power in 1933. As secretary of the Academy and president of the Kaiser-Wilhelm-Gesellschaft, Planck could not avoid dealing with the government. Convinced at first that the Nazi excesses could not last, and that Hitler's call for national revival and unity had much to be said in its favour, Planck was ready to accommodate to the demands of the new regime. At 75 he would have been relieved to give up the burdens of his offices, but he felt responsible to those who counted on his help and trusted his "immensely noble purity".

Planck's hopes for quick return to civilized behaviour in Germany were quickly dashed when his Jewish colleagues were forced out of their positions and many of them left the country. Still reluctant to make public statements, Planck did not protest against the Academy's offensive response to Einstein's resignation. He went on advising his younger colleagues to have patience and stay at their posts. Nevertheless, it was Planck who went directly to Hitler in May 1933 and tried to convince him that his policies were destroying German science. Hitler would make no distinctions, and became so enraged that Planck could only "fall silent and take my leave". His efforts to salvage what could be salvaged, to block (behind the scenes) the irrational behaviour of his fellow Nobel laureates Philipp Lenard and Johannes Stark, both enthusiastic admirers of Hitler since 1924, did have some positive results. More and more frequently, however, he had to compromise his principles and accept the unacceptable.

During the Second World War, now an octogenarian but free of offices at last, Planck continued his public lectures on science and philosophy, using them as a platform for defending the values of science and civilization and for implicit criticisms of the regime. The disasters of the war, and especially the arrest and execution of his son Erwin for complicity in the 1944 attempt to assassinate Hitler, finally broke Planck's spirit. He died in 1947, just short of his ninetieth birthday.

Heilbron's thoughtful book makes it clear that there were no easy answers to the dilemmas Planck faced. Einstein did not forgive Planck for his public silence in 1933, but he had never lived with Planck's responsibilities. One can speculate on what might have happened if Planck had made a different series of decisions, but speculation is only speculation. Planck acted in accordance with his principles and his conscience, though the world crumbling around him had little place for either. Heilbron writes in his preface that Planck's "life is a lesson", but each reader must decide for himself what that lesson is. □

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Matter of utmost gravity

Joseph H. Taylor

Was Einstein Right? Putting General Relativity to the Test. By Clifford M. Will. *Basic Books: 1986. Pp.253. $18.95.*

In the centenary year of Albert Einstein's birth, 1979, a number of books appeared which described the man and his science, especially general relativity. Seven years later, Clifford Will has added another to the list — a readable volume detailing the renaissance that has taken place in gravitational physics since a few years after Einstein's death in 1955. Writing for a general audience, Will describes (sometimes with first-hand knowledge, and always with flair) developments of the past quarter-century which provide the underpinnings of our understanding of the gravitational interaction in nature and its apparently inextricable connection with the geometry of the Universe.

The 1960s, heyday of radio astronomy, dawn of the space age and beginning of the era of atomic clocks, saw for the first time the development of experimental techniques well suited to the high-precision measurement of tiny differences between the predictions of newtonian gravitation theory, general relativity and other "currently viable alternatives". Will tells us of these developments, taking a topical approach. He starts with the reincarnated "Eötvös experiments" carried out in Princeton and the Soviet Union, which verified the equivalence principle to very high precision. Gravitational red-shift tests are described next, with emphasis on the Pound–Rebka–Snider experiments using gamma rays in the Jefferson Tower at Harvard, and the "flying atomic clocks" experiments carried out by Robert Vessot and others a few years later. Together, these tests showed conclusively that a correct theory of gravity must be a metric theory, embodying the concepts of curved space-time.

Subsequent chapters deal with modern experiments measuring the bending of radio waves by the Sun's gravity, the perihelion shift of Mercury by radar ranging techniques, the slowed propagation of signals in the solar gravitational field, extension of the equivalence principle to include the self-gravitational binding energies of the Earth and Moon, the constancy of the gravitational "constant" G, and the loss of orbital energy in the binary pulsar system by gravitational radiation. Throughout the narrative, Will sprinkles a trail of personalities and anecdotes. Robert Dicke's name appears frequently: first as the author of a 1961 article in *Scientific American* which helped to convert the teenaged Clifford Will from a career in architecture, or maybe genetics, to one in physics; later as quintessential experimenter, and co-author of a theory of gravitation to rival Einstein's; later still as a passenger on an airplane bound for Missoula, Montana, on which he was informed by Kenneth Nordvedt, then a total stranger, that the Brans–Dicke theory appeared to be inconsistent with the equivalence principle for strongly self-gravitating bodies.

Irwin Shapiro's discovery of the gravitational propagation delay for electromagnetic waves makes a good story; it includes an image of Shapiro making an eleventh-hour pitch — via long-distance telephone connection from Cambridge,

Lincoln Laboratory. Reproduced from *Was Einstein Right?*

Radar ranger — the Millstone Hill antenna, northern Massachusetts, used by researchers at the Massachusetts Institute of Technology from 1959 for radar echo observations of the planets.

Massachusetts, to the Jet Propulsion Laboratory in California, complete with locally shown viewgraphs, NASA style — pleading for inclusion of the time-delay experiment on the forthcoming Viking mission to Mars. The story of the discovery of the Hulse–Taylor binary pulsar is here, too, complete with graphical sketches reproduced from Russell Hulse's laboratory notebook and with the correct inference that graduate student Hulse and assistant professor Taylor were thoroughly astonished by the potential implications of what they had found.

Will has succeeded in what he set out to do, namely to write an interesting and accessible account of recent progress in one field of physics. □

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