LEOPOLD ERNST HALPERN AND THE
GENERALIZATION OF GENERAL RELATIVITY

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Leopold Ernst Halpern, who was a close associate of both Erwin Schrödinger and Paul
Dirac before making his own mark as a theoretical physicist of the first rank, died in
Tallahassee, Florida on 3 June 2006 after a valiant struggle with cancer. We give an
outline of his life and work, including his progress towards a unified gauge theory of
gravitation and spin.

Keywords: Schrödinger; Dirac; Gravitation; Spin; Unified Theory.

Leopold Ernst Halpern

Leopold was born in 1925 in Vienna, Austria. When Hitler’s armies invaded that
country in 1938, he and his parents managed to get on the last available boat to
British-controlled Palestine, where the family eked out an existence in the desert
near Tel Aviv. Here Leopold attended a public high school, learned Arabic and dis-
covered his love of physics, a development that did not sit well with his parents, who
had left everything behind in Austria and told him, “We cannot afford a scientist!”

He was stubborn as well as idealistic, as shown by a story that he refused to ride
in the armored schoolbus on field trips, insisting instead to be allowed to follow
the bus on his bicycle so that he could mingle freely with the local population.

When the war ended, he returned to Vienna to become a scientist, a decision that
estranged him permanently from his parents, who wanted him to remain behind
with them and enter the family accounting business. In his first years in Austria
he devoted much of his spare time to helping concentration-camp survivors and
returning prisoners of war. Most of his own extended family had been killed in the
Holocaust.

Leopold’s scientific career began in experimental solid-state physics. He com-
pleted his doctorate at the University of Vienna in 1952 with a thesis on mag-
netoresistance in bismuth [1-4] and took up a position at Rensselaer Polytechnic
Institute in Troy, New York as a Fulbright Scholar (1952-3). Growing dissatisfied with purely experimental work, however, he returned to Vienna to teach himself theoretical physics, concentrating on general relativity (a subject not then taught in Austria). His rapidly growing expertise in this field attracted the attention of 1933 Nobel Laureate Erwin Schrödinger, who invited Leopold to join him as an assistant until his own retirement from active research (1956-9). The two worked together on several projects during this period, none of which stamped Leopold more indelibly than the problem of understanding why gravity is so weak. His response to this challenge was to mount a systematic and unprecedented exploration of the frontier between gravitation and the quantum world, looking for ways in which gravity might have some observable quantum effect. This search took him through a succession of research positions at CERN (1959-60), the Institute of Field Physics at the University of North Carolina, Chapel Hill (1960-1), the Niels Bohr Institute in Copenhagen (1962-3), the Institute for Theoretical Physics at the University of Stockholm (1963-6), the Institut Henri Poincaré in Paris (1966-7), the University of Windsor in Canada (1967-70), the Institute of Fundamental Physics in Kyoto (1970), the Université Libre de Bruxelles (1970-3), the International Centre for Theoretical Physics in Trieste (1973) and the Institute for Theoretical Physics at the University of Amsterdam (1973-4). He investigated such ground-breaking topics as the interaction between classical gravitational fields and quantized matter fields, exotic elementary-particle processes (e.g. the transition of a photon into three photons, gravitational radiation of photons, photon pair creation by gravitational radiation), the sources, detection and intensity of gravitational radiation in the Universe, the possibility of stimulated photon-graviton conversion by electromagnetic fields and its corollary, the gravitational laser or “gaser” [5-34]. In each case, he found that the quantum face of gravity retreated behind a veil of secrecy, largely because the desired signal would be drowned out by noise from competing non-gravitational processes. Leopold’s calculations suggested, for instance, that a suitable gaser would need to stretch from the Earth to the Moon or beyond, and that its construction cost would exceed the combined military budgets of both superpowers – though (he wrote in 1987) it is “questionable whether they would agree to invest in that direction to experience the pleasure of intense gravitational radiation before mutual destruction” [91]. Eventually (as he told us in 2004), he concluded that gravity would never reveal itself in this way, and even began to doubt whether it could be quantized at all. The time was ripe for a new approach to the problem of unification.

The spark for this new approach came in 1974 when Leopold received an offer to take up a position at Florida State University in Tallahassee with the other winner of the 1933 Nobel Prize in physics, Paul Adrien Maurice Dirac. Dirac was to exert an influence on Leopold’s career as strong as that of Schrödinger. Within one year he turned away from the frontier between general relativity and quantum theory, and instead began constructing a new gauge theory of gravitation from scratch: one that would reduce to Einstein’s theory in the appropriate limits, but would also provide
a geometrical basis for quantum phenomena such as particle spin. The inspiration for this theory came from Dirac’s demonstration that the equation of motion for spinning particles (the famous Dirac equation) could be expressed in the language of group theory (specifically, in terms of the generators of the de Sitter group). This demonstration suggested to Leopold a way to generalize general relativity by building spin explicitly into the principle of inertia. Paraphrasing Newton, and later Einstein, he summed up his new version of this principle as follows: “A particle — structureless or spinning — moves along the projection of an orbit of the de Sitter group on the de Sitter universe, unless acted on by external forces.” The unified theory of spin and gravitation that grew out of this idea would occupy him for the rest of his career [35-87]. It would take us too far afield to review this work in detail, but we note for interested readers that Leopold expressed the view in early 2006 that the best exposition of his theory was to be found in Ref. 82. Nearly all this research was carried out in Tallahassee, with the exception of visiting positions at the Stanford Linear Accelerator Center in California (1978) and the Universities of Amsterdam (1983) and Stockholm (1985). The potential significance of Leopold’s ideas can be judged by a story from the 1980s, when his visa expired and he received a letter from U.S. immigration authorities warning of possible deportation. A friend who heard of this reported the situation to Nobel Laureate Eugene Wigner, who immediately telephoned the President of the U.S.A. and informed him that unless Leopold received permission to stay in the country, “national science will be set back for years.” Leopold received word that his papers were on the way within hours from the head of the Immigration and Naturalization Service himself.

When asked in 2005 whether his theory had given him any “happiest moments” akin to Einstein’s realization that he could explain the perihelion shift of Mercury, Leopold answered that it had. The greatest of these was the realization that the mathematics of the theory required both “inner” and “outer manifestations” of dynamical variables — i.e., it naturally accounted for both spin and angular momentum (technically, these arise from the existence of left and right invariant vectors of the de Sitter group). A close second was the discovery that the field equations of the theory, when expressed in the form of Einstein’s gravitational field equations (with extra terms), demanded the presence of a positive cosmological constant — i.e., vacuum energy. Leopold regarded the observational detection of dark energy by supernova observers in 1998 as important support for his ideas. He also felt that his theory came closer than Einstein’s to embodying Mach’s principle, in the sense that one could eliminate “sourceless” gravitational fields, because his theory supplied additional source terms in the form of spin currents associated with a Yang-Mills-type gauge field [86]. Finally, influenced by Schrödinger as well as Einstein, Leopold hoped that his theory would enable one to exclude the singular solutions that plague general relativity [87].

After Dirac’s death in 1984, Leopold moved to the Jet Propulsion Laboratory in Pasadena (1986-8), and then back to the Florida State University in Tallahassee, where he remained until 2004. These years brought him into closer contact with the
experimental gravitation community, and in particular with a proposal to test general relativity using ultra-precise gyroscopes in low-earth orbit. Known as Gravity Probe B (GPB), this experiment had its origins in discussions between Bob Cannon, William Fairbank, Leonard Schiff and others at Stanford University. (Fig. 1 shows Leopold at the first William Fairbank meeting in Rome, 1990). Leopold joined GPB as a long-term visitor in 2004 and was an active member of its theory group until the time of his death. This period overlapped with the flight of the experiment itself. The data acquired during this mission is now being analyzed, and will soon provide an answer as to whether general relativity correctly predicts the behavior of spinning test bodies in the gravitational field of the spinning Earth. The GPB experiment will likely also provide the best test for decades to come of extended versions of Einstein’s theory like that conceived by Leopold. Unfortunately, the rapid progress of Leopold’s cancer during his last years prevented him from refining his theory to the point where it could produce an unambiguous numerical prediction for the spin-axis precession of a real test body. The fear that he would leave his life’s work incomplete was a source of far greater anguish to Leopold than the prospect of death itself. He continued to wrestle with the details of his theory until his last day. A notepad on the desk in his office at GPB contains a final page of group-theory calculations ending with the question, “How to generalize?”
Leopold’s interests extended far beyond physics. He was the author of fine historical and biographical studies, not only of his mentors Schrödinger and Dirac \[88-98\] but also of his Dutch colleague Siegfried Wouthuysen \[99\] and the Austrian pioneer of radioactivity research, Marietta Blau \[100-104\]. It was the latter work which resulted in Leopold’s nomination to Fellowship in the American Physical Society in 2003.

A passionate environmentalist throughout his life, he was actively engaged locally and globally in preserving the environment and wildlife for future generations. He had a special love for the plains of eastern Africa, where he engaged in such activities as camping beside watering holes for extended periods to monitor the cheetah population. (Nobody knows exactly how many languages he spoke fluently, but they included Swahili.) He fought to preserve the tropical rainforests of Sarawak in Malaysia. In Florida, he became especially attached to the wilderness around the Wakulla river, and introduced many of his colleagues to its wonders. He took pride in his physical condition, and remained active as a swimmer, hiker and climber until his last days. Leopold was a skilled naturopath and traditional healer, becoming the only non-African to be inducted into the African Medicine Man’s Society in honor of the medical care he provided there. He participated in humanitarian projects, such as providing food and medicine to the needy, wherever he lived. Leopold also loved classical music and German poetry, and enjoyed taking part in the activities of the German-speaking community in Tallahassee.

All of these aspects of Leopold’s life can be seen as reflections of his own love of beauty and harmony, and that extends also to his practice as a physicist. In that regard, it is fitting to close with his own words from a tribute to the teacher who influenced him most \[98\]: “Dirac’s greatest impact on me during my ten years associated with him as a physicist came ... from his conviction that a good theory has to be beautiful. This view helped me liberate myself from the bounds of fashion and made me recognize theoretical physics as an art somewhat akin to music, capable of expressing ideas that are only vaguely perceived in the back of one’s mind, with the mathematical techniques as the instruments.”

Acknowledgments

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Note about the References

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