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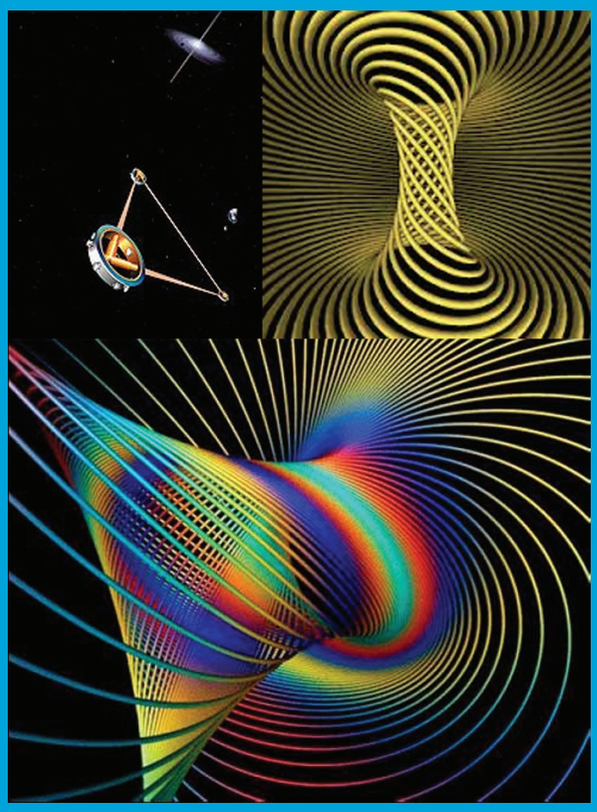
Recent Developments on Physics in Strong Gravitational Fields

V Leopoldo García-Colín Mexican Meeting on Mathematical and Experimental Physics



México City, México
9–13 September 2013

Editors
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BIOGRAPHICAL SKETCH OF DR. LEOPOLDO GARCÍA-COLÍN SCHERER

Leopoldo García-Colín Scherer was born in Mexico city on November 27, 1930. Studied both chemistry and physics at Universidad Nacional Autónoma de México and graduated as Chemist in 1953, and as Physicist in 1954. Subsequently, he obtained a Ph. D. in Physics at the University of Maryland in 1959.

Dr. García-Colín was involved in the creation of several research centres and graduate programs in chemistry and physics in Mexico. In the years 1960 through 1963 he was a founding Professor of Escuela Superior of Physics and Mathematics of the National Polytechnic Institute. During 1964-1967 of the Faculty of Physics at Universidad Autónoma de Puebla. And during the years 1967 through 1984 he participated in the foundation and consolidation of the Faculty of Sciences at UNAM.

Simultaneously, during 1967 to 1974, he created an interdisciplinary research group as Director of Basic Processes Research at the Mexican Petroleum Institute. This group included salient young chemists, physicists, and chemical engineers. Subsequently, in 1974, Dr. García-Colín was founder and Director of the Physics and Chemistry Department at Universidad Autónoma Metropolitana in Iztapalapa, Mexico City. He would work for the rest of his life in this institution, and indeed, in 2006 he became Emeritus Professor at Universidad Autónoma Metropolitana.

His professional interests centered in the areas of statistical physics and thermodynamics, and their applications in astrophysics and cosmology, hydrodynamics, superfluidity and vitrous transitions. Dr. García-Colín published around 250 papers of original scientific research, 65 educational articles, and wrote more than 17 books in these topics. With this trajectory, in 1988 he was named Investigador Nacional (that is, National Researcher), and in 2003, he was named Investigador Nacional de Excelencia.

Dr. García-Colín was a Member, VicePresident, and President of the Mexican Society of Physics. He was also a Member of the American Physical Society, the American Association for Physics Teachers, the Mexican Academy of Sciences, and the Mexican Chemical Society.

He received numerous distinctions and awards. Among them, the Prize of Physics given by the University of Maryland to their best graduate students, the Award for Young Scientists given by the Mexican Academy of Sciences in 1965, and the Medal for Excellence given by the University of Puebla, also in 1965. He was invited as van der Waals Distinguished Professor at the University of Amsterdam in 1976, and in 1988 he received el Premio Nacional de Ciencias y Artes (that is, the Presidential Medal for Sciences and Arts).

Dr. García-Colín received several Honorary degrees, among them, Universidad Nacional Autónoma de México named him doctor Honoris Causa in September 2006. Dr. Leopoldo García-Colín became a Member of El Colegio Nacional (highest distinction in Mexico) on September 12, 1977. His inaugural conference, which dealt on gas-liquid transitions, was responded by his life-long mentor Dr. Marcos Moshinsky.

Dr. Leopoldo García-Colín Scherer passed away in Mexico city on October 8, 2012. His absence will always be felt, his example will always motivate us.

Eusebio Juaristi

BIOGRAPHICAL SKETCH OF CLAUS LÄMMERZAHL

Prof. Dr. Claus Lämmerzahl was born in 1956 in Engen in the south of Germany. After leaving high school he started to study physics at the University of Konstanz. From the very beginning he specialized to Theoretical Physics and, in particular, to Gravitational Physics. In 1982, under the supervision of Prof. Dr. Jürgen Audretsch, he made his Diploma thesis about Spinorial Quantum Interferometry in curved space-time. In 1989, still at Konstanz, he made his PhD on an Axiomatic approach to space-time geometry using elements of quantum mechanics. For his PhD thesis, Prof. Lämmerzahl was awarded the Dornier-price.

After his PhD he stayed in Konstanz. Starting in 1994 he went for almost two years as post-doc to Paris (Laboratoire de Cosmologie et Gravitation, Université Marie et Pierre Curie and to the Laboratoire de Physique des Lasers at the Université de Paris at Villetaneuse) where he worked together with Prof. Dr. Christian Bordé on the atom-laser interaction in gravitational fields. In 2000 he went to the University of Düsseldorf where he was member of the experimental group of Prof. Dr. Stephan Schiller. In this connection it might be worth to say that Claus Lämmerzahl always was in close cooperation with experimentalists and his research always reflected the fact that all theories have to be confirmed by experiments. Claus Lämmerzahl always has been interested in the experimental test of the foundations of fundamental physical theories like quantum theory or General Relativity.

This continued also after he went to the Center of Applied Space Technology and Microgravity (ZARM) of the University of Bremen where he worked together with Prof. Dr. Hansjörg Dittus. In cooperation with Prof. Dittus he, among other things, organised an ESA Topical Team on Fundamental Physics on the International Space Station, proposed a satellite clock mission OPTIS (which changed the name to EGE), initiated the QUANTUS and PRIMUS projects for the experimental and theoretical investigation of Bose Einstein Condensates and atom interferometry under free fall conditions in the Bremen drop tower, and its application to fundamental tests of the Equivalence Principle for quantum matter, for example. Together with Dr. Benny Rievers they also carried through a consistent analysis and explanation of the so-called Pioneer anomaly.

Claus Lämmerzahl and his Fundamental Physics group at ZARM are interested in drawing conclusions regarding general principles of physical theories by earthbound and space experiments. The main focus is on Quantum Theory (e.g. atom interferometry and Bose-Einstein condensates), Special Relativity and General Relativity. Together with Prof. Dr. Jutta Kunz from the University Oldenburg the team has also succeeded in establishing the Research Training

Group "Models of Gravity" which is funded by the German Research Foundation DFG. One research focus is applied General Relativity with contributions to astronomy, positioning, and relativistic geodesy, in strong cooperation with Dr. Eva Hackmann, Dr. Meike List, PD Dr. Volker Perlick, Dr. Norman Gürlebeck and Dr. Dirk Pützfeld. One of his main research areas covers the theoretical modelling of tests of Special and General Relativity. His group together with Dr. Sven Herrmann is also aiming at high precision quantum test of the Equivalence Principle. Claus Lämmerzahl made contributions to the Robertson-Mansouri-Sexl test theory, developed further the standard model extension as dynamical test theory, and recently he discussed Michelson-Morley experiments and Solar system effects in Finsler geometry as an extension of General Relativity complementary to Einstein-Cartan theory. All these theoretical considerations are motivated by the experimental search for effects from Quantum Gravity. Space Technology at ZARM is investigating several topics in the field of system control theory. They are primarily concerned with guidance and control of vehicles in space and the development of control strategies. This will have applications in the French mission MICROSCOPE testing the Equivalence Principle in space with much higher accuracy than what is possible on ground. Claus Lämmerzahl is one of the Principal Investigators of this mission. This technology also can be used in future geodesy missions. The main research area of the micro satellite department is the development of micro satellite concepts for scientific applications. The vision of the micro satellite group is the demonstration of full scale scientific experiments using micro satellite hardware.

Claus Lämmerzahl is chair of the section “Relativity and Gravitation” of the German Physical Society DPG. He is Associate Editor of General Relativity and Gravitation as well as Associate Editor of Advances in Space Research. Moreover, he is speaker of the DFG Research Training Group Models of Gravity, is member of the board for the Graduate School Halostar, and was member of the Steering Committee of the Excellence Cluster Quantum Engineering and Space-Time Research (QUEST). He is also member of the International Society on General Relativity and Gravitation, of the Society for Applied Mathematics and Mechanics (GAMM), of the Olbers Society Bremen, and of the Society of the Friends of the German Aerospace Center (DLR). In 2010 Claus Lämmerzahl became Professor at University of Oldenburg, Germany. Since 2012 he is Director General of ZARM Institute and ZARM Drop Tower Operations and Service Company with more than 100 employees. He is also head of the Space Science Division at ZARM including the departments of Fundamental Physics, Theoretical Physics, Space Technology and Micro Satellites.

In the nineties Claus started his scientific collaboration with Mexican colleagues. Together with them he also has organised several conferences in Mexico, co-edited several books and Festschrifts. Together with Prof. Dr. Alfredo Macías from UAM-Iztapalapa succeeded in establishing various joint German-Mexican projects and DFG-CONACyT cooperations. Claus has supervised some postdoctoral research stays of Mexican students in Bremen. In 2008 Prof. Claus Lämmerzahl became corresponding member of the Mexican Academy of Science.

Alfredo Macías

LEOPOLDO GARCÍA-COLÍN SCHERER: A REMEMBRANCE

This 5th edition of the Leopoldo García-Colín Mexican Meeting on Mathematical and Experimental Physics is very special, because it is the first one without the presence of Leopoldo García-Colín Scherer. Don Leo, or Leo – as we called him with affection – died in Mexico City on October 8, 2012, at the age of 81, almost a year ago; he was born on November 27th, 1930, also in Mexico City. So, before presenting the Leopoldo García-Colín Medal to Professor Claus Laemmerzhal, a distinguished scientist who is the awardee on this occasion, let us take some minutes to briefly highlight the features of the work, accomplishments, and the legacy of the scientist whose name bears the prize to be granted today.

For more than half a century Don Leo was a driving force for Mexican science. His pioneering work in Statistical Physics initiated this area of physics in Mexico, an endeavor that he expanded and consolidated both, nationally and internationally. Throughout his career Don Leo was a valued researcher, since the time he defended his Ph. D. thesis on equilibrium properties of quantum gases at low temperatures, in 1959 at the University of Maryland, with Elliot Montroll as his supervisor. His first scientific publication on the evaluation of the binary distribution function of an imperfect gas, showed his predilection for kinetic theory methods, a tool which he would use extensively in his future research.

He came back to Mexico in 1960 and it was not easy for him to find a position. The interest in "statistical physics" was inexistent. Nevertheless, he got a position as Scientific Advisor in the National Nuclear Energy Commission, and in 1961 he got an academic position in the newly founded School of Physics and Mathematics of the Polytechnic Institute. This was the institution where the first course on statistical physics was given in Mexico. One notable feature of his work in Mexico during this early stages, was that in spite of being a theoretical physicist, he started to combine theoretical and applied physics. Actually, this approach to research appears as early as 1953 in his Bachelor's degree thesis in chemistry, at the National University of Mexico, where he studied the thermodynamic properties of deuterium as part of a project to build an atomic pile. Heavy water was the best moderator, but in 1953 its thermodynamic properties were classified information by the atomic powers of the time, and it was necessary to reproduce them so that they could be used by chemist and chemical engineers.

Don Leo's academic and research activities can be divided into five periods: i) classical kinetic theory (1956-1965), ii) kinetic theory of dense gases (1964-1974), iii) non-equilibrium statistical mechanics (1973-1989), iv) irreversible thermodynamics (1983-1998), v) relativistic irreversible thermodynamics (2000-2012). In his "first hour" period following his Ph. D. degree, he continued studying equilibrium properties of quantum gases using kinetic theory. A glance to his publications of this period shows his interest in calculating "the pair distribution function of a system of Bose hard spheres", or "the grand partition function of a supercooling Fermi system". Several of the articles of this period were the result of collaborations with Jean Peretti and Vittorio Canuto.

In 1966 he moved to the Nuclear Center of Mexico where he used the same strategy of combining basic and applied research. He organized a theoretical and an experimental group. They started to analyze the state of the art in neutron dispersion and to carefully study the specific characteristics of the nuclear reactor, with the purpose of designing a spectrometer to study liquid properties through neutrons spectroscopy. The spectrometer was designed here and parts of it were built by a Japanese company. Gradually it started to work and produce measurements of properties of a variety of liquids. Some results were presented at meetings, but unfortunately, the political interests of the syndicate imposed severe restrictions upon the funding and on the orientation of the scientific research. Finally the groups could no longer operate and disintegrated.

In 1967 Don Leo moved to a new position at the Mexican Petroleum Institute as Sub-Director of Basic Research, but from the scientific point of view he entered into the so called Modern Era of kinetic theory. This was the period of the virial expansion of transport coefficients, the discussion of their density dependence through logarithmic terms, and the controversy of the long time tails of the time correlation functions. Actually, he was always skeptical about their existence; he was not convinced that their existence had been verified experimentally and he thought that they were the result of deficient mathematical methods used to arrive at such conclusions. Nevertheless, from the beginning, Don Leo was at the forefront of many of these new developments of kinetic theory. He was one of the first in obtaining generalizations of the Boltzmann equation for dense gases, which allows to obtain explicit corrections for the transport coefficients for simple gases and multicomponent mixtures. His careful and difficult analysis took into account triple collisions and non-local effects. He also generalized Enskog's equation for mixtures of dense gases and obtained the Chapman-Enskog solution of the generalized Boltzmann equation. With Mel Green, his friend for many years, they arrived at a definition of temperature in the kinetic theory of dense gases. All these topics and many of the new results were of great importance both, scientifically and technologically. Many of these works were pursued with friends like Eddy Cohen, Joel Lebowitz and Jan Sengers, who visited the Mexican Petroleum Institute in those years.

An outstanding feature of his work in this period was again, the use of the same strategy of doing research, as he did in the nuclear reactor, namely, to develop the necessary basic science for specific applications. Through the organization of interdisciplinary seminars, courses, supervising Ph. D. thesis, he started several research groups in kinetic theory, transport theory, chemical kinetics, polymers, applied mathematics, among others, to support the research in refinement of petroleum by identifying and producing a variety of the necessary catalyzers for this industry. This huge research activity in physics and chemistry, produced not only scientists, laboratories and new groups, but also patents and scientific publications in the most prestigious journals. But he always was a very sharp critic of the official policies of the petroleum industry; he always complaint that those policies were inappropriate and did not develop the scientific and technological infrastructure indispensable for the development of the Mexican petroleum industry. He made public his opinions many times and made proposals, he also wrote a book entitled "The reality and the demagogic of the national technology", a book that was vetoed and not published by the government for 10 years. This lack of appropriate official policies and the conflicts of interests about the direction of development of the Petroleum Institute, destroyed the operating conditions of the research groups and many of them disintegrated. In 1974 Leo left the Mexican Petroleum Institute and moved to the public universities.

He worked partial time in the National University of Mexico for 17 years and he started a new research group in statistical physics. He also developed new groups at tha Metropolitan University in Mexico City. In this new environment he developed the third and fourth stages of his academic career. They were entirely devoted to non-equilibrium systems, an area of statistical physics where he made important contributions over the years. He used a variety of approaches at different levels of description, ranging from kinetic theory, projection operators, the generalized Langevin equation, fluctuating hydrodynamics and stochastic processes, to irreversible thermodynamics and chemical kinetics, among others. In collaboration with Mexican scientists he made many outstanding contributions in papers with titles like: "Physical aspects of projection operator's techniques", "Microscopic approach to irreversible thermodynamics", "The Burnett description of shock waves", "On the construction of an extended thermodynamics framework for irreversible processes", "A microscopic derivation of Onsager's reciprocity relations", among others.

Of course, this tremendous effort required an equally demanding and extraordinary activity as a mentor and teacher. He provided inspiration to many students to follow scientific careers. Throughout these years he was able to discover and attract young students and guided them through the vicissitudes of making science in a country where there was no science policy, or scarce research funds. For this purpose he adopted another novel strategy in Mexico: he sent many young Mexican graduated students to elaborate their Ph. D. dissertations with prominent scientists, many of which were his friends. Among them were, Robert Zwanzig, Seyburn de Groot, Nico van Kampen, Peter Mazur, Joel Lebowitz, Eddy Cohen, Radu Balescu, Jan and Anneke Sengers, George Weiss, Pierre de Gennes, Leo Kadanoff, and many others.

In his late years 2000-2012, he succeeded in starting research groups in private universities. His late interest in

relativity and biological systems lead him to form groups to explore some aspects of biological and relativistic systems from the point of view of irreversible thermodynamics and non-equilibrium statistical mechanics. This effort yielded papers with titles like: “Thermal relaxation in DNA”, “Protein unfolding in the glass transition”. “Relativistic kinetic formalism revisited”, “Relativistic magneto-hydrodynamics”, “Rayleigh-Brillouin spectrum in relativistic hydrodynamics”, “On the gravitational instability of a dissipative medium”.

On the whole, he published 253 research articles, wrote 44 books and monographs’, published 74 articles on popularization of science, and was the advisor of 49 Ph. D. dissertations. He was elected to El Colegio Nacional in 1977. He received several Doctor Honoris Causa degrees, from the Iberoamerican University in 1991, the University of Puebla in 1995, and the National University of Mexico in 2007.

Some of the research groups started by Don Leo evolved and matured, and followed different and independent directions of research. Others had a short life and were destroyed or frustrated by conflicting interests existing in government institutions, labor unions, and the ever present lack of sufficient funding to really develop science in this country. Like other pioneers, Don Leo had to renovate and continue this effort of creating research groups over and over again, in spite of the frustration due to bureaucracy and material limitations. To one research group, successful or frustrated, followed another one; to one fruitless effort, followed another renovated effort. This admirable feature of his life strongly suggests the image of Sisyphus, condemned to roll a huge stone up a hill only to have it roll down again on nearing the top. But recalling his attitude and his wonderful legacy, we also have to remember him as a happy Sisyphus, because – as Camus said – the attempt to go to the top is enough to fill out with satisfaction the life of a man.

Rosalío Rodríguez