference on Theoretical and Computational Acoustics (ICTCA2017) (together with G. Tauböck)
2018	Main organizer of international conference: "*Strobl18 – Harmonic Analysis and Applications*" (together with H.G. Feichtinger, K. Gröchenig, M. Ehler and T. Strohmer)
2019	OeAW AI fair (machine learning Hackathon and workshop)
2019	Special Session "*Time-frequency Analysis and Applications*" at the 12th ISAAC Congress (together with D. Abreu)
2019	Special Session "*Acoustical Signal Processing in biological systems: Mathematical Methods and Algorithms*" at the 23rd International Congress on Acoustics (together with H. Führ)
2019	Special Session "*Frames and PDEs*" at the 14th International Conference on Mathematical and Numerical Aspects of Wave Propagation (together with H. Harbrecht)
2019	Co-director and organizer for OeAW AI Summer School
2020	Main organizer of international conference: "*Strobl18 – Applied Harmonic Analysis and Friends*" (together with H.G. Feichtinger, K. Gröchenig, M. Ehler and T. Strohmer)
2020	Co-organizer of DAFx 20
2021	DAGA 2021 (Organization committee and co-chair)

Invited / plenary talks:

2003 – 2018	33 invited talks at workshops, seminars, etc.
2016	Keynote talk at the 19th International Conference on Digital Audio Effects, DAFx-16, Brno, Czech Republic.
2019	Plenary talk at the International Conference on Mathematical Methods in Physics,

	Marakech, Morocco.
2019	Invited Speaker at the International Workshop on Frames, Wavelets, Approximation Methods and Applications, Palermo, Italy.

Services to the research community:

Editor	Sahand Communications in Mathematical Analysis *(Editor),* Analele Universităţii "Eftimie Murgu" Reşiţa, Fascicula de *Inginerie (Associated Editor)* Special Issue *'Harmonic Analysis and Applications',* Journal Axioms *(MDPI)*
Journal Reviews	1. *Applied and Computational Harmonic Analysis,* 2. *Journal of Mathematical Analysis and Applications,* 3. *Journal of Fourier Analysis and Applications,* 4. *Linear Algebra and its Applications,* 5. *Advances in Computational Mathematics* 6. *Springer Plus,* 7. *Numerical Functional Analysis and Optimization,* 8. *Linear and Multilinear Algebra,* 9. *Journal of Mathematics and Music,* 10. *Complex Analysis and Operator Theory,* 11. *Bulletin of the Belgian Math. Society,* 12. *Discussiones Mathematicae,* 13. *Journal of Algebra and Applications,* 14. *Results in Mathematics,* 15. *Journal of Inequalities and Applications,* 16. *Bulletin of the Korean Mathematical Society,* 17. *Proceedings Mathematical Sciences,* 18. *Banach Journal of Mathematical Analysis,* 19. *Abstract and Applied Analysis,* 20. *Arabian Journal of Mathematics,* 21. *Applied Mathematics and Computation,* 22. *Mathematica Slovaca,* 23. *International Journal of Wavelets,* 24. *Multiresolution and Information Processing,* 25. *Bulletin of the Iranian Mathematical Society,* 26. *Mediterranean Journal of Mathematics.* 27. *The Journal of Nonlinear Sciences and Applications,* 28. *Turkish Journal of Mathematics,* 29. *Journal of the Korean Mathematical Society,* 30. *Iranian Journal of Mathematical Sciences and Informatics,* 31. *Hacettepe Journal of Mathematics and Statistics,* 32. *Journal of Mathematical Analysis*. 33. *Journal of Mathematical Extension,* 34. *Sahand Communications in Mathematical Analysis,* 35. *Mathematical Communications,* 36. *Filomat,* 37. *Methods of Functional Analysis and Topology,* 38. *Axioms,* 39. *Entropy,* 40. *Afrika Matematika* 41. *Boletín de la Sociedad Matemática Mexicana* 42. *Journal of Sciences, Islamic Republic of Iran* 43. *IEEE Transactions on Signal Processing,*

	44. *IEEE Transactions on Audio, Speech and Language Processing,* 45. *IEEE Signal Processing Letters,* 46. *Sensors,* 47. *Signal Processing.* 48. *Journal of the Acoustical Society of America* 49. *The Journal of the Acoustical Society of America Express Letters*
Conference Reviews	*EUSIPCO08, SAMPTA09, ICMC 2012 (paper committee – PC), CMMR2013 (PC), ICASSP14 (track chair) EUSIPCO15 (technical committee – TC), SAMPTA15, MALSIP15 (TC), ICASSP16, EUSIPCO16 (TC), SPARS17, SAMPTA2017 (PC), DAFx2017, EUSIPCO2017, ICASSP2018, LVA-ICA2018, EUSIPCO2018, ICASSP2019, DAFx2019*
Book Proposal Reviews	*Cambridge University Press*
Funding Agency Reviews	*OEAD (WTZ), NSA (AMS)*

I consider the role of reviewers in the scientific community as very important and take this role very seriously. I am happy to be recognized for that. For example, I have received the following feedback on my review work: '*In our extensive research career, we have never come across such an adequate and helpful set of reviewers. […] the review offered by reviewer 3 [me] stands out from the set of the three comprehensive reviews. […]* ***In some sense, the major improvements with respect to the first version are mainly due to the large experience of the reviewer in the area, and his willingness to help***.' or from a more recent review '[....] we are deeply indebted to the referee for giving the paper considerable attention, resulting in **a significant improvement**.'.

Languages

German: native tongue	**English**: fluent
Russian: 4 years at high school	**French**: basic knowledge

Scientific Membership

IEEE (Signal Processing Society)	Audio Engineering Society (AES)
Österreichische Mathematische Gesellschaft (ÖMG)	Europäische Mathematische Gesellschaft (EMG)
Deutsche Gesellschaft für Akustik (DEGA)	American Mathematical Society (AMS)
Gesellschaft für Angewandte Mathematik und Mechanik	

Teaching

2005	*Repetitorium zu Lineare Algebra und Geometrie 1* (University of Vienna)
2008	*Ausgewählte Kapitel aus Harmonische Analysis* (University of Vienna, together with Hans G. Feichtinger, Ole Christensen)
2009	*Angewandte Mathematik für Lehramt* (University of Vienna, Proxy of Hans G. Feichtinger)
2011	*Lineare Algebra I* (University of Vienna, Proxy of Hans G. Feichtinger)
2011	*Übung: Angewandte Mathematik für LAK* (University of Vienna)
2013	*Übung: Lineare Algebra für PhysikerInnen* (University of Vienna)
2014	*Vorlesung und Übung: Lineare Algebra für PhysikerInnen* (University of Vienna)

2015	*Übung: Lineare Algebra für PhysikerInnen* (University of Vienna)
2017 - 2019	*Laboratory Acoustics* (University of Vienna)
2017, 2019	*Frame Theory* (University of Vienna)
2018	Seminar *Frame Theory* (University of Vienna)

Special skills / commitment

Computer	*Applications*: MS Office, MS Visual Studio, Maple, MathCad, SPSS and many o. *Operating systems*: Windows (all up to Windows 10), DOS; basic knowledge of Unix, iOS. *Programming languages*: C++ (plus MFC), Matlab, Visual Basic, Java; basic knowledge of R, Python, Fortran, assembler and others. Working experience with HTML, XML and TeX
Art	Commitment to the art club "*Kunstwerkstatt Tulln*" (1988-1996). 1996 president.
Baseball	Commitment to the baseball club "*Ravens Tulln*" for years (1999 - present), past member of its board, team player.

Other hobbies and interests

Music	playing the drums (teaching, giving performances and recording)
Sound engineer	experience as sound and light engineer
Sport	baseball, skiing, volleyball, sailing, judo
Games	of all kinds, especially role-playing, computer, board and card games

Publications

I have authored or co-authored **48 peer-reviewed international journal papers**, as well as 6 book chapters, 32 peer-reviewed and 17 other proceedings publications.

Citations: 1902 (Google Scholar), 1423 (Research Gate), 960 (Scopus), 626 (Web of Science)
h-index: 26 (Google Scholar), 22 (Research Gate), 19 (Scopus), 15 (Web of Science).

I have summarized ten key publications below.

1. P. Balazs, "*Basic Definition and Properties of Bessel Multipliers*", **Journal of Mathematical Analysis and Applications**, Volume 325, Issue 1, pp. 571-585, (2007)

   Gabor multipliers, also known as Gabor filters, are a particular way to implement time-variant filters. In this paper this concept was extended to general frames, and builds the framework for novel time-variant approaches for other analysis / synthesis systems. **This paper was cited 116 times**.

2. P. Majdak, P. Balazs, B. Laback, "*Multiple Exponential Sweep Method for Fast Measurement of Head Related Transfer Functions*", **Journal of the Audio Engineering Society**, Vol. 55, No. 7/8, pp. 623 - 637 (2007)

   In this paper an improved method for the system estimation with exponential sweep is given, optimizing the amount of time or the signal-to-noise ratio. This paper was cited **158 times; it shows the applicability of time-frequency methods for acoustical applications in audio engineering.**

3. P. Balazs, J.-P. Antoine, A. Gryboś, "*Weighted and Controlled Frames: Mutual Relationship and first Numerical Properties*", **International Journal of Wavelets, Multiresolution and Information Processing**, Volume 8, pp. 109-132 (2010)

   In this paper the notions of weighted and controlled frames are systematically developed, including their mutual relationship. The connection to frame multipliers is shown and exploited. The paper closes with numerical experiments showing how weights can be used for improving the frame bound ratio. This paper was cited **78 times**. This paper is a befitting **combination of analytical and numerical result**s. It shows nicely that solving some technicalities can lead to interesting new concepts and results. It led to a lot of other research generalizing controlled frames to more other setting. It was also picked up for the definition of scalable frames.

4. P. Balazs, B. Laback, G. Eckel, W. Deutsch, *"Time-Frequency Sparsity by Removing Perceptually Irrelevant Components Using a Simple Model of Simultaneous Masking"*, **IEEE Transactions on Audio, Speech and Language Processing**, Vol. 18 (1), pp. 34-49 (2010)

   In this paper a novel and efficient algorithm for determining and removing perceptually irrelevant time-frequency components of a sound is presented. The algorithm is based on a model of simultaneous masking in the auditory system, which is implemented as an adaptive Gabor multiplier. This paper was cited **79 times, and shows clearly the applicability of frame theory in psycho-acoustical applications.**

5. P. Balazs, M. Dörfler, N. Holighaus, F. Jaillet and G. Velasco, "*Theory, Implementation and Application of Nonstationary Gabor Frames*", **Journal of Computational and Applied Mathematics**, Vol. 236 (6), pp. 1481-1496 (2011)

   In this paper an extension of Gabor theory is proposed that allows time-dependent windows. This leads to the construction of frames with time-frequency resolution changing over time or frequency. We give explicit formula for the canonical dual frame for a particular case, the painless case. We show that wavelet transforms, constant-Q transforms and more general filter banks may be modelled in this framework. This paper was cited **133 times**. **It nicely demonstrates the flexibility allowed by frame theory.**

6. P. Søndergaard, B. Torrésani, P. Balazs, "*The Linear Time/Frequency Analysis Toolbox*", **International Journal of Wavelets, Multiresolution and Information Processing**, 10, 1250032 (2012)

   The Linear Time Frequency Analysis Toolbox is a MATLAB/Octave toolbox for computational time-frequency analysis. It is intended both as an educational and computational tool. The toolbox provides the basic Gabor, Wilson and MDCT transform along with routines for constructing windows (filter prototypes) and routines for manipulating coefficients. It also provides a bunch of demo scripts. This paper was cited **109 times**. It is an important step towards supporting **open science and reproducible research in time-frequency transform** implementations.

7. D. Stoeva, P. Balazs, "*Invertibility of Multipliers*", **Applied and Computational Harmonic Analysis**, Vol. 33 (2), pp. 292-299 (2012)

   Here sufficient and/or necessary conditions for the invertibility of multipliers are determined. For invertible multipliers a formula for the inverse operator is determined and n-term error bounds are given. Furthermore the case when one of the sequences is a Riesz basis is completely characterized. This paper was cited **58 times**.

8. P. Balazs, M. Dörfler, M. Kowalski, B. Torrésani, *"Adapted and adaptive linear time-frequency representations: a synthesis point of view"*, **IEEE Signal Processing Magazine** (special issue: Time-Frequency Analysis and Applications), Vol. 30 (6), pp. 20-31 (2013)

   In this surview article we give an overview of linear time-frequency representations, focusing mainly on the introduction of flexibility, more precisely the construction of time-frequency waveform systems that can be adapted to and the choice of the synthesis framework rather than the usual analysis framework. This paper was cited **39 times**. It demonstrates the advantages of mathematics for signal-processing tasks like adapting a time-frequency representation to the needs of the engineer.

9. M. Speckbacher, P. Balazs, "*Reproducing pairs and the continuous nonstationary Gabor transform on LCA groups*" **Journal of Physics A: Mathematical and Theoreti**cal 48 (39), 395201 (2015)

   In this paper we introduce and investigate the concept of reproducing pairs as a generalization of continuous frames. Reproducing pairs yield a bounded analysis and synthesis process while the frame condition can be omitted at both stages. Moreover, we investigate certain continuous frames (resp. reproducing pairs) on LCA groups, which can be described as a continuous version of nonstationary Gabor systems. This paper was cited **21 times**. The introduced general concept was picked up by many researchers and allowed, e.g., the solution of the last open problem of Gabor by the authors in a follow-up paper.

10. Z. Prusa, P. Balazs P. Søndergaard, B. Torrésani, P. Balazs, "*A noniterative method for reconstruction of phase from STFT magnitude*", **IEEE /ACM Transactions on Audio, Speech, and Language Processing** 25 (5), pp. 1154-1164 (2017)

    A noniterative method for the reconstruction of the short-time Fourier transform (STFT) phase from the magnitude is presented, based on the direct relationship between the partial derivatives of the phase and the logarithm of the magnitude of the un-sampled STFT with respect to the Gaussian window. Experiments show that the algorithm performs well even in the discretized setting (discrete Gabor transform) with low redundancy using compactly supported windows such as the Hann window. Due to the noniterative nature, the algorithm is very fast and it is suitable for long audio signals. We present an extensive comparison with the state-of-the-art algorithms in a reproducible manner. This paper was cited **19 times**. It showed that even in area of tremendous worldwide scientific focus like in phase retrieval a novel analytic approach is possible, proving the usefulness of mathematics for applications. Moreover, solutions of iterative phase reconstruction algorithms can be improved considerably by initializing them with the phase estimate provided by this algorithm.

Full Publication List:

for a current publication list with preprints and links to the journals see also
http://www.balazs.at/wissenen.html

Publications in peer-reviewed journals:

1. P. Balazs, H.G. Feichtinger, M. Hampejs, G. Kracher, "*Double Preconditioning for Gabor Frames*", **IEEE Transactions on Signal Processing**, Vol. 54 (12), pp. 4597-4610 (2006)
2. P. Balazs, "*Basic Definition and Properties of Bessel Multipliers*", **Journal of Mathematical Analysis and Applications**, Vol. 325 (1), pp. 571-585, (2007)
3. P. Majdak, P. Balazs, B. Laback, "*Multiple Exponential Sweep Method for Fast Measurement of Head Related Transfer Functions*", **Journal of the Acoustical Engineering Society**, Vol. 55, No. 7/8, pp. 623-637 (2007)
4. P. Balazs, W. Kreuzer, H. Waubke, "*A stochastic 2D-model for calculating vibrations in random layers*", **Journal of Computational Acoustics**, Vol. 15, No. 3, pp. 271–283 (2007)
5. P. Balazs, M. El-Gebeily, "*A Systematic Study of Frame Sequence Operators and their Pseudoinverses*", **International Mathematical Forum** 3, no. 5, pp. 229-239 (2008)
6. P. Balazs, "*Matrix Representation of Operators Using Frames*", **Sampling Theory in Signal and Image Processing**, Vol. 7, No. 1, pp. 39-54 (2008)
7. P. Balazs, "*Hilbert-Schmidt Operators and Frames Classification, Approximation by Multipliers and Algorithms*", **International Journal of Wavelets, Multiresolution and Information Processing**, Vol. 6, No. 2, pp. 315-330 (2008)
8. P. Balazs, "*Frames and Finite Dimensionality: Frame Transformation, Classification and Algorithms*", **Applied Mathematical Sciences**, Vol. 2, no. 41-44, pp. 2131-2144 (2008)
9. P. Balazs, B. Laback, G. Eckel, W. Deutsch, *"Time-Frequency Sparsity by Removing Perceptually Irrelevant Components Using a Simple Model of Simultaneous Masking"*, **IEEE Transactions on Audio, Speech and Language Processing**, Vol. 18 (1), pp. 34-49 (2010)
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