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# Recent Researches in Applied Informatics

Proceedings of the 2<sup>nd</sup> International  
Conference on Applied Informatics  
and Computing Theory (AICT '11)



**Prague, Czech Republic, September 26-28, 2011**

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Institute for Environment, Engineering, Economics and Applied Mathematics

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## Table of Contents

<b>Keynote Lecture 1: Dominating the Constancy in Enhanced Multivariate Product Representation (EMPR) Via Support Function Selection</b> <i>Metin Demiralp</i>	11
<b>Plenary Lecture 1: On Computational Techniques based on Nonlinear and Fuzzy Systems Theory for NMR Spectroscopy Data Mining</b> <i>Dimitris Karras</i>	13
<b>Plenary Lecture 2: Rayleigh Quotient Flattening Methods for the Eigenvalue Problems of Linear Operators Between Separable Hilbert Spaces</b> <i>N. A. Baykara</i>	14
<b>Analysis of a Telemonitoring System based on a Bluetooth Body Area Network using Smartphones</b> <i>M. J. Moron, A. Gomez-Jaime, J. R. Luque, E. Casilari, J. A. Gazquez</i>	17
<b>Magnitooptic Properties of the <math>Pb_{1-x}Mn_xTe</math> Semimagnetic Semiconductors' Thin Films</b> <i>M. Mehrabova, T. G. Ismayilov, I. R. Nuriyev</i>	23
<b>New Identity of <math>a^n \pm b^n</math> Expression</b> <i>Asker Ali Abiyev</i>	28
<b>The Correlation of Abiyev's Balanced Square with Periodic Law</b> <i>Asker Ali Abiyev</i>	33
<b>High Dimensional Model Representation (HDMR) Based Folded Vector Decomposition</b> <i>Letisya Divanyan, Metin Demiralp</i>	39
<b>Conic Transformational High Dimensional Model Representation In Comparison With Hermite-Pad/e Approximants</b> <i>Zeynep Gundogar, N. A. Baykara, Metin Demiralp</i>	45
<b>Weight Optimization in Enhanced Multivariate Product Representation (EMPR) for Given Supports at the Fluctuation Free Integration Limit</b> <i>Ayla Okan, N. A. Baykara, Metin Demiralp</i>	52
<b>Multivariable Function Approximation by Using Fluctuationlessness Approximation Applied on a Weighted Taylor Expansion with Remainder Term</b> <i>Ercan Gurvit, N. A. Baykara, Metin Demiralp</i>	58
<b>Function Flattening Transformational High Dimensional Model Representation</b> <i>N. A. Baykara, Metin Demiralp</i>	64
<b>Weighted Singular Value Decomposition for Folded Matrices</b> <i>Suha Tuna, N. A. Baykara, Metin Demiralp</i>	70

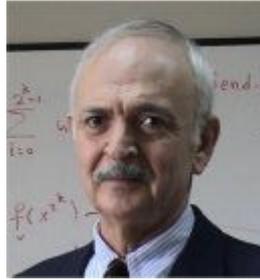
<b>Towards A New Multiway Array Decomposition Algorithm: Elementwise Multiway Array High Dimensional Model Representation (EMAHDMMR)</b>	76
<i>Muzaffer Ayvaz, Metin Demiralp</i>	
<b>Decision-Making in the Knowledge Processing in Enterprises in the Czech Republic</b>	82
<i>Petra Maresova, Josef Drahekoupil</i>	
<b>LZ-based Adaptive Compression for Images</b>	88
<i>Bruno Carpentieri</i>	
<b>A Knowledge-Based Framework for the Support of Sensor Web Deployment Using Multi-Agent Geo-Simulation</b>	92
<i>Mehdi Mekni, Normand Bergeron, Hedi Haddad, Bernard Moulin</i>	
<b>Modelling of the Logistic System with Shared Interoperation Buffer Stores</b>	101
<i>Robert Bucki, Bronislav Chramcov</i>	
<b>Array Flattening Based Univariate High Dimensional Model Representation (AFBUHDMMR)</b>	107
<i>Emre Demiralp, Metin Demiralp</i>	
<b>A Gentle Introduction to High Dimensional Model Representation Under Nonproduct Type Weights</b>	113
<i>Metin Demiralp</i>	
<b>A Support System for Web Service Integration Based on User Profiles</b>	119
<i>Tatsuya Okabe, Keinosuke Matsumoto, Naoki Mori</i>	
<b>Evaluation of Centres of Stripes in the Interferogram Image</b>	125
<i>Jan Richter, Jiri Stastny</i>	
<b>AHSPeR: Adaptive Hypermedia System Oriented toward Personalization of Readings Plans</b>	131
<i>M. Giugni, F. Grimon, J. Fernandez, J. Monguet, A. Guerra</i>	
<b>Establishing Distance Education: The Tools, Challenges and Experiences</b>	136
<i>Lejla A. Bexheti, Marika A. Trpkovska, Arbana B. Kadriu</i>	
<b>Automatic Control Method of DDoS Defense Policy through the Monitoring of System Resource</b>	140
<i>Daewon Kim, ByoungKoo Kim, Ikkyun Kim, Jintae Oh, Jongsoo Jang, Hyunsook Cho</i>	
<b>Flower Information Retrieval using Color Feature and Location-based System</b>	146
<i>Wichian Premchaiswadi, Nucharee Premchaiswadi</i>	
<b>Mastermind – Method of the System Approach in the Algorithm Development and Computer Simulation</b>	152
<i>Stepan Hubalovsky</i>	
<b>Accessing Information Systems with Mobile Devices and Information Security</b>	158
<i>Blaz Markelj, Igor Bernik</i>	

<b>A Fundamental Conception to Formulate Image Data Hiding Scheme Based on Error Diffusion</b>	162
<i>Masakazu Higuchi, Shuji Kawasaki, Jonah Gamba, Atsushi Koike, Hitomi Murakami</i>	
<b>A Multi-Criteria Approach for Assessment of Agricultural Systems in Context of Sustainable Agriculture</b>	167
<i>Constanta Zoie Radulescu, Marius Radulescu, Adrian Turek Rahoveanu, Magdalena Turek Rahoveanu, Silviu Beciu</i>	
<b>Influence areas as a Tool for Testing of Image Restoration Methods</b>	172
<i>Igor V. Gribkov, Peter P. Koltsov, Nikolay V. Kotovich, Alexander A. Kravchenko, Alexander S. KoutsaeV, Andrey S. Osipov, Alexey V. Zakharov</i>	
<b>Broadband Internet Access for Rural Africa: Finding a Viable Model</b>	178
<i>Alwyn J. Hoffman, Dawid P. De Wet</i>	
<b>Improvement on Shortest Path Algorithm in Tactical Decision Support Systems</b>	186
<i>Petr Stodola, Jan Mazal</i>	
<b>Pattern Recognition Based Method Used in Identifying Impaired Speech</b>	190
<i>Valentin Velican, Ovidiu Grigore, Corina Grigore</i>	
<b>A New Search Mechanism for Unstructured Peer-to-Peer Networks</b>	195
<i>Chia-Hung Lin, Sun-Yuan Hsieh</i>	
<b>Spatial-Temporal Data Evaluation</b>	201
<i>Dana Klimesova, Eva Ocelikova</i>	
<b>Fault Diagnosis for Hypercube-Like Networks</b>	205
<i>Tai-Ling Ye, Sun-Yuan Hsieh</i>	
<b>Launching Distributed Denial of Service Attacks by Network Protocol Exploitation</b>	210
<i>Jasek Roman, Benda Radek, Vala Radek, Sarga Libor</i>	
<b>Algorithms for Time Series Comparison</b>	217
<i>Jiri Fejfar, Arnost Motycka, Stepan Filipek</i>	
<b>Multi-Layered Evolutionary System suitable to Symbolic Model Regression</b>	222
<i>Tomas Brandejsky</i>	
<b>Improving Parallel Data Flow Support in a Visualization and Steering Environment</b>	226
<i>Mihai L. Mocanu, Cosmin M. Poteras, Constantin S. Petrisor</i>	
<b>A State Machine-Based Parallel Paradigm Applied in the Design of a Visualization and Steering Framework</b>	232
<i>Cosmin M. Poteras, Mihai L. Mocanu</i>	
<b>Factors Influencing Employment in the EU</b>	237
<i>Denisa Vasilescu, Larisa Aparaschivei, Speranta Pirciog</i>	

<b>A New Approach Using Ants Algorithm to Optimize Load Balancing and Prioritization Process In-Dependent and Independent Models for the Scheduling Problem in Distributed Grid Networks</b>	242
<i>M. Vaziri, H. Rashidi</i>	
<b>Advanced Technology for Management Support</b>	251
<i>J. Nemecek, K. Cebisova, J. Hribik</i>	
<b>CRM and Cloud Computing</b>	255
<i>J. Nemecek, L. Vankova</i>	
<b>Simulation Scenarios of Employment on the Romanian Labor Market</b>	260
<i>Madalina E. Andreica, Amalia Cristescu, Speranta Pirciog</i>	
<b>A Re-Examination of Okun's Law in the Presence of the Shadow Economy. An Empirical Investigation for the Case of United States</b>	265
<i>Adriana AnaMaria Alexandru, Ion Dobre, Catalin Ghinararu</i>	
<b>Problems with Evaluation of Benefits and Costs from Advanced Technology Utilization</b>	271
<i>Libuse Svobodova</i>	
<b>Visual Programming Language in Geographic Information Systems</b>	276
<i>Zdena Dobesova</i>	
<b>Time Measurement Synchronization using GPS Units</b>	281
<i>Zdenek Slanina, Vladimir Kasik, Karel Musil</i>	
<b>Car Dynamics Model - Design for Interactive Driving Simulation Use</b>	285
<i>Petr Bouchner, Stanislav Novotny</i>	
<b>Linear Electromechanical Actuator as a Replacement of Hydraulic Cylinder for Electric Motion Platform for Use in Simulators</b>	290
<i>Evzen Thondel</i>	
<b>A New Expert System for Pediatric Respiratory Diseases by Using Neural Networks</b>	296
<i>Ahmed A. Radwan, Hazem M. El-Bakry, Hager M. El Hadad</i>	
<b>Authors Index</b>	307

## Keynote Lecture 1

### Dominating the Constancy in Enhanced Multivariate Product Representation (EMPR) Via Support Function Selection



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**Abstract:** Enhanced Multivariate Product Representation (EMPR) has been recently proposed by the “Group for Science and Methods of Computing” which is under leadership of Metin Demiralp. EMPR involves High Dimensional Model Representation (HDMR) which was proposed by I.M. Sobol and has been developed basically by H. Rabitz, M. Demiralp and their groups in last two decades. HDMR decomposes a multivariate function to components ordered in ascending multivariate starting from constancy. EMPR introduces “Support Functions” to multiply HDMR components such that the resulting representation becomes composed of terms which have same multivariate as the original function’s. Support functions are particularly chosen univariate functions each of which depends on a separate independent variable. The constant component is multiplied by all support function factors while the univariate components are multiplied by all support functions except the one depending on the same independent variable as the relevant univariate component’s. As we proceed to higher multivariate components the number of the support function factors decreases because of the discarded factors of same independent variables as the relevant component’s. Regarding to this definition HDMR corresponds to the EMPR case where all the support functions are unit constant functions. EMPR, like HDMR, is composed of  $2^N$  terms for a multivariate function of  $N$  variables. The words “term” and “component” have different meanings in contrast to HDMR. Component implies the function showing a specific multivariate whereas term means the product of the component under consideration by the relevant support functions. The first term of EMPR is the product of the constant component by the all support functions. The next  $N$  terms are composed of univariate components multiplied by the corresponding  $(N - 1)$  number of support function. The following  $N(N - 1)/2$  terms are composed of the products of the bivariate components with the relevant support functions and so on. The  $k$ th group of terms are composed of the product of the  $k$ th component by the relevant support functions. Thus, EMPR is also a finite term involving decomposition like HDMR. Despite this finiteness, the number of the terms may grow undesiredly when  $N$  tends to grow unboundedly. Hence, not the whole decomposition but its truncations at some multivariate components like preferably constant, more meaningfully univariate, or at most, bivariate ones are desired to be used in practical applications. EMPR components, as in HDMR, are mutually orthogonal, under an appropriately given weight and over a specified orthogonal geometrical hypervolume, and, this permits us to define some functionals we call “Additivity Measurers” or “Quality Measurers”, to estimate how constant, univariate or bivariate EMPR is. They reflect the contributions of some level truncations to the target function in norm square. Of course the most lovely case is the constant function although it is somehow trivial. If the constancy can not be achieved exactly then constancy dominance is sought. Quality measurers form a well ordered sequence between 0 and 1 inclusive, and, the closer constancy measurer to 1 the better numerical efficiency in the truncation at the constant component. Even though there is almost nothing to do for having constant term dominance in HDMR except the weight function selection, EMPR has more flexibilities, the support functions to this end. By appropriately choosing them it is possible to maximize the contribution of the constant component to the target function in norm square. As proven by us, the constancy of HDMR approaches to 1 when its geometry suppressed to 0 in size, so does the EMPR’s. This brings the idea of choosing support functions in such a way that the considered function’s weighed integral, giving EMPR’s constant component, becomes having asymptotically flat kernel, that is, some number of first derivatives of the kernel vanish at a specified point in the domain of EMPR. Presentation will focus on these issues by also emphasizing on certain practicality aspects.

#### Brief Biography of the Speaker:

Metin Demiralp was born in Turkey on 4 May 1948. His education from elementary school to university was entirely in Turkey. He got his BS, MS, and PhD from the same institution, Istanbul Technical University. He was originally chemical engineer, however, through theoretical chemistry, applied mathematics, and computational science years he was mostly working on methodology for computational sciences and he is continuing to do so. He has a group (Group for Science and Methods of Computing) in Informatics Institute of Istanbul Technical University (he is the founder of this institute). He collaborated with the Prof. Herschel A. Rabitz’s group at Princeton University (NJ, USA)

at summer and winter semester breaks during the period 1985–2003 after his 14 months long postdoctoral visit to the same group in 1979–1980. Metin Demiralp has more than 90 papers in well known and prestigious scientific journals, and, more than 170 contributions to the proceedings of various international conferences. He gave many invited talks in various prestigious scientific meetings and academic institutions. He has a good scientific reputation in his country and he is one of the principal members of Turkish Academy of Sciences since 1994. He is also a member of European Mathematical Society and the chief–editor of WSEAS Transactions on Computers currently. He has also two important awards of turkish scientific establishments. The important recent foci in research areas of Metin Demiralp can be roughly listed as follows: Fluctuation Free Matrix Representations, High Dimensional Model Representations, Space Extension Methods, Data Processing via Multivariate Analytical Tools, Multivariate Numerical Integration via New Efficient Approaches, Matrix Decompositions, Multiway Array Decompositions, Enhanced Multivariate Product Representations, Quantum Optimal Control.

## Plenary Lecture 1

### On Computational Techniques based on Nonlinear and Fuzzy Systems Theory for NMR Spectroscopy Data Mining



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**Abstract:** Magnetic resonance spectroscopic imaging (MRSI) integrates spectroscopic MRS and imaging methods to acquire spatially localized MRS spectra associated with a specific patient. MRSI is a relatively new imaging entity for clinical applications while MRS is a more widely used signal processing modality in clinical practice. Both are related to NMR spectroscopy and scanners. The goal of this plenary talk will be to present the computational techniques for processing such complex spectra towards efficient NMR data mining regarding potential applications in clinical practice. These techniques will be based on Nonlinear Signal Processing methodologies including Dynamical Systems Analysis and Global Optimization methods as well as on Fuzzy Systems Theory involving development of suitable Fuzzy Descriptors. A series of experiments illustrate the feasibility and potential of the proposed approaches using synthetic images and model MRS signals derived from benchmark MRS spectra, towards successful data mining in clinical applications.

#### **Brief Biography of the Speaker:**

Dimitrios A. Karras received his Diploma and M.Sc. Degree in Electrical and Electronic Engineering from the National Technical University of Athens, Greece in 1985 and the Ph. Degree in Electrical Engineering, from the National Technical University of Athens, Greece in 1995, with honours. From 1990 and up to 2004 he has collaborated as visiting professor and researcher with several universities and research institutes in Greece. Since 2004, after his election, he has been with the Chalkis Institute of Technology, Automation Dept., Greece as associate professor in Digital Systems and Signal Processing as well as with the Hellenic Open University, Dept. Informatics as a visiting professor in Communication Systems (since 2002). He has published more than 50 research refereed journal papers in various areas of pattern recognition, image/signal processing and neural networks as well as in bioinformatics and more than 150 research papers in International refereed scientific Conferences. His research interests span the fields of pattern recognition and neural networks, image and signal processing, image and signal systems, biomedical systems, communications, networking and security. He has served as program committee member in many international conferences, as well as program chair and general chair in several international workshops and conferences in the fields of signal, image and automation systems. He is, also, editor in chief of the International Journal in Signal and Imaging Systems Engineering (IJSISE), topics editor in chief of the International Journal of Digital Content Technology and its Applications (JDCTA) as well as associate editor in various scientific journals. He has been cited in more than 350 research papers, his h-index is 8 and his Erdos number is 5.

## Plenary Lecture 2

### Rayleigh Quotient Flattening Methods for the Eigenvalue Problems of Linear Operators Between Separable Hilbert Spaces



**Professor N. A. Baykara**  
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**Abstract:** An algebraic Rayleigh quotient is a ratio of two quadratic forms whose kernel matrices can be considered as symmetric or Hermitian without any loss of generality. The vectors in these types of entities are taken from a Cartesian space whose dimensionality is equivalent to the number of the elements of those vectors. Cartesian spaces are structures very close to the real life spaces which can be perceived by our sensual organs. Analogues to real spaces, the distance between the points, the norm of the vectors each of which is considered to represent a point in the space, and the angle between the vectors are all defined in Cartesian spaces. Hence, in the sense of linear vector spaces theory they belong to the class of Hilbert spaces. The only restriction in Cartesian spaces is the members of the space. They are specific structures, algebraic vectors while the members of a given Hilbert space can be any kind of mathematical object as long as it fulfills the requirements to form a linear vector space. The dimensionality of a Cartesian space is generally finite as long as infinite algebraic vectors are not under consideration. Whereas the dimensionality of Hilbert spaces are generally infinite in the most widely encountered practical cases. For example, functions, univariate or multivariate, form a Hilbert space where the inner product is the integral over the product of two functions appearing as the argument of the relevant functional. These spaces which can be called function spaces are infinite dimensional since any function belonging to such a space can be uniquely expressed as a linear combination of certain linearly independent universal functions which are denumerable. The denumerability brings the concept of separability. We focus on only separable Hilbert spaces. The linear operators on the other hand, mapping from an Hilbert space to itself very frequently comes to the scene in many applications of mathematical and engineering modellings. A quadratic form for such an operator is defined as the inner product of an arbitrary function's image under the considered operator with the same arbitrary function. If a quadratic form of this type is accompanied by a condition, like normalization, on the arbitrary function then it is better to use Rayleigh quotient which is a ratio between the quadratic form and a divisor quadratic form like the one having unit operator as the argument, instead of introducing Lagrange multipliers. The kernel of the divisor quadratic form does not need to be a unit operator and some other, but preferably positive definite, operators can be used to this end. Then the Rayleigh quotient can be called "Weighted Rayleigh Quotient". It is very well known that the extrema of a Rayleigh (or Weighted Rayleigh) quotient are the eigenvalues of the eigenvalue (or weighted eigenvalue) problem of the linear operator under consideration and these values are achieved when the arbitrary function of the Rayleigh (or Weighted) quotient becomes equal to the eigenvector(s) corresponding to the relevant eigenvalue. This implies that making a Rayleigh quotient sufficiently at around an eigenvalue of the related eigenvalue problem facilitates the solution of the spectral problem related to the considered Rayleigh quotient. The solution of the eigenvalue problem related to the extremization of a Rayleigh quotient may not be easy depending on the structure of the linear operator under consideration, the weight operator (if any) and certain accompanying conditions like boundary conditions. So certain approximation methods may be required. Their construction can be based on certain facilitating features of the Hilbert space under consideration. However, beyond those, it is possible to consider some closure properties. For example the subspace composed of multiples of an eigenfunction must be closed under the action of the considered linear operator. Similarly if there are some conditions to define the subspace (these conditions must be linear and homogeneous for producing subspace) the image of a function from that subspace under the relevant operator should be inside the same subspace. The so-called Wronskian approaches and Space Pruning techniques are amongst the approaches are based on these types of ideas. The talk will focus on these issues within the given time limitations.

#### Brief Biography of the Speaker:

N. A. BAYKARA was born in Istanbul, Turkey on 29th July 1948. He received a B.Sc. degree in Chemistry from Bosphorous University in 1972. He obtained his PhD from Salford University, Greater Manchester, Lancashire, U.K. in 1977 with a thesis entitled "Studies in Self Consistent Field Molecular Orbital Theory", Between the years 1977–1981

and 1985–1990 he worked as a research scientist in the Applied Maths Department of The Scientific Research Council of Turkey. During the years 1981-1985 he did postdoctoral research in the Chemistry Department of Montreal University, Quebec, Canada. Since 1990 he is employed as a Staff member of Marmara University. He is now an Associate Professor of Applied Mathematics mainly teaching Numerical Analysis courses and is involved in HDMR research and is a member of Group for Science and Methods of Computing in Informatics Institute of Istanbul Technical University. Other research interests for him are “Density Functional Theory” and “Fluctuationlessness Theorem and its Applications” which he is actually involved in. Most recent of his concerns is focused at efficient remainder calculations of Taylor expansion via Fluctuation-Free Integration, and Fluctuation-Free Expectation Value Dynamics.

## Authors Index

Abiyev, A. A.	28, 33	Grigore, C.	190	Murakami, H.	162
Alexandru, A. A.	265	Grimon, F.	131	Musil, K.	281
Andreica, M. E.	260	Guerra, A.	131	Nemecek, J.	251, 255
Aparaschivei, L.	237	Gundogar, Z.	45	Novotny, S.	285
Ayvaz, M.	76	Gurvit, E.	58	Nuriyev, I. R.	23
Baykara, N. A.	45, 52, 58	Haddad, H.	92	Ocelikova, E.	201
Baykara, N. A.	64, 70	Higuchi, M.	162	Oh, J.	140
Beciu, S.	167	Hoffman, A. J.	178	Okabe, T.	119
Bergeron, N.	92	Hribik, J.	251	Okan, A.	52
Bernik, I.	158	Hsieh, S.-Y.	195, 205	Osipov, A. S.	172
Bexheti, L. A.	136	Hubalovsky, S.	152	Ovidiu, G.	190
Bouchner, P.	285	Ismayilov, T. G.	23	Petrisor, C. S.	226
Brandejsky, T.	222	Jang, J.	140	Pirciog, S.	237, 260
Bucki, R.	101	Kadriu, A. B.	136	Poteras, C. M.	226, 232
Carpentieri, B.	88	Kasik, V.	281	Premchaiswadi, N.	146
Casilari, E.	17	Kawasaki, S.	162	Premchaiswadi, W.	146
Cebisova, K.	251	Kim, B.	140	Radek, B.	210
Cho, H.	140	Kim, D.	140	Radek, V.	210
Chramcov, B.	101	Kim, I.	140	Radulescu, C. Z.	167
Cristescu, A.	260	Klimesova, D.	201	Radulescu, M.	167
De Wet, D. P.	178	Koike, A.	162	Radwan, A. A.	296
Demiralp, E.	107	Koltsov, P. P.	172	Rahoveanu, A. T.	167
Demiralp, M.	39, 45, 52	Kotovitch, N. V.	172	Rahoveanu, M. T.	167
Demiralp, M.	58, 64, 70	Koutsaev, A. S.	172	Rashidi, H.	242
Demiralp, M.	76, 107, 113	Kravchenko, A. A.	172	Richter, J.	125
Divanyan, L.	39	Libor, S.	210	Roman, J.	210
Dobesova, Z.	276	Lin, C.-H.	195	Slanina, Z.	281
Dobre, I.	265	Luque, J. R.	17	Stastny, J.	125
Drahokoupil, J.	82	Maresova, P.	82	Stodola, P.	186
El Hadad, H. M.	296	Markelj, B.	158	Svobodova, L.	271
El-Bakry, H. M.	296	Matsumoto, K.	119	Thondel, E.	290
Fejfar, J.	217	Mazal, J.	186	Trpkovska, M. A.	136
Fernandez, J.	131	Mehrabova, M.	23	Tuna, S.	70
Filipek, S.	217	Mekni, M.	92	Vankova, L.	255
Gamba, J.	162	Mocanu, M. L.	226, 232	Vasilescu, D.	237
Gazquez, J. A.	17	Monguet, J.	131	Vaziri, M.	242
Ghinararu, C.	265	Mori, N.	119	Velican, V.	190
Giugni, M.	131	Moron, M. J.	17	Ye, T.-L.	205
Gomez-Jaime, A.	17	Motycka, A.	217	Zakharov, A. V.	172
Gribkov, I. V.	172	Moulin, B.	92		