# Professor Rastko Stojanović, PhD 1926-1972

**Smilja Milanović** *

It has been thirty years since the tragic death of professor Rastko Stojanovic. He lost his life in an automobile accident, on April 28, 1972, on the highway Belgrade-Zagreb, twenty kilometers away from Zagreb.

Dr Stojanovic was born on November 26, 1926 in Belgrade to father Dusan, PhD and mother Stana, PhD, born Popovic, and according to her son Rastko the first women dentist in Serbia. He completed primary and secondary education in Belgrade, graduating from high school in 1945. The same year, in September, he enrolled at, what was then, the Faculty

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of Philosophy at the University of Belgrade, specializing in subject group II-Applied Mathematics. When the university reform was carried out and the Faculty of Philosophy divided, Rastko Stojanovic became a student of the new Faculty of Mathematics and Natural Sciences from which he received his degree in 1949 with specialization in Mechanics and grade point average of 9.15.

After studies at the University, from September 1949 until September 1, 1953, Rastko Stojanovic was assigned, as a high school teacher, to work at the High Technical School in Belgrade, where he held practical sessions in Mathematics I and Mathematics II. During this period he also completed his military service. From September 1, 1953 to February 1, 1956 he taught at the Department of Mechanics and Astronomy at the Faculty of Mathematics and Natural Sciences in Belgrade, and on February 1, 1956 became a Teaching Fellow for the subject Rational Mechanics.

Rastko Stojanovic earned his doctoral degree on March 16, 1955, with a thesis "The Motion of Rigid Body in Riemannian Space of Constant Curvature."

Dr Stojanovic was elected for the first time as an Assistant Professor on July 1, 1958, for the subject Rational Mechanics at the Department of Mechanics and Astronomy at the Faculty of Mathematics and Natural Sciences. He was re-elected for this position on July 1, 1963, and on February 1, 1968, became an Associate Professor. After his re-election for this position in 1971, he was immediately recommended for a position of (full) Professor:

*"Based on preceding information on candidate R. Stojanovic, here undersigned personnel clerks agree that he is qualified both as a scientist and an educator to receive the title of a professor." (signed: Academician professor Tatomir Andjelic, PhD, professor at PMF, professor Aleksandar Milojevic, PhD, professor at PMF, and professor Vlatko Brcic, PhD, professor at the Faculty of Civil Engineering)*

Unfortunately, the proposed promotion did not take place because of his untimely death.

Dr Stojanovic was well versed in foreign languages: he spoke, read and wrote English and Slovenian, spoke and read German and French and understood Russian and Italian.

From this short biography it is not possible to deduce much about life and work of Dr Rastko Stojanovic. Nonetheless, based on documents

available to us today, i.e. essays for his elections and re-elections, scientific articles and books, as well as personal acquaintance of the author with Dr Rastko Stojanovic and his colleagues and students, much can be learned about his scientific work. Unfortunately, there is very little information on childhood and youth years of Dr Stojanovic. We recall that, several months after his death, an article appeared in one of local weekly newspapers (we believe it was one of the weekly newspapers of "Politika") in which his mother was interviewed. From it, we learned that Rastko fell in love with mountains from an early age, since his family (mother, father, brother, and he, himself) went mountain climbing whenever possible, especially every summer.

Based on what we know, we can say that Dr Stojanovic was a good man in the widest sense of the word, successful and prolific scientist, and a passionate alpinist. He was versatile in his interests, always aspiring for the best and achieving it.

Dr Stojanovic was a mountain climber and later alpinist from an early age. We recall that as a child he visited not seaside but glaciers of Alps, Dolomite or Prokletija Mountains, where he skied over the summer and conquered their peaks. He knew all our mountains well, and served as a guide to countless student groups while he was a Teaching Fellow and Assistant Professor at the University. Consequently, many students, even from different faculties, got to know Dr Stojanovic. He is forever present in memories of their student years. In a short biography submitted for the re-election for the position of Associate Professor he wrote:

*"I am the Head of the Department for Alpinism at the Mountain Climbing-Skiing Association of Belgrade since 1953. Until 1970 I was a Board Director for Alpinism of the Mountain Association of Serbia. I am an active alpinism instructor, and have led a large number of winter and summer courses and a large number of climbing expeditions here and abroad. I am a certified Alp guide since 1967, the only one who does not live in Slovenia." (From a biography written within the application for a competition for a re-election of one of the associate professors for the subject Rational mechanics at the Department of Mechanics, on April 26, 1971)*

This citation is meant to elucidate personality and character of Dr Rastko Stojanovic, to point out his versatility as well as his aspiration to always strive toward the summit and conquer it.

Rastko Stojanovic began scientific and pedagogical work in 1949, a time of difficulties and isolation from the rest of the developed world, an unfavorable period for science and especially young scientists in our country. In spite of such conditions, he worked diligently and persistently, overcoming difficulties in his own way and succeeding. His first scientific work was published in 1952, a veritable success since he served military duty from October 26, 1950 to November 1, 1951.

His first works, or rather first nine, published in various domestic and foreign journals up to year 1958, treated the topic of rigid bodies and in particular the problems of geometrization of mechanics. Certain number of works dealt with the mechanics of discrete systems. The basic question he was concerned with in all of them was the use of tensor calculus and theory of transformation groups in mechanics. At that time tensor calculus was a new mathematical method which, among other, and thanks to Dr Stojanovic, found wide application, and was for a while the most widely used method in Mechanics.

The year 1958 was a turning point in Dr Stojanovic's career both as a scientist and as a scientific researcher. Namely, that year he began working on the problem of Continuum mechanics in new and not well researched fields, his contribution being the application of his extraordinary knowledge of tensor calculus and differential geometry to these fields. In addition, he worked on problems of formation of general non-linear constitutive relation, non-linear thermoelasticity, plastic flow, and development of theory of incompatible deformations. Moreover, a number of his works dealt with coupled electro-magneto-thermo-mechanical effects. In all of his works Dr Stojanovic showed interest for influence of couple stress and asymmetric stress tensor on deformation. As a consequence, he pursued the application of the theory of micropolar continua, particularly in civil engineering, theory of construction and rock mechanics.

While commenting on the period after year 1958, we ought to mention that Dr Stojanovic received a *Richard-Morton-Gastprofessur Scholarship* and spent a year 1961-1962 at the University of Technology in Stuttgart, where he expanded his research and made many personal contacts with well known scientists from all over the world interested in the problem of Continuum mechanics. We would like to pause here and reiterate that Dr Rastko Stojanovic was, at that time, one of few of our scientists who achieved scientific and professional reputation in our country, in Belgrade.

Thus, while visiting Germany as an experienced scientist, and due to his professional reputation and excellence, an interest of international community for Belgrade had been awakened. The same contributed to the good reputation of the Belgrade School of Mechanics.

In order to work successfully in a wide field of mechanics, in 1962 Dr Stojanovic formed a team of researchers comprised of teaching fellows, assistant professors and professors from several faculties of the University of Belgrade, and later from other universities in our country. His research results, as well as the results of interest from foreign authors were presented every Tuesday from 18 to 20h at the Seminar of Rheology, at the premises of the Department of Mechanics at the Faculty for Mathematics and Natural Sciences. This seminar is held even today, at the same time and at the same place. Many doctoral and master thesis, as well as new areas of Continuum mechanics and new methods for solving concrete problems were and still are discussed during these sessions. In that way, the Seminar of Rheology whose founder was he maintains its original purpose.

Dr Stojanovic devoted a great part of his creative energy to help and conduct young researchers in the field of mechanics. He, personally, directed seven doctoral dissertations and three master thesis, and at the time of his death he was in charge of two master thesis and two doctoral dissertations, Jovo P. Jaric and Milan V. Micunovic. However, even if he was not officially in charge, de facto, he also directed several PhD dissertations . Here we mention some, at that time, PhD students who spent a lot of time with Dr Stojanovic discussing very different scientific problems in mechanics: Bozidar D. Vujanovic, Lazar Rusov, Luka Vujosevic, Slavko Djuric, Milan Plavsic, Dragovan Blagojevic, Milan Gligoric. Some of them were officially guided by Prof. Tatomir Andjelic, the late chairman of the Institute of mechanics. Here we can also name late Rastko Cukic and Dobrosav Ruzic.

Dr Stojanovic was invited, several times, as a visiting professor to different universities. He also held courses abroad. He had established a particularly good collaboration with the International Centre for Mechanics in Udine, Italy. Many young scientists had thus the opportunity to attend lectures and courses organized every year. In chronological order Dr Stojanovic's visits abroad were :

a) From February 16, 1961 to February 15, 1962 at the University of

Technology in Stuttgart where he held two courses "Methods of tensor analysis and differential geometry in mechanics" and "Foundations of continuum mechanics."

b) At the invitation of Polish Academy of Sciences he held three lectures in Warsaw (at the Institute for fundamental technological resereach of PAN) and Krakow (at Krakow Polytechnic Institute).

c) In April 1969 he was at the Conference on mechanics of polar continua in Rome, where he held a one hour lecture under the title "On Deformation Measures in Theory of Generalized Elastic Cosserat Mediums."

d) From September 16, 1969 to October 28, 1969 he held thirty lectures at the International Center for Mechanics in Udine, Italy, under the title "Mechanics of Polar Continua."

e) From June 28 to July 20, 1970, and at the invitation of the International Centre for Mechanics in Udine, he held a course of twenty-five lectures under the title "New Results in Theory of Polar Continua."

Since 1954 Dr Stojanovic participated at nine Yugoslav congresses for Rational and Applied Mechanics, either as a lecturer or one-hour introductory lecturer. Twice, he held lectures on the Symposium of Yugoslav Laboratories for Investigation and Research of Materials and Construction. All lectures and reports from these conferences and symposiums have been published in journals or collection of works from these scientific meetings.

Dr Stojanovic also participated with lectures many times at international conferences such as: GAMM conferences in Hamburg (1957), Hanover (1959) and Wurzburg (1961), Polish National Conference on Mechanics of Polar Continuum in Zakopani (1964), IUTAM Symposium in Freuenstadt and Stuttgart (1967), International Conference on Mechanics of Polar Continuum in Rome in 1968 with invited lecture; Romanian National Conference on Applied Mechanics (1971); International Conference on Mechanics in Obervolfah (1971). He could not participate at the conference on Fundamental Aspects of Theory of Dislocation held in April 1969 in Washington organized by the National department for standards USA because he could not afford the travel expenses. His report was read by professor M. Mishicu from Bucharest. All announcements and reports from these conferences have been published in the appropriate scientific journals or collections of works from these meetings. Dr. Stojanovic

was not in a position to accept many invitations to scientific conferences due to lack of financial funding. During the school year 1970/71 alone he could not accept the invitation for the participation at the scientific conferences in India, Australia, Canada and Poland.

A large number of Dr Stojanovic's works has been cited in foreign expert literature. For example, professor Bilby from the University of Sheffield, England, in his lectures on geometric aspects of continuous theory of dislocation, held during the summer school for theory of defects in the structure of materials in Poland in 1965, said in his introduction that his discussion has been based on the works of Bilby, Kroner, Seeger, Stojanovic and an unpublished work of Bilby, Zorawski, Gardner and Stroh. The published work contains a whole chapter entitled " Stojanovic's Equations and Kroner's Equations," and was dedicated to a new method of solving equations of the theory of dislocations. This chapter was published as an article in 1962 in "Physica Status Solidi," 2, under the title "On the reference state problem in the non-linear elasticity theory of continua with dislocation." Professor R.L.Huston from the University of Cincinnati, Ohio, published several works based solely on articles written by professor Stojanovic. Commenting on a method of solving non-linear relations between stress and deformation in elasticity, published in 1960, he calls it "an ingenious method . . . suggested by Stoyanovich in 1960." Unfortunately, no one, not even Dr Rastko Stojanovic held a detailed list on how many times his works were cited.

Since 1959, Dr Stojanovic reviewed articles for the chapter on Mechanics and Elasticity and Plasticity in the journal "Zentralblatt fur Mathematik," where he published 150 reviews. In 1965, upon the foundation of "International Journal for Solids and Structures," with professor G. Hermann from Stanford University, as editor, and Pergamon Press, Oxford, as a publishing house, he became a member of the Editorial advisory board.

The following article has been published by the Institute for history of natural sciences ANSSSR after professor Stojanovic's death:

*"Rastko D. Stojanovic is an eminent researcher in analytical mechanics and mechanics of continuous media. In a domain of analytical mechanics he obtained several results concerning spatial properties of groups and stability of group motion. He investigated in detail the application of Lie groups on described motions of conservative dynamic systems, and*

*also considered the motion of rigid bodies in Riemannian spaces of constant curvature in 2D and 3D spaces. In the field of the theory of elasticity, Stojanovic investigated the influence of microstructure on macroscopic behavior of (oriented) elastic materials, and he also worked on other general models of the mechanics of elastic bodies. Stojanovic's work on thermoelasticity deals with problems of non-linear theory. He is also credited with the work on geometrical interpretation of thermoelasticity. Dr. Stojanovic worked on a theory of dislocations and established a relation between internal stresses and continuously distributed dislocations in a non isotropic elastic medium. He also worked on problems of plastic flow in material." (ANSSSR, Institute for the history of natural sciences and technology, 3-4, (56-57))*

In our country, Dr Stojanovic was a member of the Yugoslav Society for Mechanics since its foundation in 1954, and a member of its Executive Committee since 1958. From 1962 to 1970 he was the Secretary general of the Society and since 1970 its vice president and president. He participated in the organization and was a main organizer of the Yugoslav Congress of mechanics in 1962, 1964, 1966, 1968 and 1970.

During his life, professor Stojanovic did not receive a large number of official awards from the state. Worth noting, however, is the October Award for the Scientific Work, which he received in 1969 for the work "Dislocations in Generalized Cosserat Continuum." At the time Dr Stojanovic was 43, and we believe the youngest to receive such an award.

In 1972, family of Dr Stojanovic, with the agreement of the Yugoslav Society for Mechanics, established Dr Rastko Stojanovic Foundation. This organization ensures the continuation of Dr Stojanovic legacy in promoting the development of mechanics in our country and providing significant assistance and encouragement to young scientists. At every Yugoslav congress of mechanics, it awards the best scientific work of young scientists.

The pedagogical work of professor Rastko Stojanovic consisted of lectures at the undergraduate level but also much work at the graduate level, that is in direct creation and preparation of scientific works with graduate students and direction of their doctoral dissertations and master thesis. At the undergraduate level, he was one of the professors who went over the material fairly quickly, insisted his students should grasp the essence of the material and focus on clear presentation of their ideas. For sub-

jects he taught (Rational Mechanics, Continuum Mechanics, Differential Geometry, Non-linear Continuum Mechanics) he had his own textbooks or authorized notes, even when lectures were held abroad. He questioned quickly and effectively and discerned the capacity of a student well. Even more important was his work with graduate students, that is formation of a new generation of young scientists in one of the modern branches of mechanics. His work with graduate students was successful and fruitful, as shown by a number of thesis produced by his graduate students, which we have mentioned already. What made him different from many colleagues was an unusually high level of energy which he used effectively, his beaming optimism, talent to motivate his colleagues to work, ability to collaborate with his colleagues and his talent to gather young people and direct them in different fields of continuum mechanics.

Finally, we would like to point out that Dr Rastko Stojanovic is a rare and exceptional figure not only in the field of mechanics but among all our scientists. Based on the information we have presented here and the bibliography that follows, it is apparent that his contribution to the field of mechanics, especially in the domain of continuum mechanics is invaluable and irrefutable. It would be no exaggeration to say that he was the founder of the modern school of analytical mechanics and continuum mechanics in our country and that his works in these fields are estimated and important. Furthermore, we would like to say that he has introduced a new method of team in our midst, which is one more reason his name became a part of history of mechanics in Yugoslavia.

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[2]The creation of this article has been initiated by academician Božidar Vujanović, retired professor from the Faculty of technical sciences in Novi Sad. He belonged to a first generation of students at the Department for mechanics and held Dr. Rastko Stojanović in high esteem both as his student and a colleague. Academician Vujanović has also contributed to this article with his suggestions and the materials in his possession pertaining to this subject.

The final form of the text has been done by Prof. Jovo P. Jarić,a student, a PhD student, an assistant and a colleague of Prof. Rastko Stojanović.

For all their help, the author of this article wishes to express her sincere thanks.

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# RAAG and Geometry

Rastko Stojanovitch

The wide spectrum of interests of RAAG members suggests me one question: Where are the limits of the applications of geometry?

All processes in the world take place in the space. Our knowledge of the space is based on the observations, which are dependent on the perceptibility of our senses. Hence, two conclusions may be derived. First, our ideas about the space are formed from the restricted sources of information as our senses are, and second, physical processes can not be separated from the properties of the space.

If the geometry is to be understood as the theory of the spaces, it must be inadmissible to build it on the too subjective and elementary observations supplied by our senses. The geometry must have the status of a Natural Science, more precisely, it must be treated as a branch of Physics. The methods of Physics, both experimental and theoretical, must be used for the study of the space in which we live.

The present state of geometry is unsatisfactory, at least as I see it. Euclidean geometry is an approximate theory based on a set of "obvious" facts, but these facts are too much related to our senses. The non-euclidean geometries are nice generalizations, never in contradiction with the primitive experience (and containing it as a special case), but such geometries are only mathematically possible generalizations and we have no guarantees that there are no other mathematically possible generalizations which would be different from the today known geometries and which would suit even better our physical theories.

In connection with this, there is another question. In all our theories in physics we always assume a certain geometry. In classical mechanics it is the euclidean

geometry, in the continuum theory of dislocations and in Professor Kondo's theory of yielding it is the geometry of linearly connected spaces with torsion, etc. With the exception of the general theory of relativity I do not know for an experiment which would explicitly serve for the experimental verification of the geometric assumptions. The question is whether the geometry is at all unique, or each physical process has its own geometry.

If geometries are determined by physical processes, the space must be completely amorphous, structureless. That seems to me very improbable.

Influence of the structure of the space on physical processes and interconnections of geometry with physical phenomena seem to be much wider than we have realized yet. The theory of relativity gave just the first impulse in the investigation of these interconnections, but there are some fields of research belonging to the classical physics where the structure of the space is indispensable. A very simple example is the phenomenon of internal stresses produced by incompatible deformations. A continuous body with incompatible deformations suffers a geometric constraint and in order to remain as a whole in the space in which it is, the internal stresses appear in the body as a reaction to this geometric constraint. Doesn't this give a sufficient evidence of the omnipresence of geometry?

If we agree that geometry is a branch of physics, we can not study it separately, but together with the processes which might furnish us with some information about the structure of the space. It is inevitable then to forward the unifying studies of the basic sciences and geometry.

RAAG is in its essence the sponsor of this approach to the problems of contemporary science. The Geometry of Observations, developed in the RAAG Memoirs, principally by Professor K. Kondo, represents already a very serious basis for the farther studies of geometry as a branch of physics. At the present state in the field even some contradictory points of view on the fundamental assumptions are not excluded. I am sure, however, that already the near future will show how far-reaching are the ideas of the organizers of RAAG and how important is the role of RAAG in the development of our knowledge of the physical world in which we live.