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REMEMBRANCE OF PROFESSOR EMIL CHIFU (1925-1997) THE *PROMOTER* OF *SCIENCE IN COSMOS*: *THE FIRST ROMANIAN EXPERIMENT IN COSMOS* – PROPOSED BY EMIL CHIFU (1977) AT BABES BOLYAI UNIVERSITY OF CLUJ-NAPOCA – *APPROVED BY NASA OF USA* (1978) – AND *IMPLEMENTED* IN 1985 – IN THE MISSION OF NASA ON *SPACELAB-3*

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Abstract. *This article is aimed to pay tribute to Professor Emil Chifu, a brilliant Romanian scientist, a physical chemist and biophysicist, from Babes-Bolyai University of Cluj-Napoca (UBB). He had many fields of research interest: Physical Chemistry of thin films and biological membrane models, Langmuir monolayers and Langmuir-Blodgett surface layers, Chemical Thermodynamics, Colloidal and Surface Chemistry, Biophysical Chemistry, and Physicochemical Hydrodynamics of free drops (Marangoni effect), the behavior of liquids in cosmos, as well as the Chemistry of natural compounds with industrial and medical applications. Professor Emil Chifu is recognized in the academic world, because he published excellent articles in these research fields. His achievements were recognized by NASA (National Aeronautics and Space Administration) of the United States of America. Through an international competition, Professor Chifu proposed an international research project (1977), accepted by NASA (1978), and gained the first scientific research project in Romania, between UBB and NASA of USA (1977-1987). This research project was approved for exploring in cosmos by NASA and it was successfully achieved in SpaceLab-3 Mission of NASA (1985). Professor Chifu and his research team received the prestigious Gheorghe Spacu prize of Romanian Academy in 1983, for the scientific research realized in this international research project with NASA. Certainly, Professor Emil Chifu is considered as a major promoter for his innovative work and impact on the surface flow of liquids and drop dynamics, in the absence of gravity, under the influence of interfacial tension gradients (Marangoni effect and Langmuir-Blodgett superficial layer) on free drop dynamics in cosmos. Therefore, Professor Chifu contributed to the revolutionary work in surface chemistry, as other influential scientists, like Carlo Marangoni, Irving Langmuir and Katharine Burr Blodgett, are also considered major promoters for their innovative work in*

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surface chemistry. Professor Chifu was also a scientist of great character and an unforgettable chief (1971-1991) of the Physical Chemistry Department in Faculty of Chemistry and Chemical Engineering at Babes-Bolyai University of Cluj-Napoca. He developed physical chemistry and surface chemistry and encouraged us to fight for the best science and academic teaching in Romania, showing the scientific research life to the world through our achievements.

Professor Emil Chifu was born on July 17, 1925 in Herta, county of Dorohoi, Romania (today, Ukraine). He died on April 1, 1997, in Cluj-Napoca.

This year 2025 marks the 100 years from the birthday of Professor Emil Chifu and 48 years, from *the first scientific research project on the liquids behavior in cosmos* proposed (1977) by Professor Emil Chifu, and accepted (1978) by NASA (National Aeronautics and Space Administration) of the United States of America, for exploring in cosmos in the Mission of NASA in *SpaceLab-3,* launched on the Space Shuttle Challenger, on April 29, 1985, and ended on May 6, 1985.

The eminent Romanian scientist, Professor Emil Chifu was a brilliant physical chemist and biophysicist, recognized by the international scientific community, on his outstanding scientific research articles and grants [1-10].

He was also a remarkable professor scientist of great character and an unforgettable chief of the physical chemistry department in the Faculty of Chemistry and Chemical Engineering, at "Babes-Bolyai" University of Cluj-Napoca, UBB, and developed physical chemistry and encouraged us to fight for the best science and academic teaching in Romanian.

He was one of the founders of the modern science of colloids, surfaces and membrane phenomena, thermodynamics and hydrodynamics of thin layers formed by surface active substances self-assembled into supramolecular structures at liquid interfaces.

Professor Emil Chifu formed a modern school of scientific research in the thermodynamics and physical chemistry of colloids and surfaces, at the Faculty of Chemistry and Chemical Engineering, Babes-Bolyai University of Cluj-Napoca [1-10]. Currently, this school, along with its research team, is known as the Scientific Research Center of Excellence in Physical Chemistry and it is accredited in the UBB, founded in 2006 and led by Director Professor Maria Tomoaia-Cotisel (2006-present).

Professor Emil Chifu was the first Romanian scientist whose original research proposal (1977) "Surface Flow of Liquids in the Absence of Gravity" based on the highest rank scientific results [10], was selected in 1978 by NASA, of the USA, and after being rigorously valued by NASA, it was approved on the 28th of March, 1978, to be experimented on Space Laboratory in the Mission 3 of NASA (***SpaceLab-3***).

This research project [10] proposed by Professor Emil Chifu represents ***the first Romanian cosmic experiment*** approved by the NASA of USA and it refers to two types of space investigations: ♦surface flow between two liquid surfaces joined by surface channels and ♦surface flow on a liquid drop in the absence of gravity; both were planned by NASA to be realized on the first flight of the Drop Dynamics Module (**DDM**) known as **"Chifu's experiment"**. The DDM experiment was scheduled by NASA to be explored on the *SpaceLab-3*.

On the basis of this international research project, a Framework Agreement (FA) was settled between the Romanian Commission for Space Activities (CRAS) and the NASA of USA, as reported by Ioan Ursu, the president of the National Council for Science and Technology (**CNŞT**) in Romania, in the address no. 2460/16th December 1978 to the Ministry of National Education and Instruction.

The preparatory experiments, in the laboratory phases, were performed within the framework of a contract between UBB, Professor Emil Chifu being the project responsible and simultaneously the chair of the physical chemistry department, and the CNŞT for the period of 1977-1980.

The setup model of ***Chifu's experiment*** was performed in the *Jet Propulsion Laboratory* (**JPL**) of the California Institute of Technology, Pasadena, USA in 1981, and it was implemented in 1985 on the DDM in the NASA mission of the SpaceLab-3.

Professor Chifu and his research team studied the dynamics of the "free" liquid drop immersed in another liquid with equal density, in simulated microgravity laboratory conditions in UBB, Romania. Valuable theoretical and experimental results have been advanced by professor Chifu and his coworkers aiming at exploring the **drop dynamics in cosmos**, on SpaceLab-3, in which the microgravity conditions were rigorously satisfied. The investigation of the professor Chifu's proposal in space conditions is **a premiere** in the study of the drop dynamics in imponderability [10-17], because the implied physical and chemical phenomena are of a major interest, both for the science and technology of liquids in the cosmic space and for industrial processes as well as for examination of cell movements and biological membrane movement.

Professor Chifu was awarded (together with his research team) with the prestigious "Gheorghe Spacu" prize by the Romanian Academy in 1983, for the scientific research realized in this international research project with NASA, and for the group of papers entitled "The physical chemistry of interfacial films".

The NASA SpaceLab-3 provides descriptions of the experiments, such as *Module Experiment* **II**: Dynamics of Rotating and Oscillating Free Drops, and **II-I:** Drop dynamics module integrated double rack, to be performed during the SpaceLab-3 NASA Mission in cosmos.

The availability of low gravity environment in the Spacelab-3 flight has provided *the first*

opportunity to perform experiments on the drop dynamics for the rigorous testing of existing theories. The NASA data obtained in cosmos yields very good agreement with theoretical evaluations of scientific research of Professor Chifu, on the dynamics of rotating and oscillating drops [10-17], such as equilibrium shapes of drops, in rotation and oscillation of drops. Additionally, the NASA data revealed new aspects that are not yet identified in the perfect systems made under terrestrial conditions.

Definitely, Professor Emil Chifu is considered as a *major promoter* for his innovative work and impact on the surface flow of liquids and drop dynamics, in the absence of gravity, under the influence of interfacial tension gradients (Marangoni effect and Langmuir-Blodgett superficial layer) on free drop dynamics in cosmos. Therefore, Professor Chifu contributed to the revolutionary work in surface chemistry, as other influential scientists, like Carlo Marangoni, Irving Langmuir and Katharine Burr Blodgett, are also considered major promoters for their innovative work in surface chemistry.

The space experiment of Professor Chifu has started with the *multi-disciplinary frontier research* in the physical chemistry and biophysics of Langmuir and Langmuir-Blodgett layers, described in over 60 published papers, from which we recorded some [10-39].

Further, the results of the scientific investigations in domains such as: thermodynamics of irreversible phenomena, liquid/liquid extraction, studies on nickel carbonyl powders, on sulphurous ores, on the foaming power of detergents have been implemented in the economic sphere on the basis of the research contracts concluded with important mining centers in Deva and Baia Mare, with chemical industries in Victoria, Ploiești, Făgăraș, as well as with the Central for drugs and cosmetics, in Bucharest.

Furthermore, Professor Emil Chifu taught university courses in chemical thermodynamics, colloid chemistry, biophysics of Langmuir and Langmuir- Blodgett layers as model of natural membranes, and the physical chemistry of surfaces and Marangoni effect of surface flow. The scientific rigor of his lectures earned him the respect of many generations of students. He has supervised over **80** bachelor's theses and over **20** specialization papers in physical chemistry. **Seven** doctoral theses were completed and defended under his scientific supervision.

Moreover, Professor Chifu strengthened the collaboration among scientists for accelerating discovery and tackling complex problems by combining diverse talents and expertise, sharing resources, or fostering innovation. A great example is the strong collaboration with Professor Petre T. Frangopol, eminent Romanian scientist, and a brilliant chemical engineer and biophysicist, from *the Institute of Atomic Physics (IFA),* located at Măgurele, established in 1990. An enhanced biophysical characterization of various lipids in Langmuir monolayers, as biological membrane models [32, 34-36], was achieved. The lipid interaction with anesthetic molecules facilitated the understanding of the interfacial mechanism of anesthesia [32, 35];

articles were jointly published in mainstream journals, such as *Biochimica et Biophysica Acta, Gazzetta Chimica Italiana, Chemistry and Physics of Lipids*. Also, Professor Petre T. Frangopol fully supported the recognition of Professor Chifu in the discovery of the dynamics of free drops in cosmos [6-9].

The fruitful collaboration with the famous Professor Peter J. Quinn, from the University of London, King's College, U.K., started in 1981. Professor Quinn a renowned biochemist proposed an international scientific research project, on the research domain of the Ph.D. thesis of Professor Maria Tomoaia-Cotisel, with scientific advisor Professor Emil Chifu, namely on Langmuir monolayers of phospholipids and carotenoids.

This research project became *the first international research project* of UBB with University of London, Kings College, approved by Ministry of National Education, in 1981 with project's Director, Professor Maria Tomoaia-Cotisel for (1981-1990; then, it was extended to 2000). The financial support was given by British Council in U.K., and National Council for Science and Technology (**CNŞT**) in Romania. Many articles were jointly published [24, 27, 29, 33, 34, 36, 39] in prestigious journals: *Chemistry and Physics of Lipids, Biochemical Journal*, *Biochimica et Biophysica Acta, Journal of Colloid and Interface Science.*

Very important in Professor Chifu's biography were the specializations abroad and the contacts with personalities of the international scientific life. Aa a member of various Romanian and International scientific societies, Professor Chifu collaborated with scientists from the prestigious universities, such as University of Paris, Moscow, Florence, Tübingen, Buffalo and Ottawa.

Collaboration allowed for interdisciplinary approaches as scientific knowledge expands, leading to higher-quality results and new research avenues. Furthermore, the collaboration of Professor Chifu was started with Professor David Allan Cadenhead, from State University of New York at Buffalo, United States of America, on relaxation phenomena in apocarotenoid (strong anti-oxidants) monolayers, published in well-known and very important *Langmuir,* journal [31].

Moreover, the collaboration of Professor Chifu with Professor M. Kates and Dr. L.C. Stewart, from University of Ottawa, in Canada, during the 1992 [33] and 1999 [36], conducted to publications - on lipid monolayers at fluid interfaces: published namely in *Chemistry and Physics of Lipids.*

Professor Chifu published many articles in leading (mainstream) journals: *Annali di Chimica* (Rome); Gazzetta Chimica Italiana; Chemistry and Physics of Lipids; Biochemical Journal; Biochimica et Biophysica Acta; Journal of Colloid and Interface Science; Langmuir Journal; Rev. Roum Chim;

Professor Chifu is also cited in many articles in leading journals. He also took part with plenary invited conferences and communications to International Conferences and

workshops in his line of study (in Belgium at the Free University of Brussels, in France at the University of Provence, Marseille). At home, he organized and supervised conferences on Colloidal Chemistry, Physical Chemistry, Chemistry of Membranes and Interfacial Phenomena.

Professor Emil Chifu became Emeritus Professor in 1990 at Babes-Bolyai University of Cluj-Napoca. He published over 160 research articles and 14 academic university books; 4 books were revised and completed posthumously by his collaborators [40-43].

The results of scientific research investigations were based on scientific research grants and contracts. His research team, a true academic school established years ago, is successfully developing and deepening these studies to this day.

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