

## WERNER ISRAEL (1931-2022)



Werner Israel, an immense contributor to general relativity and the theory of black holes, died peacefully on May 18, 2022, at age 90. He was surrounded by his loving family, Werner telling stories until his final breath. He is survived by his daughter Pia, son-in-law Ralph, and grand-daughter Allison. Inge, the love of his life, passed away in 2019, and their beloved son Mark died from the consequences of a tragic traffic accident in 2010.

Werner Israel was born in Berlin, Germany on October 4, 1931. The family escaped the Nazi regime in 1936 and settled in Cape Town, South Africa, where they eventually owned a hardware store. Because of the parents' poor health, Werner and his younger brother Peter were placed in an orphanage for a few years. There Werner discovered the wondrous world of astronomy and expanded his education with frequent visits to the public library. Discovering that the mastery of astrophysics required some knowledge of mathematics, he proceeded to educate himself in that topic, mostly by studying textbooks at the beach.

Werner attended the University of Cape Town and earned BSc (1951) and MSc (1954) degrees. His studies were interrupted for a couple of years when his father sadly passed away, and his mother needed help with the hardware store. In 1956 he moved to Ireland with a scholarship, and joined the Dublin Institute for Advanced Studies, where he worked under the supervision of J.L. Synge. The Dublin years were to have a lasting effect on his career and life: Synge's style of research can be seen perpetuated in Werner's own, and in Dublin he met and married Inge Margulies (then named Inge Lee, because her father felt the new name would be more pleasing to the Irish ear), a woman of enormous talent and charm, a writer of plays, short stories and poetry. Inge's life had a remarkable parallel with Werner's: she also was born in Germany, and her family fled to France and then Ireland.

In 1958 Werner accepted a faculty position in the Department of Mathematics at the University of Alberta. The first years in Edmonton were very difficult for him; he was saddled with thirteen hours of lectures per week, six days a week. Somehow he managed to complete his thesis, obtain his PhD from Trinity College, Dublin (1960), and publish some papers during these early years. In 1972 he transferred to the Department of Physics, where he stayed until his retirement in 1996. After retiring, Werner and Inge settled in Victoria, British Columbia. He kept on with his research activities, taking an adjunct professorship at the University of Victoria, where he continued to supervise students and publish papers well into his eighties.

Werner's research world opened up considerably when he was invited (by Ivor Robinson) to attend the first Texas Symposium on Relativistic Astrophysics, held in Dallas in December, 1963. The meeting was prompted by the recent discovery of quasars and the realization that strong gravitational fields were required to explain such massively energetic phenomena. From this time on, Werner dedicated most of his scientific career to the theoretical exploration of what would, in a few years, be called black holes.

Werner made many seminal contributions to our understanding of black holes. In 1966 he formulated a thin-shell formalism [1] and exploited it to devise simple models of complete gravitational collapse to a black hole. This paper, like most of his work, develops an elegant mathematical formalism that is put to

the service of important physics. It has since been used by countless researchers in a multitude of applications.

In 1968 Werner formulated a uniqueness theorem for the Schwarzschild solution [2], the statement that among all static, asymptotically flat spacetimes that are solutions to the Einstein field equations in vacuum, the Schwarzschild spacetime is the only one that possesses a nonsingular event horizon. This powerful theorem, the proof that all nonrotating black holes are spherical and characterized by a single parameter (its mass), took the relativity community by surprise, and placed Werner firmly within its elite group.

In 1976 Werner provided his own derivation of the Hawking effect [3], that a black hole emits a thermal flux of quantum particles with a temperature proportional to the horizon's surface gravity; this effort generalized previous calculations and got to the true essence of the phenomenon. In 1986 he established a third law of black-hole dynamics [4], the statement that no continuous process can reduce the surface gravity of a black hole to zero within a finite time.

While Werner is best known for his varied contributions to black-hole physics, he has published important papers on virtually every subject in general relativity. Among a large number of examples are theories of nonequilibrium thermodynamics [5] and transport phenomena [6], a theory of polarizable media in electrodynamics [7], a theory of superfluidity [8], and a study of cosmic strings [9].

For his achievements Werner received many prestigious awards. In 1972 he was elected Fellow of the Royal Society of Canada, and in 1986 he was elected to the Royal Society of London. In 1981 he received the Medal of Achievement in Physics from the Canadian Association of Physicists. In 1994 he was made Officer of the Order of Canada, and in 1995 he was awarded the very first Medal for Outstanding Achievement in Theoretical and Mathematical Physics by the Canadian Association of Physicists and the Centre de Recherches Mathématiques. He was a founding member of the Cosmology program of the Canadian Institute for Advanced Research.

In spite of his superlative stature in the field of gravitational physics, Werner remained remarkably humble and unassuming throughout his life. In all the commentaries that were received from colleagues and friends following his death, a constant thread is how kind, caring, generous, warm and gentle Werner was in his interactions with others. His delicate sense of humour, often at his own expense, was another trademark. It was on full display when he went on stage wearing a flamboyant wig to embody Albert Einstein, in a moving play on Mileva Marić authored by Inge (who played Mileva). Werner was also known for his great erudition and love of music and movies. He was a fabulous mentor to his graduate students and postdocs, and an extremely effective educator in the classroom.

He is sorely missed.

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