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# CONSIDERATIONS ON SOME OPPORTUNITIES FOR OPTIMIZING NONCONVENTIONAL TECHNOLOGIES USING SUPERMATHEMATICS

**Dumitru MNERIE, Remus BOBOESCU, Gabriela-Victoria MNERIE**

***Abstract:*** *The conception and design of complex surfaces is often limited to the difficulty of defining them through mathematical relationships, which facilitate their generation with the help of nonconventional technologies, respectively based on the numerical commands of the appropriate technological equipment. For almost 50 years, the supermathematics of the Romanian scientist Mircea-Eugen Şelariu has determined a lot of discussions and debates regarding the understanding and applicability of the new development of mathematics. Supermathematics is itself a nonconventional approach to classical mathematics. The present work includes some notions regarding the definition, characterization, and interpretation of supermathematics, with the study of some directions of applicability in the field of optimizing the use of nonconventional technologies, respectively to facilitate the design of optimized software programs, with perspectives to widen the possible diversity of generation/processing of complex geometric surfaces.*
***Key words:*** *Supermathematics, periodic functions, generation of surfaces, nonconventional technologies.*

## 1. INTRODUCTION

Nonconventional approaches in various fields have determined, most of the times, the emergence of revolutionary solutions to technological problems, with important practical applicability. Thus, in 1994 a team of researchers led by Vivekanandhan published details of a more efficient computer software package for off-line programming of spray coating robots. The package developed (called CA-COATS) allowed the spray gun to follow computer-controlled paths in coats of predetermined constant thickness. well defined, generating complex surfaces. Today, this technology is very advanced, known as 3D printing. These programs can also be extended to make the necessary commands for the controlled removal of the material, with the help of the water jet, [1]. Solving the technological generation of complex surfaces has concerned several researchers. The results of the application are interesting, based on direct machining, which is achieved by generating efficient tool paths directly from the point cloud data, stored in STL format, to obtain with high efficiency, by machining free-form surface geometries, having complex processing areas. This skips the surface mount process and consists of three main steps: digitization, toolpath generation and machining. This algorithm can be used in the 3-axis milling operation using a ball end mill, as a tool. The division of the working surface into the sequences is included and highly suggestive B-spline curves are generated on each sequence [2]. At the beginning of the Millennium, complex, ultra-precise surface processing systems were created, [3]. Various approaches have emerged over time, such as the generic approach to efficiently generate arbitrary vector optical fields (VOFs) based on meta surfaces exhibiting full-matrix but inhomogeneous Jones-matrix distributions, [4].

In most solutions, a mathematical substantiation of the paths travelled by the tool was needed, to obtain complex surfaces, designed for different purposes, whose requirements can be among the most important in terms of shape/profile, dimensions, as well as other characteristics. The term "supramathematics" was invented by Felix Berezin, in the period 1960-1970, defining it as a branch of mathematical physics. In this category are known the applications of "Lie superalgebras" on the behavior of the 2 generic

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types of elementary particles: bosons and fermions. The author, in the context of the theory of superstrings, had a special concern over some objects of study that include supervarieties, superalgebras (e.g. super Minkowski space, super-Poincaré algebra), super geometry, superschemes, supermetrics/supersymmetry, respectively and supergravity, [5].

In 2016 Wegner notices the fact that supermathematics has existed for several decades, introduced by physicists, but with expressed interests from mathematicians as well. But mathematical theorists perceive supermathematics only as formal analogues, which have no clear applicability requirement. That is why a multidisciplinary study on the theoretical offer of supermathematics is necessary, to find as soon as possible concrete ways of practical applicability, for example, aimed at simplifying the definition and generation of complex surfaces, with the help of numerical commands, made with the help of some functions provided by supermathematics, [6]. Professor Florentin Smarandache from the University of New Mexico, published in 2007 a book that provides more details on „Selariu SuperMathematics Functions", [7], research in the field by Professor Mircea Eugen Șelariu, which began in 1969 Since then, the so-called super-mathematics functions (*SMF*) have been designed to be the basis for the generation, most of the time, of technical, neo-geometrical objects, [8]. Thus, this nonconventional approach to mathematics is considered appropriate to be studied more to find a more extensive technical applicability, with a beneficial role in the optimization of dimensional processing, based on nonconventional technologies.

## 2. THEORETICAL FOUNDATIONS

From a theoretical point of view, in principle, the fundamental approach to the principles on which supermathematics is based started from certain considerations in physics, with engineering investigation methods. It started from the analysis of circular motion with different angular velocities that occur in the operation of mechanisms and from the study of vibrations. The amplitude of the motion is a periodic function of the angular variable. This is treated similarly to the angle at the centre on the trigonometric circle. For the angle associated with a real variable, the trigonometric functions sine and cosine can be defined. Another form of generalized trigonometry is thus obtained which has been called „supermathematics" (SM). Introduced continuous functions that periodically exhibit points where they are not differentiable. Based on them, surfaces are generated that can be applied in technique and design.

In the beginning, the supermathematics initiated and developed by Mircea Eugen Șelariu, wanted to be a way to find an exact mathematical formula for the functions that appeared on the screens of the vibration measuring devices. These functions are periodic functions like the sinusoid, but with shifted maximum and minimum values. The proposed solution was to modify the definitions of trigonometric functions (*FT*). This was achieved by separating the points O (the origin of the system), *C* (the centre of the trigonometric circle) and *E* (the pole of the semi-straight line) following the trigonometric circle. In classical trigonometry these points appear confused. Trigonometric functions are called circular functions. Their separation will give rise to new mathematical developments. They defined:

- Central circular functions (FCC): $C \equiv O \equiv E$, (Classical trigonometry);
- Eccentric circular functions (FCE) $C \equiv O \neq E$.

Similarly, high circular functions and exotic circular functions have been explained.

Thus, supermathematics deals with eccentric, elevated and exotic circular functions.

Another applied idea was to replace the trigonometric circle with a regular polygon, for example a square. The real axis wrapped around it leads to the definition of some trigonometric functions.

Based on these considerations, numerical algorithms are developed that transform the square into a circle and the cube into a sphere.

In fact, it is considered the appearance of some novelty mathematics complements, with the name ex-centric mathematics (EM), including certain entities valued much more important and extremely numerous, in comparison with those existing in centric mathematics (CM), classic.

In references, the following notations are also used:

- *FT/FC = Trigonometric / Circular Functions;*
- *MC = Math Centric.*
- *ME = Eccentric Math.*
- *SM = Super Math = MC-ME.*
- *F SM = SM functions.*
- *F SM - C = F SM - Circular.*
- *F SM - CE = F SM- C Eccentric.*
- *STC = Central Trigonometric System.*
- *STE = Eccentric Trigonometric System*, [7].

The uniqueness of the mathematical „work" created by Mircea Eugen Șelariu is explained by the fact that he succeeds very well in combining the „Centric mathematics" with „Eccentric mathematics" [8].

It can be appreciated that supermathematics (SM) is defined as an ensemble consisting of familiar /ordinary mathematics, defined in this paper as "centric mathematics" (CM), to differentiate it from the new mathematics, referred to here as eccentric mathematics (EM).

Thus, the equality can be expressed synthetically: $SM = CM \cup EM$.

Starting from the consideration that, for any point belonging to a plane, located in an eccentric position of coordinates E (e, ε), a new EM is associated with it, then each CM corresponds to an infinity of EM points. Thus, CM=SM represents a particular case, resulting when the eccentricity is zero. It can be concluded by stating that SM infinitely multiplies the totality of the known circular/trigonometric functions, introducing a lot of new circular functions, of the form *aex, bex, dex, rex*, etc., valued much more important than the classical/old ones. This reasoning leads to a finality in which all known mathematical entities will be infinitely multiplied, introducing new ones. It is noted that:

- to linear, perfect, ideal systems it corresponds CM

- to non-linear, real, imperfect systems it corresponds SM.

What is very interesting is the fact that by introducing SM into mathematics, the considered limit between linear and non-linear systems, between the ideal and the real, between the characteristics of perfection and imperfection, disappears. Thus, according to the SM principles, two eccentricity coordinates are marked: e - linear, respectively ε, the angular one. Thus, the eccentricity E(e,ε) is defined by the polar coordinates, these becoming the new dimensions of space, including as dimensions of its formation and deformation [9].

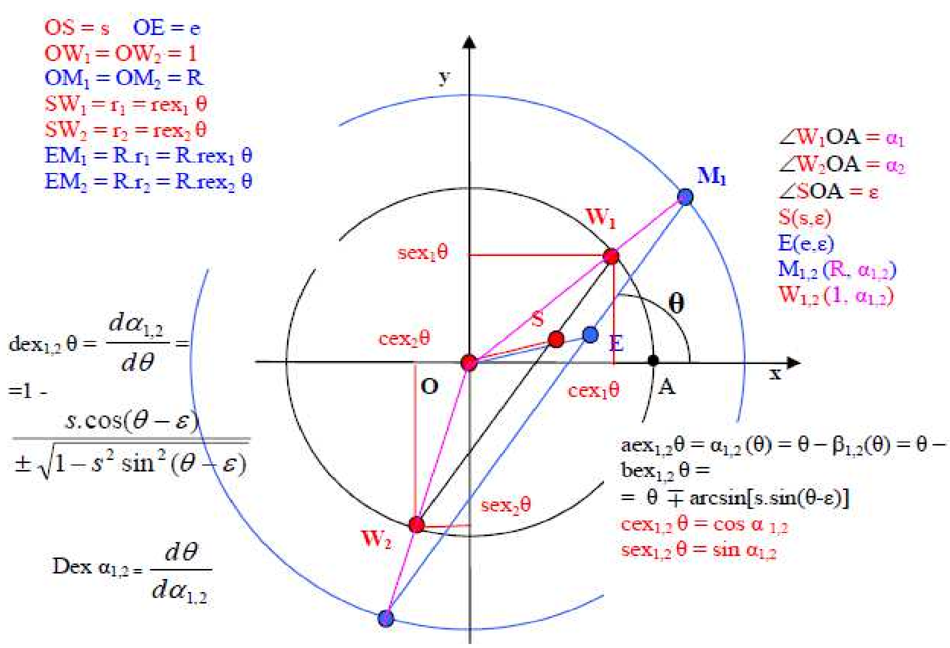


**Fig. 1.** Graphical expression of the way to define the Eccentric Circular Super Mathematics Functions (EC-SMF), [7]

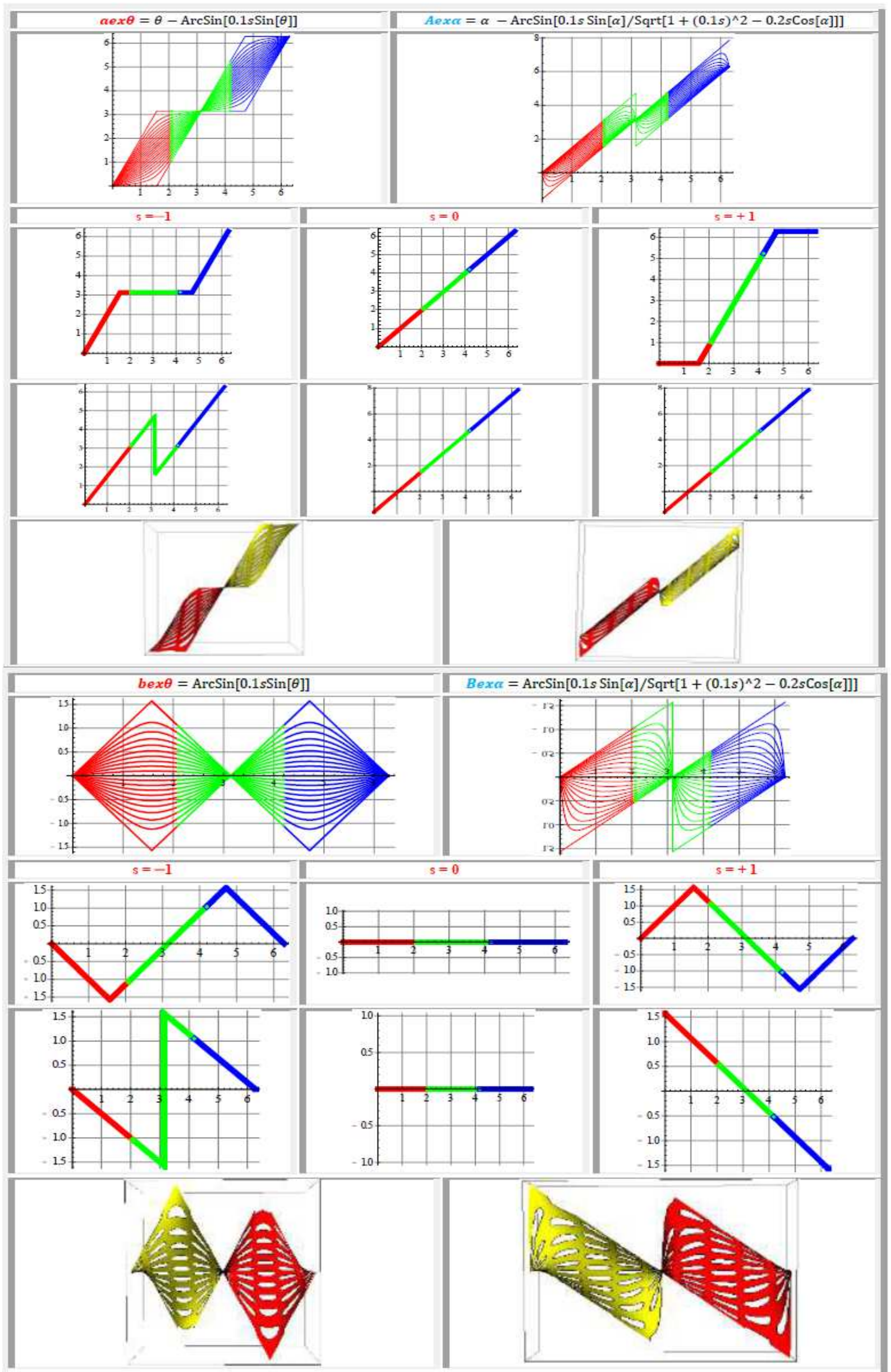


**Fig. 2.** Exemplification of the graphs of the functions defined by the FSM-CE: eccentric amplitudes ▲ and beta eccentric ▼, *aex* and *bex* by $\theta$◄ and *Aex* and *Bex* by $\alpha$. ►, [11

Figure 1 summarizes the Ex-Centric Circular Supermathematics functions.

The relations are established:

- The function $x = \cos\alpha$, is part of the family of functions $x = cex\,\theta = cex\,(\theta, s, \varepsilon)$, where $s = e/R$, and $\varepsilon$ represents the polar coordinates of the eccentric $S(s, \varepsilon)$, corresponding to the unit , respectively the trigonometric circle, or $E(e, \varepsilon)$. It is associated with a specific circle, of radius $R$, considered as a pole of a line $d$, which is in rotational movement around point *E* or *S*, having the angle of position *θ*.

The ex-centric trigonometric functions, respectively the ex-centric circular supermathematical functions *(EC-SMF),* resulting by intersecting the line *d* with the unit circle, are thus generated.

In the same figure, the definition of the eccentric cosine of *θ* is also explained, as being denoted $cex\,\theta = x$, where *x* is the projection of the point W, located at the intersection of the line *d* with the trigonometric circle *C(1,O),* Cartesian coordinates of the point W.

There is a certain straight line, passing through the point *S* inside the circle ($s \leq 1 \rightarrow e < R$), which intersects the circle in two points, denoted *W1* and *W2.*It follows the fact that there are 2 determinations of the eccentric circular supermathematical functions (*EC-SMF*): one is the main one, having the index 1, *cex1θ*, and the other is a secondary one *cex2θ*, denoted with the index 2, respectively *cex1,2 θ*.

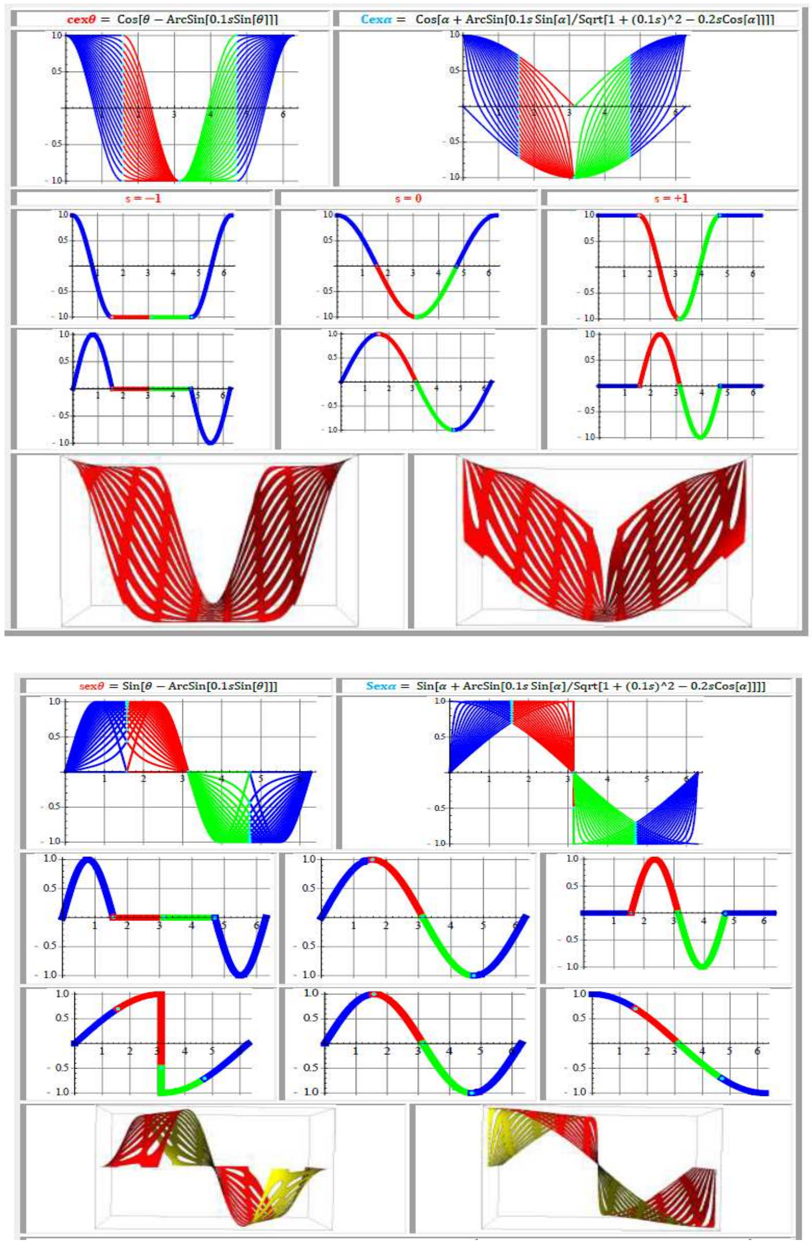


**Fig. 3.** Example of graphs of functions defined by *FSM-CE*: eccentric cosine – *cexθ* and *Cex α*, respective sine eccentric *sex θ* and *Sex α*, [12]

The generic points E and S are called ex-centers because they have been excluded from the center *O(0,0)*. It is precisely this exclusion that leads to the emergence of EM and implicitly MS. Thus, the number of mathematical objects made the leap from to infinity. A single function in CM, such as *cos α*, corresponds to an infinity of functions *cex θ*, due to the possibilities of placing the eccentric *S* and/or *E*, in the reference plane. [10]

Figure 2 shows some examples of the graphs of the functions defined by the FSM-CE, where eccentric amplitudes ▲ and eccentric beta ▼, *aex and bex of θ*◀ and Aex and Bex of α are observed, [11]. Figure 3 also shows some examples of graphs of functions defined by FSM-CE: eccentric cosine – c*exθ* and Cex α, respectively sine eccentric sex θ and Sex α, [12].

## 3. THE APPLICABILITY OF SUPERMATHEMATICS IN SUPPORT OF NONCONVENTIONAL TECHNOLOGIES

The applications of supermathematics in technology are primarily related to the definition and representation of periodic functions. These are revealed by supermathematics. A type of function even if it is one of several variables or of one variable and several parameters can be used to represent some experimental data. Likewise, the definition and representation of some functions can be used in design, suggesting the shape of some bodies. Thus, the use of supermathematics is a source of design ideas for geometric bodies. In modelling, it is desired that the complicated forms of some common bodies be obtained by a single function.

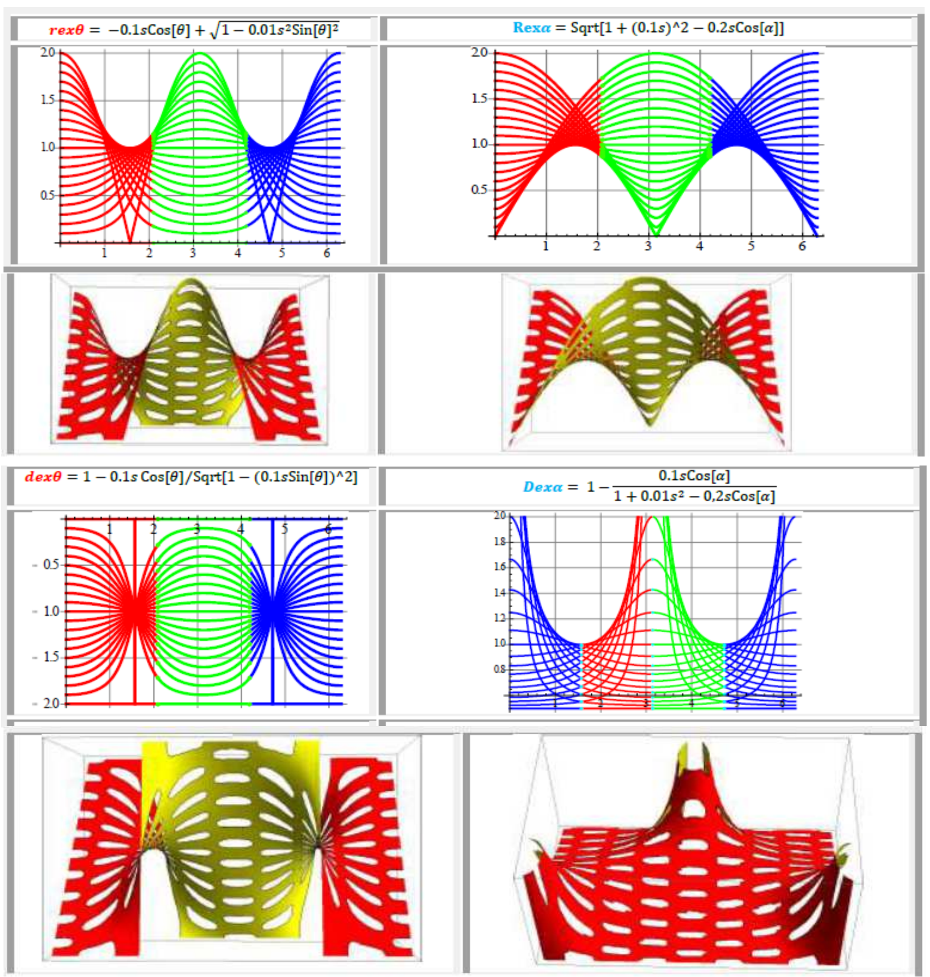


**Fig. 4.** Exemplification of the graphs of the functions defined by the *FSM-CE*: radially eccentric *rexθ* and *Rex α*▲ and eccentric derivatives *rexθ* and *Rex α*▲ and derivate eccentric derivates *dexθ* and *Dex α*▼, [11]

Considering the exceptional experience in studying devices, Selariu's supermathematics can be found in the functioning of some mechanisms. This means that the description of their operation, through determined velocities and accelerations, can be expressed using functions from supermathematics and treated in its own terms. Examples can be considered: the centric connecting rod-crank motor mechanism, the eccentric connecting rod-crank motor mechanism, the cylindrical cam mechanism.

Figure 4 shows some examples of the graphs of the functions defined by the FSM-CE: radial eccentrics rexθ and Rex α▲ and eccentric derivatives rexθ and Rex α▲ and eccentric derivatives dexθ and Dex α▼, [11].

Another application of eccentric circular supermathematical functions (*FSM-CE*), *cexθ*, *sexθ*, etc., constitutes the possibility of being a continuous basis for the approximation of functions, on the one hand, and offers the possibility of exact modelling of some functions / curves and /or surfaces, until recently considered non-mathematical, on the other hand.

Since, between two functions, such as *sinix* and *sin(i+1)x*, in the base of the trigonometric centric system (*STC*), there are no other functions, $n \subset Z$, the *STC* is considered a discrete basis of functions. Under the same conditions ($n \subset Z$), the supermathematical trigonometric system (*STS*) *sex(nx)* ∩ *cex(nx)* constitutes a continuous basis of approximation functions, because, between two of the basic functions $sex[ix, s = 0) = sinx$ and $sex[(i + 1)x, s = 0] = sin\,(i+1)x$ an infinity of other functions are interposed, which can continuously fill the space between them, when the numerical eccentricity s takes values from the range $s \in [-\infty, +\infty]$ or in the domain $s \in [-1, +1]$.

Thus, sex(x), for a numerical eccentricity $s \in [0, \pm 1]$, degenerates, at the two extreme limits of the interval, into *sinx* and, respectively, into *sin2x*, i.e., into two of the adjacent / bordering functions of the STC basic, but only within a certain range. It is known that all FSM-CE for $s = 0$ degenerate into *FCC*. Thus, $sex(x, s = 0) = sin\ x$. The periodic interval, with period $2\ \pi$, in which $sex(x) \in sin2x$ is $x \in [-\pi/2, +\pi/2]$ *for* $s = -1$ and $x \in [\pi/2, 3\ \pi/2]$, for $s = +1$.

These functions approximation applications are graphically highlighted, such as the example in figure 5.

The process of improving the approximation precision could continue by adding a function to reduce the maximum differences, only that, due to the rounding errors, the operation in the classical system.

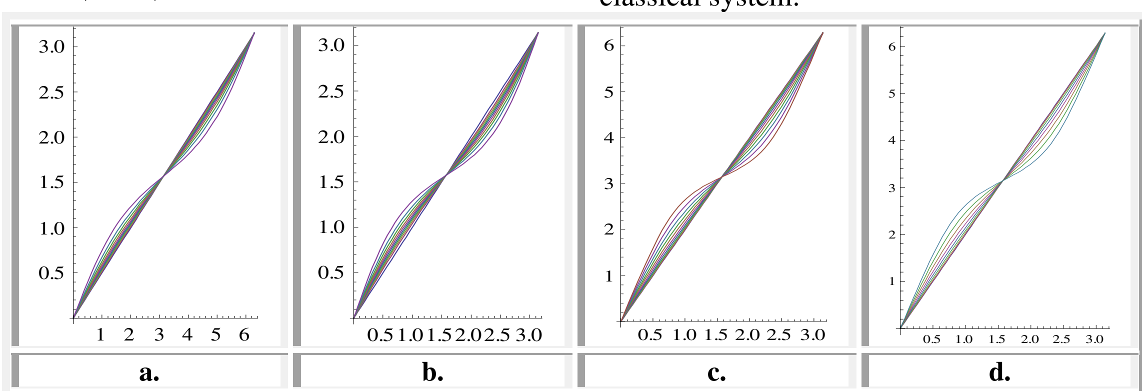

**Fig. 5.** Graphical exemplification of function approximation; example of the Jacobi function, [11]
(**a**) - am (*u,m*), modified, $m=k^2 \in [0,1]$; (**b**) - modified $k \in [0,1]$; (**c**) - respective FSM-CE $aex(2\theta, S(s = 2k^2/3;$
(**d**) - FSM-CE $aex\ (2\theta, S(s = k^2, \varepsilon = 0)), s \in [0; 0,8]$.

For example, considering the small number of terms of the approximation function of the elliptic Jacobi amplitude function, it is possible to obtain, by applying to supermathematical functions with a very high, of at least 15 exact decimals, the function *K(k)*, of the complete elliptic integral of the first case, (Figure 5).

It is deduced that centric mathematics is a particular case, with zero eccentricity, of supermathematics and that supermathematics has topological dimension 2 while centric mathematics only has topological dimension zero, of a point (*E O C*). In addition, with new functions, an infinity of new 2D or 3D shapes are obtained, among which we mention the hybrid geometric objects: the cone-pyramid, which starts as a pyramid with a square base and ends as a right circular cone, obtained by continuously transforming of the circle into a square with the *dex* function, the cylindrical-square-triangular pipe to which, in addition to the previous transformation, of the continuous transformation of the circle into a triangle is added with the help of the *cex* function, etc. which are the basis of a new method of representing technical parts called SM-CAD / CAM and which allows the purely (super)mathematical drawing of any technical part (see the house and the plane). With the major advantages deriving from this action and which refer to an enormous saving of memory; memorizing only the mathematical expressions of the piece's shape and not the immensity of points (pixels) that make it up, (figure 5), [11]

In addition to the format, in a nonconventional way on which the supermathematics initiated by Eugen Mircea Selariu is based, it is considered that this can contribute to the simplification of the calculation algorithms necessary for the establishment of the software programs for controlling the active systems of nonconventional processing, of some complex surfaces, much too complicated to define by the methods of classical mathematics.

## 4. CONCLUSIONS

This extension of mathematics (SM) could have appeared more than 300 years ago, when Euler, when defining trigonometric functions as direct circular functions, would not have chosen 3 overlapping points that impoverished mathematics: pole E, corresponding to a semi-straight line, the center of the trigonometric circle C (unit), respectively the origin O (0,0), related to a reference point / rectangular system. SM appeared with the expulsion of the E pole from the center, calling it an eccentric point. The use of supermathematics greatly facilitates the theoretical treatment of these mechanisms and can contribute to solving some optimization problems.

Mircea Eugen Selariu's supermathematics has been appreciated in more than 50 years since its initiation. Prestigious university mathematicians from the USA called it „mathematics of the third millennium”. Including in the CERN server (CERN Document Server) there are several articles about it.

Supermathematics was born from the millennial and desperate effort of man to model the world as it is: complex and non-linear, not linear, and simplistic. Supermathematics is the fulfilment of the dream of mathematicians to have an infinity of mathematics and to operate with them as simply as possible, [11].

Through the principles of supermathematics, real connections were created between the abstract approaches of mathematicians and the practical applicability always found by engineers. Thus, steps have been taken in the literature of mathematics, from the circular domain to the elliptic domain, broadening the approaches, from point to surfaces, in which eccentric elliptic functions can be expressed by eccentric circular functions. Openings have been created towards the definition of closed plane curves, called "quadrilobes" [13], of cosine $coq\theta$ and sine $siq\theta$ type, which, like the eccentric circular supermathematical function (FSM-CE) eccentric derivative, of eccentric variable $dex\theta$, they can achieve the continuous transformation of the circle in a square, of the cone in a pyramid, respectively of the circular cylinder in a square cylinder. These *quadrilobes* are closed eccentric supermathematical (SM) curves (quadratic eccentrics) obtained by the mathematical hybridization of 2 closed centric mathematical curves: the circle and the square.

In addition to the format, in a nonconventional way on which the supermathematics initiated by Eugen Mircea Selariu is based, it is considered that this can contribute to the simplification of the calculation algorithms necessary for the establishment of the software programs for controlling the active systems of nonconventional processing, of some complex surfaces, much too complicated to define by the methods of classical mathematics.

## 5. ACKNOWLEDGMENTS

The authors wish to express their sincere appreciation for the exceptional achievements of the researcher Mircea-Eugen Şelariu, who this year turned 85 years old.

**Fig. 6.** Researcher Mircea-Eugen Șelariu

He was born on February 27, 1938, in the town of Călan, Hunedoara County. He completed his higher studies at the Polytechnic Institute "*Traian V*uia" in Timisoara, currently named the *Politehnica* University of Timisoara, an institution where he remained as a teaching staff upon retirement (year 2000). He continued his research activity for 8 years in an institutionalized system, within the within INCD-EMC, (National Research and Development Institute for Electrochemistry and Condensed Matter), Timisoara branch, after which he completed his studies, mainly at his own residence. According to his own confessions, the inspiration to approach supermathematics came to him in the period 1969-1970, when he benefited from a DAAD scholarship for specialization carried out within the University of Stuttgart, at the department, respectively the Institute of Machine Tools. Throughout his career, he was recognized as a very good specialist in the design of devices and machine tools, in which field he had national and international collaborations. For his merits, he obtained important distinctions, among which: in 1971, the "*Traian Vuia*" prize awarded by the Romanian Academy, respectively the award of the Romanian Academy for the creation of the REMT-1 industrial robot (1983). In the specialized literature, in 1971, the contributions to the edition of the „*Manual of the Mechanical Engineer*" Vol. III TCM, Chapter no.18 called „*Design of devices*". Treatise on the design of devices is better known. Design of Multiax is Heads devices; Laboratory instructor for Device Design, as well as the book that also appeared in Romanian, in the field that brought him fame „Supermathematics", Vol. I, and II, edited by *Politehnica* Timisoara Publishing House, 2012. He was the initiator of the Mechatronics specialization, (1988), the creator in 1971 of the first didactic robot, and in 1972, creator of the first Romanian industrial robot, called „Voinicel 1". He had an important period of collaboration in the research undertaken with Prof.dr.Doc.ing. Aurel Nanu, the pioneer of nonconventional technologies in Romania. Probably the tenacity and with which he worked exemplary as a scientific researcher, demonstrating a real vocation as a champion, was also given by the experience gained in practicing performance sports, significant results proven in gymnastics, athletics, and football.

The present work is also intended to be a tribute to the researcher Mircea Eugen Șelariu, for his entire activity dedicated to engineering and applied mathematics, on his ***85th birthday*** this year.

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## Cconsiderente asupra unor oportunități privind optimizarea tehnologiilor neconvenționale cu ajutorul supermatematicii

**Abstract: Conceperea și proiectarea unor suprafețe complexe se limitează de multe ori la dificultatea definirii acestora prin relații matematice, care să faciliteze și generarea acestora cu ajutorul tehnologiilor neconvenționale, respectiv pe baza comenzilor numerice ale echipamentelor tehnologice adecvate. De aproape 50 ani supermatematica omului de știință român Mircea-Eugen Șelariu a determinat o mulțime de discuții și dezbateri privind înțelegerea și aplicabilitatea noii dezvoltări ale matematicii. Supermatematica este în sine o abordare neconvențională a matematicii clasice. Prezenta lucrare cuprinde câteva noțiuni privind definirea, caracterizarea și interpretarea supermatematicii, cu studierea unor direcții de aplicabilitate în domeniul optimizării folosirii tehnologiilor neconvenționale, respectiv de a facilita proiectarea unor programe soft-ware optimizate, cu perspective de a lărgi diversitatea posibilă de generare/prelucrare a unor suprafețe geometrice complexe**

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