

# CONTRIBUTION OF SLOVAKIA IN THE FUZZY SETS THEORY

**Martin Kalina**

Dept. Math. Slovak University of Technology, Radlinského 11  
813 68 Bratislava, Slovakia

## 1. Introduction

In the more than 30 years old history of the theory of fuzzy sets, thousands of papers in this domain have been published all over the world. In the last ten years, also Slovakia has added several valuable contributions. The aim of this paper is to give a (surely not exhaustive) overview of Slovak "fuzzy" results.

The beginning of Slovak research on fuzzy sets theory goes back to the first European fuzzy workshop in Warszawa in 1986, where the concept of fuzzy quantum spaces was introduced by B. Riečan and A. Dvurečenskij [103], and the fuzzy connectives in the framework of expert systems were discussed by R. Mesiar [93]. Later, J. Bán [8,9] started investigating the fuzzy valued mappings. The real starting point for a wide group of Slovak fuzzy researchers was the first big international conference (organized in the former Czechoslovakia) held in Bechyně, 1990, which was coorganized by Riečan and Mesiar. Since 1992, the regular biannual international conferences are organized in Liptovský Ján by Military Academy in Liptovský Mikuláš, under the scientific direction of E. P. Klement from Austria, B. Riečan and R. Mesiar. Actually, there are several topics investigated by Slovak fuzzy researchers. Well known is the Slovak school on fuzzy quantum structures (Dvurečenskij, Riečan, Chovanec, Kôpka, etc.) with several remarkable results in the MV algebras domain. Interesting results were obtained in the area of fuzzy connectives, especially in the triangular norms theory (Mesiar, Šabo, Viceník, Smutná). Another remarkable area includes the calculus of fuzzy numbers (Mesiar, Kolesárová, Marková-Stupňanová, Harman) and the area of fuzzy linear algebra (Cechlárová, Gavalec). Most recently, the fuzzy analysis is investigated (Kalina, Janiš). Note that several recent results in the fuzzy domain were presented by Slovak researchers at the 7th world congress IFSA97 in Prague which was coorganized by them jointly with the Czech colleague. In the next sections, we briefly recall some results from the mentioned areas.

## 2. Fuzzy quantum structures

The domain of fuzzy quantum structures has been intensively investigated by Riečan, Dvurečenskij, Chovanec, Kôpka, Jurečková, Rybáriková, Markechová, Tirpáková, Mesiar, Kolesárová, etc. Several analogons of classical results were obtained (e.g. limit theorems). The structure of fuzzy quantum spaces was characterized by Mesiar in [66] and by Dvurečenskij in [19] and thus making previously obtained results more transparent or easier provable. Similarly, the characterization of fuzzy quantum logics [72, 77] by Mesiar gave a complete picture of the domain.

An important concept of fuzzy difference poset was introduced by Kôpka in 1992 (at the first famous FSTA conference) and later developed and generalized (under the name difference poset) by Kôpka and Chovanec and by many other domestic and foreign scientists from the area of quantum structures. An exhaustive overview of the mentioned results can be found in the monograph of Riečan and Neubrunn [106]. Recently, the efforts of the mentioned group in the MV algebras investigation gave rise to several important results on the measure theory on MV algebras, see e.g. Riečan [103].

### 3. Fuzzy connectives

The starting point of the fuzzy connectives research in Slovakia came from the investigation of the propagation of uncertainty in the expert systems by Mesiar. An efficient help of E. P. Klement for several Slovak scientists (literature, lectures in Slovakia, stages of Slovak researchers in Linz) enabled to obtain several deep results on triangular norms (Mesiar, Vicieník, Smutná) and related operators (Šabo, Komorníková, Kolesárová, Mesiar).

Recall, e.g., the characterization of the fuzzy sigma-algebras based on fundamental triangular norms and of the corresponding measures by Mesiar [67, 70] and Mesiar with Navara [89]. Among others, note the construction methods for t-norms by means of pseudo-inverses of monotone functions, where Vicieník [116] showed that pseudo-inverse need not be a quasi-inverse (which was believed to be true till Vicieník's paper appeared). Smutná [108] showed that the strictness of a t-norm need not imply the Archimedean property and the Archimedean property need not result to the relative cancellativity ( $T(x,y) = T(x,z)$  iff  $T(x,y)(y - z) = 0$ ), see [109]. As a continuation of the work of Klement, Mesiar and Pap, Vicieník [115] showed that an additive generator may generate a t-norm possessing even a non-trivial idempotent element. New class of aggregation operators based on triangular norms was proposed by Kolesárová and Komorníková [41]. Several interesting results on implicators may be found in papers of Šabo [111] and Mesiar (also with DeBaets) [3,74]. The limit and approximation properties of t-norms important for practical applications were studied by Mesiar in [86,87]. Note that 7 papers written by Slovak researchers (jointly with foreign coworkers) will appear in a special issue of Fuzzy Sets and Systems devoted to triangular norms which is just in press (e.g., 41, 90, 116).

### 4. Fuzzy numbers

Triangular norm-based calculus of fuzzy numbers seems to be one of the favorite Slovak topics. The first pioneer in the domain was Harman [26]. Among the most important results recall the transformation principle by Mesiar [80, 82] which allowed to improve several previous results (e.g. of Fuller, Hwong, etc.), but also to solve some philosophical problems (e.g., what type of fuzzy numbers shape is preferable). The fuzzy arithmetics was intensively studied in the works of Mesiar, Marková-Stupňanová and Kolesárová. A series of improvements and generalizations of results on analytical expressions of t-norm based additions of fuzzy numbers was closed in [6, 58, 83]. Idempotents for fuzzy addition based on a t-norm  $T$  [59, 60] are important also in the pseudo-analysis of E. Pap (as idempotents of pseudo-convolutions). The preserving of shapes [38, 39, 40, 82] allows to reduce the computation with fuzzy quantities to the computation with parameters, similarly as in some special cases in the probability theory. Most recently, new types of fuzzy quantities (generated fuzzy quantities) were proposed and studied by Mareš, Mesiar (and DeBaets), see [5, 48].

### 5. Conclusions

We have briefly mentioned some of interesting and valuable results from the fuzzy set theory area obtained by Slovak researchers. These and several other results are published in the papers given in the next list of references. It was not the aim of this paper to describe all Slovak results in the domain (what is, in fact, impossible) but to give an impression of the work in the fuzzy area in Slovakia. All these results form the theoretical background of the fuzzy set theory. However, though there are also several applications of the fuzzy set theory, see e.g. [108], real industrial applications are still missing. Nevertheless, we hope that this lack will be any soon not true, as far as the first contacts with the industry have been already opened.

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## References

- [1] B. De Baets, A. Marková, Addition of LR-fuzzy intervals based on a continuous t-norm, Proc. IPMU'96, Granada, 1996, 353-356.
- [2] B. De Baets, R. Mesiar, Fuzzy partitions and their entropy, Proc. IPMU'96, Granada, 1996, 1419-1424.
- [3] B. De Baets, R. Mesiar, Residual implicators with respect to a continuous t-norm, EUFIT'96, Aachen, 1996, 27-31.
- [4] B. De Baets, R. Mesiar, T-partitions, T-equivalences and pseudo-metrics, Proc. 7th IFSA, Prague, 1997, Vol. I, 187-192.
- [5] B. De Baets, M. Mareš, R. Mesiar, T-partitions of the real line generated by idempotent shapes, Fuzzy Sets and Systems 91 (1997), 177-184.
- [6] B. De Baets, A. Marková-Stupňanová, Analytical expressions for the addition of fuzzy intervals, Fuzzy Sets and Systems 91 (1997), 203-213.
- [7] B. De Baets, R. Mesiar, T-partitions, Fuzzy Sets and Systems 97 (1998) 211-224.
- [8] J. Bán, Radon-Nikodym theorem and conditional expectation for fuzzy valued measures and variables, Fuzzy Sets and Systems 34 (1990), 383-392.
- [9] J. Bán, Ergodic theorems for random sets and fuzzy random variables in Banach spaces, Fuzzy Sets and Systems 44 (1991), 71-82.
- [10] S. Bodjanová, Measures of fuzziness of fuzzy partitions, Acta Math. Univ. Comen. 52-53 (1987), 201-222.
- [11] K. Cechlárová, Fuzzy discrete dynamic systems - efficient algorithms using digraphs, Tatra Mount. Math. Publ. 6 (1995), 5-12.
- [12] K. Cechlárová, Efficient computation of the greatest eigenvector in fuzzy algebra, Tatra Mount. Math. Publ. 12 (1997), 73-80.
- [13] F. Chovanec, M. Jurečková, Law of large numbers on a D-poset of fuzzy sets, Tatra Mount. Math. Publ. 1 (1992), 15-18.
- [14] F. Chovanec, F. Kôpka, On fuzzy convergence of fuzzy observables in F-quantum spaces, BUSEFAL 44 (1990), 16-18.
- [15] F. Chovanec, F. Kôpka, On a representation of observables in D-poset of fuzzy sets, Tatra Mount. Math. Publ. 1 (1992), 19-25.
- [16] F. Chovanec, E. Rybáriková, Ideals in D-posets of fuzzy sets, Tatra Mount. Math. Publ. 12 (1997), 191-200.
- [17] A. Dvurečenskij, On the existence of probability measures on fuzzy measurable spaces, Fuzzy Sets and Systems 43 (1991), 173-181.
- [18] A. Dvurečenskij, Remarks on representation of fuzzy quantum posets, Math. Slovaca 44 (1994), 429-440.

- [19] A. Dvurečenskij, On a representation of observables in fuzzy measurable spaces, *J. Math. Anal. Appl.* 197 (1996), 579-588.
- [20] A. Dvurečenskij, F. Chovanec, Fuzzy quantum spaces and compatibility, *Int. J. Theor. Physics* 27 (1988), 1069-1082.
- [21] A. Dvurečenskij, B. Riečan, On joint distribution of observables for F-quantum spaces, *Fuzzy Sets and Systems* 39 (1991), 65-73.
- [22] A. Dvurečenskij, B. Riečan, Fuzzy quantum models, *Int. J. General Systems* 20 (1991), 39-54.
- [23] A. Dvurečenskij, A. Tirpáková, Ergodic theory on fuzzy quantum spaces, *BUSEFAL* 37 (1988), 86-94.
- [24] M. Gavalec, Periodicity of matrices and orbits in fuzzy algebra, *Tatra Mount. Math. Publ.* 6 (1995), 35-46.
- [25] M. Gavalec, Reaching matrix period is NP-complete, *Tatra Mount. Math. Publ.* 12 (1997), 81-88.
- [26] A. Harman, On the associativity of the product of the modified real fuzzy numbers, *Tatra Mount. Math. Publ.* 1 (1992), 45-50.
- [27] V. Janiš, Fixed points of fuzzy functions, *Tatra Mount. Math. Publ.* 12 (1997), 13-20.
- [28] V. Janiš, Linearity of fuzzy functions derivatives; *BUSEFAL*, in this volume.
- [29] M. Kalina, Derivatives of fuzzy functions and fuzzy derivatives, *Tatra Mount. Math. Publ.* 12 (1997), 27-34.
- [30] M. Kalina, On fuzzy smooth functions, *Tatra Mount. Math. Publ.* 14 (1998), 153-159.
- [31] E. P. Klement, R. Mesiar, E. Pap, On the relationship of associative compensatory operators to triangular norms and conorms, *Int. J. of Uncertainty, Fuzziness and Knowledge-based systems* 4 (1996), 129-144.
- [32] E. P. Klement, R. Mesiar, E. Pap, A characterization of the ordering of continuous t-norms, *Fuzzy Sets and Systems* 86 (1997), 189-195.
- [33] A. Kolesárová, Representation of fuzzy observables, *Proc. of 2nd Winter school on measure theory*, eds. A. Dvurečenskij a S. Pulmannová, Lipt. Ján, 1990, 117-120.
- [34] A. Kolesárová, On the structure of fuzzy observables, *Proc. Int. Sem. Bechyn'90*, Academia a Kluwer Pub. Comp. (1992), 190-197.
- [35] A. Kolesárová, Fuzzy possibility measures and their integral representation, *Proc. PROBASTAT'91*, Bratislava 1991.
- [36] A. Kolesárová, Triangular norm-based addition of linear fuzzy numbers, *Tatra Mount. Math. Publ.* 6 (1995), 75-82.
- [37] A. Kolesárová, Preserving of similarity of fuzzy numbers, *Fuzzy seminar Linz'97*, Linz, 1997, 115-119.
- [38] A. Kolesárová, Similarity preserving additions of fuzzy numbers, *Proc. 7th IFSA*, Prague, 1997, Vol. II, 165-168.
- [39] A. Kolesárová, Similarity preserving t-norm-based addition of fuzzy numbers, *Fuzzy Sets and Systems* 91 (1997), 215-229.
- [40] A. Kolesárová, Triangular norm-based addition preserving linearity of T-sums of linear intervals, *Mathware and Soft Computing* 5 (1998), 91-98.
- [41] A. Kolesárová, M. Komorníková, Triangular norm-based iterative compensatory operators, *Fuzzy Sets and Systems*, in press.

- [42] A. Kolesárová, B. Riečan, T-fuzzy observables, *Tatra Mount. Math. Publ.* 1 (1992), 73-82.
- [43] A. Kolesárová, B. Riečan, T -fuzzy observables, *Int. J. Theor. Physics* 32 No. 10 (1993), 1897-1909.
- [44] M. Komorníková, R. Mesiar, Aggregation operators with a generator, 3rd CES, Roma, 1996, 519-524.
- [45] M. Komorníková, R. Mesiar: Triangular norm-based aggregation of evidence under fuzziness, in : B.Bouchon-Meunier "Fusion under fuzziness", *Physica Verlag, Series Studies in Fuzziness*, 1997.
- [46] F. Kôpka, D-poset of fuzzy sets, *Tatra Mount. Math. Publ.* 1 (1992), 83-89.
- [47] F. Kôpka, Compatibility in D-posets of fuzzy sets, *Tatra Mount. Math. Publ.* 6 (1995), 95-102.
- [48] M. Mareš, R. Mesiar, Composition of shape generators, *Acta Math. et Informat. Univ. Ostraviensis* 4 (1996), 37-46.
- [49] D. Markechová, F-quantum spaces and their dynamics, *Fuzzy Sets and Systems* 50 (1992), 1-10.
- [50] D. Markechová, The conjugation of fuzzy probability spaces to the unit interval, *Fuzzy Sets and Systems* 47 (1992), 87-92.
- [51] D. Markechová, A note to the Kolmogorov-Sinaj entropy of fuzzy dynamical systems, *Fuzzy Sets and Systems* 64 (1994), 87-90.
- [52] D. Markechová, A.Tirpáková, The Lebesgue decomposition theorem for fuzzy measurable spaces, *Fuzzy Sets and Systems* 68 (1994), 203- 210.
- [53] A. Marková, Some remarks on the pseudo-linear algebra, *Tatra Mount. Math. Publ.* 6 (1995), 125-130.
- [54] A. Marková, Additions of L-R fuzzy numbers, *BUSEFAL* 63 (1995), 25- 29.
- [55] A. Marková, A note on g-derivative and g-integral, *Tatra Mount. Math. Publ.* 8 (1996), 71-76.
- [56] A. Marková, Pseudo-linear algebra, *Int. J. Fuzzy Mathematics* 4 (1996), 79-84.
- [57] A. Marková - Stupňanová, Triangular norm-based arithmetics of fuzzy quantities, *Proc. 3rd CES, Roma, 1996*, 525-529.
- [58] A. Marková, T-sum of L-R fuzzy numbers, *Fuzzy Sets and Systems* 85 (1997), 379-384.
- [59] A. Marková - Stupňanová, Idempotents of T-addition of fuzzy numbers, *Tatra Mount. Math. Publ.* 12 (1997), 65-72.
- [60] A. Marková - Stupňanová, A note to the addition of fuzzy numbers based on a continuous Archimedean t-norm, *Fuzzy Sets and Systems* 91 (1997), 253-258.
- [61] A. Marková - Stupňanová, On the law of large numbers for fuzzy numbers, *BUSEFAL* 75 (1998).
- [62] R. Mesiar, A remark on Piasecki's Bayes formula for fuzzy probability measure, *Fuzzy Sets and Systems* 37 (1990), 245-246.
- [63] R. Mesiar, The Bayes principle and the entropy on fuzzy probability spaces, *Int. J. General Systems* 20 No. 1 (1991), 67-72.
- [64] R. Mesiar, A note to the characterization of possibility measures of fuzzy events using Markov-kernels, *Fuzzy Sets and Systems* 46(1992), 301- 303.
- [65] R. Mesiar, Pseudo-fundamental triangular norms and g-T-tribes, *Fuzzy Sets and Systems* 52 (1992), 97-101.

- [66] R. Mesiar, Fuzzy observables, *J. Math. Anal. Appl.* 174 No.1 (1993), 178-193.
- [67] R. Mesiar, Fundamental triangular norm-based tribes and measures, *J. Math. Anal. Appl.* 177 (1993), 633-640.
- [68] R. Mesiar, Fuzzy measurable functions, *Fuzzy Sets and Systems* 59 (1993), 35-42.
- [69] R. Mesiar, Fuzzy logics and observables, *Int. J. Theor. Physics* 32 No. 7 (1993), 1143-1151.
- [70] R. Mesiar, On the structure of T -tribes, *Tatra Mount. Math. Publ.* 3 (1993), 167-172.
- [71] R. Mesiar, On the integral representation of fuzzy possibility measures, *Int. J. General Systems* 23 No. 2 (1994), 109-121.
- [72] R. Mesiar, h-fuzzy quantum logics, *Int. J. Theor. Physics* 33 No. 7 (1994), 1417-1425.
- [73] R. Mesiar, Fuzzy implications, *Proc. EUFIT'94, Aachen 1994*, ed. H.-J. Zimmermann, Elite Found., 1994, 1378-1382.
- [74] R. Mesiar, Computation over LR-fuzzy numbers, *Proc. CIFT'95, Trento 1995*, 165-176.
- [75] R. Mesiar, Compensatory operators based on triangular norms, *Proc. EUFIT'95, Aachen 1995*, ed. H.-J. Zimmermann, Elite Found., 1995, 131- 135.
- [76] R. Mesiar, Choquet-like integrals, *J. Math. Anal. Appl.* 194 (1995), 477-488.
- [77] R. Mesiar, Do fuzzy quantum structures exist?, *Int.J. Theor. Physics* 34 (1995), 1609-1614.
- [78] R. Mesiar, Fuzzy sets, difference posets and MV-algebras, in: *Fuzzy logic and soft computing*, eds.: B.Bouchon-Meunier, R.R.Yager and L. A. Zadeh, World Scientific, Singapore, 1995, 345-352.
- [79] R. Mesiar, On some constructions of new triangular norms, *Mathware and Soft Computing* 2 (1995), 39-45.
- [80] R. Mesiar, A note to the T-sum of L-R fuzzy numbers, *Fuzzy Sets and Systems* 79 (1996), 259-261.
- [81] R. Mesiar, LR-fuzzy numbers, *Proc. IPMU'96, Granada, 1996*, 337-342.
- [82] R. Mesiar, Shape preserving additions of fuzzy intervals, *Fuzzy Sets and Systems* 86 (1997), 73-78.
- [83] R. Mesiar, Triangular-norm-based addition of fuzzy intervals, *Fuzzy Sets and Systems* 91 (1997), 231-238.
- [84] R. Mesiar, k-order PAN-discrete fuzzy measures, *Proc. 7th IFSA, Prague, 1997, Vol. I*, 488-490.
- [85] R. Mesiar, Approximation of continuous t-norms by strict t-norms with smooth generators, *BUSEFAL* 75 (1998).
- [86] R. Mesiar, On the pointwise convergence of continuous Archimedean t-norms and the convergence of their generators, *BUSEFAL* 75 (1998).
- [87] R. Mesiar, A note on extension of discrete triangular norms, *BUSEFAL*, in this volume.
- [88] R. Mesiar, M. Komorníková, Aggregation operators, *Prim'96, Budva, Novi Sad, 1997*, 193-212.
- [89] R. Mesiar, M. Navara, T -tribes and T -measures, *J. Math. Anal. Appl.* 201 (1996), 91-102.
- [90] R. Mesiar, M. Navara, Diagonals of continuous triangular norms, *Fuzzy Sets and Systems*, in press.
- [91] R. Mesiar, E. Pap, Triangular norms from different points of view, *Fuzzy Sets and Systems* 96 (1998), 183-190.

- [92] R. Mesiar, K. Piasecki, On some possibility of generalization of the Bayes method of inference, *Fuzzy Sets and Systems* 37(1990),351-357.
- [93] R. Mesiar, P. Píř, Fuzzy model of inexact reasoning in medicine, *Comp. meth. and progr. in biomedicine* 30 No. 1 (1989), 1-8.
- [94] R. Mesiar, J. Rybárik, Pseudo-arithmetical operations, *Tatra Mount. Math. Publ.* 2 (1993), 185-192.
- [95] R. Mesiar a J. Rybárik, PAN-operations structure, *Fuzzy Sets and Systems* 74 (1995), 365-369.
- [96] R. Mesiar, J. Rybárik, Entropy of fuzzy partitions - a general model, *Fuzzy Sets and Systems* 99 (1998), 73 - 80.
- [97] B. Riečan, On a fuzzy approach to quantum mechanics, *Proc. Int. Sem. Bechynf'90, Academia a.Kluwer Pub. Comp.* (1992), 207-217.
- [98] B. Riečan, Fuzzy connectives and quantum models, *Proc. EMCSR'92, Vienna, 1992*, 335-338.
- [99] B. Riečan, Research on observables in fuzzy quantum spaces in Slovakia, *Fuzzy Sets and Systems* 59 (1993), 321-322.
- [100] B. Riečan, Representation of observables in fuzzy quantum logics, *Math. Slovaca* 44 (1994), 123-130.
- [101] B. Riečan, Upper and lower limits of sequences of observables in D- posets of fuzzy sets, *Math. Slovaca* 46 (1996), 419-431.
- [102] B. Riečan, On limit theorems in fuzzy quantum spaces, *Fuzzy Sets and Systems*, in press.
- [103] B. Riečan, Weak observables in MV algebras, *Int. J. Theor. Physics*, in press.
- [104] B. Riečan, A. Dvurečenskij, Randomness and fuzziness, in: *Progress in Fuzzy Sets in Europe (Warszawa 1986)*, PAN, Warszawa, 1988, 321-327.
- [105] B. Riečan, D. Markechová, The entropy of fuzzy dynamical system, general scheme and generators, *Fuzzy Sets and Systems* 96 (1998), 183- 190.
- [106] B. Riečan, T. Neubrunn, *Integral, Measure, and Ordering*, Kluwer and Ister Sc., Dordrecht and Bratislava, 1997.
- [107] J. Rybárik, The entropy of the Q-F dynamical system, *BUSEFAL* 48 (1991), 24-26.
- [108] W. Slany, J. Vařčák, A consistency checker for a fuzzy diagnosis system applied to warm rolling-mills in steelmaking plants, *FUZZIEEE'96, New Orleans, September 1996*, 206-212.
- [109] D. Smutná, On a peculiar t-norm, *BUSEFAL* 75 (1998).
- [110] D. Smutná, A note on non-continuous t-norms, *BUSEFAL*, this volume.
- [111] M. Šabo, On the continuity of t-reverse of t-norms, *Tatra Mount. Math. Publ.* 6 (1995), 173-178.
- [112] M. Šabo, On equality of implicators, *Proc. 7th IFSA, Prague, 1997, Vol. I*, 255-258.
- [113] J. Šajda, Uncertainty measures of fuzzy propositions and their use in fuzzy inference, *Tatra Mount. Math. Publ.* 1 (1992), 141-150.
- [114] A. Tirpáková, Ergodic theorem on fuzzy quantum spaces, *BUSEFAL* 39 (1989), 34-40.
- [115] A. Tirpáková, D. Markechová, Signed measures and Hahn-Jordan decompositions of fuzzy measurable spaces, *Demonstratio Math.* 29 (1996), 37- 42.

- [116] P. Vicaník, A note on generators of t-norms, BUSEFAL 75 (1998).
- [117] P. Vicaník, A note to a construction of t-norms based on pseudo-inverses of monotone functions, Fuzzy Sets and Systems, in press.
- [118] P. Vicaník, Additive generators and discontinuity, BUSEFAL, this volume.
- [119] P. Vojtáš, Boolean universe versus fuzzy sets, Tatra Mount. Math. Publ. 6 (1995), 179-186.
- [120] P. Vojtáš, Fuzzy reasoning with flexible selection of t-operators, Proc. 7th IFSA, Prague, 1997, Vol. I, 345-350, cit. praca: [RCD7]
- [121] M. Vrábelová, J. Beňová, A note on the upper integral of fuzzy sets, Acta Math. Inf. 1 (1992), 17-25.

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