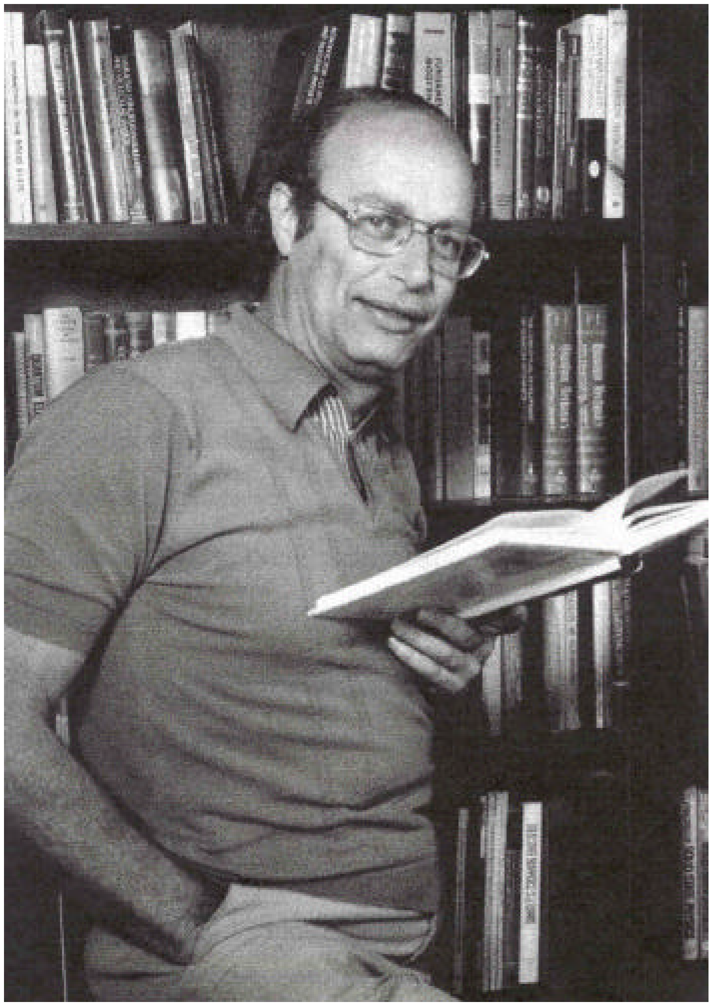

LEOPOLDO MAXIMO FALICOV

June 24, 1933–January 24, 1995

BY MANUEL CARDONA, MARVIN L. COHEN, STEVEN G. LOUIE

Leopoldo (Leo) Máximo Falicov died on January 24, 1995 after a short illness involving cancer of the esophagus. He was a professor of physics at the University of California, Berkeley, and a specialist in the theory of condensed matter physics. He was elected as a member of the National Academy (Section 33) in 1983. He was also a member of the Academia Nacional de Ciencias Exactas, Fisicas y Naturales of Argentina, and the Royal Danish Academy of Sciences and Letters. He was a fellow of the American

Physical Society, Britain's Institute of Physics, and the Third World Academy of Sciences. He received numerous fellowships including the Sloan, Fulbright, and Guggenheim fellowships, and an honorary Doctor of Science degree from the University of Cambridge.

Falicov's early (postdoctoral) work, performed at the University of Cambridge (England, 1958–1960) established and elucidated the complex nature of the electronic band structures of metals (such as magnesium, aluminum, zinc, cadmium, etc.) and the details of their Fermi surfaces [4]. At the University of Chicago (1960–1969), he proposed the existence of magnetic breakdown in metals that possess small energy band gaps and coauthored an important paper on superconductive tunneling [5]. At Berkeley (1969–1995), he was also responsible for a number of "firsts" in theoretical condensed matter physics, including the so-called Falicov-Kimball theory of semiconductor-metal transitions[14], the theory of resonant photoemission [19], resonant Raman scattering [15], and many others. A book on group theory and its applications to solid state physics [11], based on a course he taught at the University of Chicago and now out-of -print, has been a standard textbook to a couple of generations of condensed matter physicists. Falicov's theoretical work was complemented through strong interactions with experimentalists. Because of his talent for spatial visualization, Falicov's theories were often geometrically based and very clearly defined. The intense experimental research on Fermi surfaces of metals and semimetals in the 1960s and 1970s resulted in data which could be viewed as parts of puzzles. Falicov's work on Fermi-surface geometries allowed consistent interpretation of the data and brought the pieces of the puzzles together. Some of his drawings of Fermi surfaces were considered to be works of art, such as the "Falicov-monster" model for magnesium and his "poisoned-turnips" model for arsenic.

These pictures have been reproduced in standard textbooks and on covers of conference proceedings. His great command of geometry and symmetries was reflected in the excellent text he wrote on group theory.

Leo Falicov was born in Buenos Aires, the federal capital of Argentina, in June 24, 1933. His parents were both of Eastern European Jewish origin. His father, Isaías Félix Falicov, was born in Argentina whereas his mother, Dora Samoilovich, emigrated to Argentina with her parents at an early age. It seems that her father left southern Russia to avoid being drafted into the Russo-Japanese war. Those of us who knew Leo for many years were very aware of his Argentinean roots which reflected themselves not only in his speech (both in Spanish and in English) but also in his attitudes and his gentle, mild-mannered temperament.

Leo's parents both studied dental medicine at the University of Buenos Aires where they probably met. While this may sound surprising given their recent immigrant Jewish background, one must keep in mind that Argentina was, at the turn of the twentieth century, one of the world's strongest economies and an immigrant's paradise. Compulsory and free lay public education had been established in the mid-eighteen hundreds by D.F. Sarmiento, the first civilian president of Argentina. The quest for higher education and learning found fertile ground in Argentina at the turn of the twentieth century. However, in spite of the available opportunities, the economic realities of early immigrants compelled Leo's parents to study dentistry, a professional course that was not only one of the shortest in those days but also provided financial independence at an early age. The Falicov-Samoilovich couple also had a son Raúl four years younger than Leo. Raúl studied medicine in Argentina and also emigrated to the United States (Argentina is often mentioned as one of the few countries in the world with a serious brain drain problem). Raúl lived in San Diego until he succumbed to cancer in 1989. Leo's parents also had a daughter, Estela, who was ten years younger than Leo. Estela, a sociologist, now lives in Buenos Aires.

Like most Argentineans, Leo attended public grammar school (in Buenos Aires) and then a highly prestigious public high school, the Colegio Nacional de Buenos Aires. He graduated in all cases with the highest grades and honors. We have attempted, without success, to find out whether any specific person may have exercised a significant influence on his analytical and mathematical abilities and interests. His father seems to have had a general interest in mathematics and, even more so, in games which require considerable intellectual effort, such as bridge. Leo inherited his father’s interests and developed remarkable skills in such pastimes (he won a number of bridge championships). After graduating from the Colegio Nacional de Buenos Aires, Leo entered the state-owned School of Engineering and Natural Sciences at the University of Buenos Aires and remained in his parents' home during the ensuing studies. Like many other adolescents, this must have been a period of considerable soul searching for Leo, in particular concerning his professional interests and future. He hesitated between an engineering and a chemistry curriculum. He remained in Buenos Aires till 1955 when he moved to Bariloche, managing to obtain a *licenciado* degree (something between a bachelor and a master, common in Spanish speaking countries) in Chemistry from Buenos Aires in 1957, after only two years of residence in Bariloche and in spite of the heavy workload there.

We have learned that while a student at the University of Buenos Aires, Leo became a very close friend of two highly gifted young men, Enrique Bonacalza (who was murdered in 1997 near Bariloche) and Edgardo Slemenson. Early in 1955 they must have heard that a new graduate school of physics was about to open in San Carlos de Bariloche, a beautiful spot at the foot of the Patagonian Andes, located in splendid isolation 1800 km away from Buenos Aires, straight line, on the shore of lake Nahuel-Huapi. The new school was to be run by the Argentinean Atomic Energy Commission (CNEA) and not only would tuition be free but the students were all to receive a stipend to cover their living expenses. Correspondingly, admission requirements would be very strict (a policy, unusual in Latin America, that has been kept to the present day). Leo and his friend Bonacalza applied for admission to the new school and had no difficulty passing the entrance examination. They both moved to Bariloche in the spring (our fall) of 1955 and graduated with the *licenciado* degree in Physics in 1958, Leo with the highest honors and as the valedictorian of the first graduating class. Nearly simultaneously, Leo wrote a doctoral dissertation on the Lennuier effect [1], an intriguing phenomenon observed in Paris in 1947 by the doctoral student whose name it bears. The effect, as explained by Leo, involves quantum-mechanical frequency shifts in the resonance fluorescence of atomic vapors (e.g. mercury) at low pressure.

In order to gain perspective about Leo and his career we must now delve into the series of bizarre events that led to the creation of what is now called, after its first director, the Instituto de Física Balseiro, in a rather isolated but extremely beautiful spot of the Argentinean Patagonia. World War II left Argentina, a country rich in foodstuffs and raw materials, in very good financial shape. Its liberal immigration policies had attracted a considerable number of European professionals and intellectuals, among others, fugitives from Franco’s dictatorship in Spain and from the anti-Semitism of other European dictators. They were joined, at the end of the war, by a few more, escaping not only from the justice of the Allies but also from postwar devastation and penury. They gave a welcome boost to the budding Argentinean academic establishment. The physicists among them, however, soon felt the frustration of their isolation, compounded by the ubiquitous secrecy that accompanied the atomic research performed by the nuclear powers. Some of the Argentinean physicists were able to approach President Perón, a populist military dictator, concerning the necessity for Argentina to develop its own nuclear program. In 1948, a young Austrian-German chemist (born in the Czech Sudetenland) by the name of Ronald Richter managed to gain access to Perón and to offer him a scheme to achieve, with rather simple means, controlled nuclear fusion and thus to obtain an inexhaustible source of inexpensive energy. The scientific basis of the scheme, if any, seems to have been the concept of the Boltzmann distribution: among a large ensemble of atoms in thermal equilibrium there are always a few, at the top of the distribution, that possess the energy required to achieve fusion. The scheme falls into the category of what is nowadays called cold fusion. Richter's only credentials were an unpublished Dr. Sc. thesis from the German University in Prague, but Perón was fascinated by the scheme and approved its support without any peer review. Some aeronautical engineers had just succeeded in building for Perón an aircraft factory. His decision to support Richter may have been based on the ensuing belief that any project undertaken by Germans is bound to be successful: after all, the airplanes flew.

After a brief start in his friend's aircraft factory, Richter approached Perón with claims of espionage and sabotage and the need to move his labs to an isolated place protected by the outmost secrecy. After a search by plane of the most remote areas of the country, Richter decided to bring his lab to Isla Huemul, a beautiful 1km^2 island in the middle of lake Nahuel Huapi. Perón agreed and gave Richter full executive powers, as his representative, to run civil and professional life on the Island, and on some adjacent areas around Bariloche, whichever way he would see fit. He moved his lab to Bariloche early in July of 1949, designing labs and "reactors" which led to civil engineering works of Pharaonic proportions. In March 1951, Perón set up a press conference in Buenos Aires at which he and Richter announced what they claimed to be the first observations of controlled fusion at Huemul, details being cloaked in secrecy. The details of the conference, as described in a fascinating book by Mariscotti [Mario A.J. Mariscotti, el Secreto Atomico de Huemul, Estudio Sigma, Buenos Aires, 1996], are strikingly similar to those of the press conference held at the University of Utah in 1980s in order to announce the discovery of cold fusion [Gary Taubes, *Bad Science*, the short life and weird times of cold fusion, Random House, N.Y., 1993]. As in the latter case, the report of Richter's achievement received wide international coverage and serious and concerned study from organizations such as the AEC in the United States which recommended (according to the declassified minutes of a meeting held on July 26, 1951) to grant Prof. Lyman Spitzer (Princeton) $50,000 to perform "research in the area in which Dr. Richter had claimed success".

As in the case of the Utah cold fusion 40 years later, once the initial announcement was made public, demands for details and more visible results grew from day to day. Lack of new results, Richter's mismanagement of engineering contracts, and Peron's rising difficulties with the military forced the President, adamant to admit the possibility of a fiasco for which he would have been responsible, to send a commission to Bariloche to investigate the facts. The few competent physicists available in Argentina were not to his liking, so he appointed as members a priest, a naval officer, two engineers (one of them a Berkeley alumnus) and a young physicist by the name of *José A. Balseiro*, who was doing postdoctoral work in England and was asked to return immediately to

Argentina. The report of the commission was devastating: It recommended immediate closure of Richter's laboratories. After several bizarre incidents, Perón reluctantly agreed to send a landing squad to Huemul and to close the labs. This happened on Nov. 22, 1952, a few months after the dramatic death of Evita. The total cost of the project has been estimated at 300 million of US dollars (today's value). Huemul Island and its buildings became the property of the military and were used occasionally for target practice. They were privatized a few years ago and are now in the hands of a company that offers excellent guided tours of Richter's installations. It will probably never be known whether Richter was a misguided visionary or a fraudulent crook (or a combination thereof).

Mounting political unrest, from the death of Evita till Perón's ouster by the military in 1955, made the pursuit of scientific activities all but impossible, especially in Buenos Aires. Hence, a few visionary academics conceived the idea of setting up an elite school of physics in Bariloche, making use of the abandoned equipment and of the empty buildings on the lakeshore. It was argued that talented young men graduating from this school would be able to prevent the occurrence of a mishap similar to that of Richter. The negotiations with possible sponsors were long and difficult. Finally classes started in the Argentinean spring of 1955, at about the time of Perón's ouster. Leo joined the first entering class. The first director of the new physics school was José A. Balseiro. Bariloche remained indeed insulated from the ensuing political turmoil, as had been hoped by its founding fathers. [A biography of Balseiro, written by two friends of of Leo from his Bariloche days, has recently appeared: A.López Dávalos and N. Baldino, J.A. Balseiro: Crónica de una Ilusión. Fondo de Cultura Económica, Buenos Aires 1999].

Balseiro, a gifted physicist with limited research experience, had already proved, as chairman of the Huemul commission, to be an excellent administrator. He was able to recruit a competent and dedicated faculty, including Spanish mathematicians, German and Austrian physicists, Italians, and some of the best Argentinean scientists at hand. To them Leo owed, by his own admission in the correspondence available to us, a great deal of his theoretical training. He graduated in 1958, having obtained the maximum grade of *Sobresaliente* (Outstanding) in the 39 courses he took (a record number for three years!). He must have attracted Balseiro's attention as the brightest of his students and a relationship of mutual admiration, respect and friendship developed between them. The Instituto Balseiro kindly made available to us copies of six of the long letters written regularly by Leo to Balseiro in the period from Oct.1958 (from Cambridge) until April 1961(from Chicago). They are mostly written in Leo's beautiful handwriting in elegant, flowery Spanish, never forgetting to apologize for the "long silence" since writing his last letter. We also have a copy of one of the answering letters from Balseiro written in June 1961, shortly before his untimely death in March 1962, at the age of 43 (from leukemia). He is buried in a simple grave in front of the Institute's library which now bears the name of Leopoldo M. Falicov.

In his first letters to his mentor, written after his arrival to Cambridge, Leo points out that hardly any courses were offered there whose contents he was not thoroughly familiar with (thanks to Bariloche). As an exception, he mentions Volker Heine's lectures on group theory which no doubt must have been an important source for the book Leo wrote in Chicago [11]. He also describes the many seminars he attended on current research topics and adds: "the rest lacks any interest" (this statement should lead to an exercise in humility when read by faculty members of the famous English university). He mentions, however, being very impressed by the "hands on" attitude of his English classmates who got involved in current research projects in spite of their insufficient background. He adds that they were also very impressed by the depth of his knowledge and the education he had received in Bariloche. This, and some of the letters that followed, expressed his firm desire to return to Bariloche. Later on, he begins to wean himself from his "Alma Mater" and in the last letter, written from Chicago, he is saddened by the fact that "to the *muchachos* who now work in Bariloche I must almost be a stranger".

Leo's rise through the academic ranks from postdoctoral researcher to full professor at the University of Chicago was rapid. His outstanding scientific achievements during this period were matched by his teaching. His lectures were extremely clear and he was accessible to students who were all impressed by his extraordinary handwriting. His blackboards were works of art filled with equations involving Arabic, Greek, and German script lettering together with diagrams that were drawn as if rulers were used.

While on sabbatical leave from Chicago at Cambridge University in 1966, Leo was first approached to consider joining the Berkeley faculty which he did in 1969 as Professor of Physics. He served concurrently as a faculty senior scientist and principal investigator in the Materials Sciences Division of the Lawrence Berkeley National Laboratory. At Berkeley he continued to produce outstanding research and Ph.D. students and was a highly regarded instructor. In addition, Leo attracted outstanding postdoctoral researchers. Many who were from South America and other Spanish speaking countries returned home and greatly influenced the development of physics in their countries.

Leo's international connections were vast. He and his wife, Marta, greatly enjoyed their stays in Denmark. He often traveled to Europe and Asia and served on a large number of external evaluation committees. Leo held visiting positions at more than 20 universities around the world.

At Berkeley, it was quickly realized that Leo's organizational skills, his rapid handling of paperwork, and his ability to make good decisions made him an ideal candidate for committee chairs and faculty administration. When he was chair of the Physics Department (1981–83), he claimed responsibility for hiring nine new faculty and performed his duties with unusual speed. During this period he managed his research group without any decrease in activity. He was almost quantum mechanical—seeming to be in "his chairman's office" and "his own office" at the same time. When he retired in 1994, he was awarded the Berkeley Citation to acknowledge his high level of service to the University.

Leo met his wife, Marta Puebla, on the boat from Buenos Aires to England. She was going to study painting in London, under the auspices of the British Council. On the boat they both met César Milstein, a fellow Argentinean and British Council scholarship holder, who received the Nobel Prize for Medicine in 1984. Leo and Marta were married in August, 1959. There is one short reference to that event in his correspondence with Balseiro: “I have very important private news: Next Thursday, and coinciding with the beginning of vacations at the lab, I am getting married and shall go for a month to get to know the Continent. My (by now no longer so) future wife has spent a year learning painting in London…she is now in Cambridge preparing herself for her change in civil status”. In 1968, Marta gave birth to twin boys, Alexis and Ian. Ian’s difficulties in starting to talk led to the realization that he was hearing and speaking impaired. This handicap received utmost attention from Marta and Leo. Their colleagues and friends were (and still are) most moved by the admirable way they managed this handicap and how they succeeded in communicating with Ian and giving him the same type of education Alexis received, avoiding special schools and colleges. They both attended public schools in Berkeley; any kind of private schools would have meant for Leo and Marta betraying their Argentinean principles of free and lay public education. Both sons attended the University of California at Berkeley, Alexis graduating with a major in physics and Ian in computer science. Ian went on to obtain a master's degree in computer science at UC Santa Cruz while Alexis obtained a Ph.D. in theoretical physics at MIT. However, instead of carrying on Leo’s torch, Alexis then went to medical school at Harvard, graduating as an M.D. in 1999. Both sons are married and have one (Alexis) and two (Ian) children. Alex is an orthopedic surgeon working at several hospitals associated with the University of Washington while Ian works as a computer expert for a private company, Surety, in Reston, Virginia.

The label "Renaissance Man" is overused these days, but it is an apt description of this unusual man who is sorely missed. He was a highly skilled rug weaver, an activity he pursued on old-fashioned looms as a form of relaxation. Leo Falicov's life was rich with art, music, literature, and hobbies. Leo courted his Marta by reciting from Pablo Neruda and Garcia Lorca while sitting by a river in Cambridge, England. He loved the opera, he could recite poetry and quote literature in three languages, he collected art and played the piano. His sense of humor and wry stories made him a favorite dinner companion. He is fondly remembered as a vibrant individual and brilliant scholar from whom his family, friends, colleagues, and students derived love and support.

L.M. Falicov Selected Publications

1. The Theory of Photon Packets and the Lennuier Effect. Il Nuovo Cimento **16**, 247 (1960).

2. Effect of Spin-Orbit Splitting on the Fermi Surface of the Hexagonal Close Packed Metals (with M.H. Cohen), Phys. Rev. Let **5**, 544 (1960).

3. Magnetic Breakdown in Crystals (with M.H. Cohen), Phys. Rev. Lett. **7**, 231 (1961).

4. The Band Structure and Fermi Surface of Magnesium. Phil. Trans. Roy. Soc. London **A255**, 55 (1962).

5. Superconductive Tunneling (with M.H. Cohen and J.C. Phillips), Phys. Rev. Lett. **8**, 316 (1962).

6 Spin-Orbit Coupling in the Band Structure of Magnesium and Other Hexagonal-Close-Packed Metals (with M.H. Cohen), Phys. Rev. **130**, 92 (1963).

7. Experimental and Theoretical Study of Magnetic Breakdown in Magnesium (with M.G. Priestley and G. Weisz), Phys. Rev. **191**, 616 (1963).

8. The Superconductive Energy Gap (with D.H. Douglass, Jr.). *Progress in Low Temperature Physics*, Vol. IV, edited by C.J. Gorter (North Holland Publishing Co., Amsterdam, Netherlands, 1964), p. 97.

9. Magnetoresistance and Magnetic Breakdown (with P. Sievert), Phys. Rev. Lett. **12**, 558 (1964).

10. Fermi Surface of Arsenic (with P.J. Lin), Phys. Rev. **142**, 441 (1966).

11. *Group Theory and its Physical Applications*. University of Chicago Press, Chicago, Illinois, 1966.

12. Magnetic Breakdown in Metals (with R.W. Stark), in *Low Temperature Physics*, Vol. V., edited by C.J. Gorter (North Holland Publishing Co., Amsterdam, Netherlands, 1967), p. 235.

13. Superconductivity and Band Structure from a Single Pseudopotential: Zinc and Cadmium (with P.B. Allen, M.L. Cohen, and R.V. Kasowski), Phys. Rev. Lett. **21**, 1794 (1968).

14. Metal-Insulator Transitions: A Simple Theoretical Model (with R. Ramirez and J.C. Kimball), Phys. Rev. B **2**, 3383 (1970).

15. Resonance Raman Scattering at the Forbidden Yellow Exciton in Cu_2O (with P.Y. Yu, Y.R. Shen, and Y. Petroff), Phys. Rev. Lett. **30**, 283 (1973).

16. Low Temperature Conductivity of Transition-Metal Oxides (with B. Koiller). J. Solid State Chem. **12**, 349 (1975).

17. Model Calculation of the Electronic Structure of a (111) Surface in a Diamond-Structure Solid (with F. Yndurain), J. Phys. C: Solid State Phys. **8**, 147 (1975).

18. New Theory of Binary Alloys with Short-Range Order Properties (with F. Yndurain), Solid State Commun. **17**, 1545 (1975).

19. Resonant Photoemission in Nickel Metal (with C. Guillot, Y. Ballu, J. Paigne, J. Lecante, K.P. Jain, P. Thiry, R. Pinchaux, and Y. Petroff), Phys. Rev. Lett. **39**, 1632 (1977).

20. Acceptor Complexes in Germanium: Systems with Tunneling Hydrogen (with E.E. Haller and B. Joos), Phys. Rev. B **21**, 4729 (1980).

21. Isotope-Induced Symmetry Change in Dynamic Semiconductor Defects (with J.M. Kahn and E.E. Haller), Phys. Rev. Lett. **57**, 2077 (1986).

22. Exactly Soluble Model for Antiphase Boundaries in Binary Ordering Alloys (with D.C. Chrzan), *Phys. Rev. B*, **40**, 8194 (1989).

23. Metastable Charge Density-Wave States in $NbSe_3$ Studied by Magnetotransport(with H-A. Lu, C.G. Slough, R.V. Coleman, and A. Maiti), *Phys. Rev. B* **44**, 6037 (1991).

24. Heavy-Fermion Systems In Magnetic Fields: The Metamagnetic Transition (with J.K. Freericks), *Phys. Rev. B* **46**, 874 (1992).

25. Theory of the Negative Magnetoresistance of Ferromagnetic-Normal Metallic Multilayers (with R.Q. Hood), J. Appl. Phys. **76**, 6595 (1994).