not poor logic. Bell thought that the conventional ideas about measurement theory, with its 'collapsing' wave packets, were fundamentally flawed, and he was very sympathetic towards ideas for improving the situation, such as the nonlinear collapse theory. Although he readily conceded that the standard theory was fine "for all practical purposes" (which he derided as FAPP), he insisted that measurements had to be described by the equations themselves, and not as something postulated independently.

On the other side of this argument, Kurt Gottfried defends the standard interpretation of the theory, although he cedes many points to Bell's attack. This argument may seem convincing to most working physicists, but Bell would probably have replied with his wonderfully dismissive word: FAPP-TRAP!

Finally, there are three articles by collaborators of Bell on other topics. One of these is a fascinating article by Jon Magne Leinaas on the Unruh effect, as seen in the behaviour of electrons in an accelerator (according to this amazing effect, a particle in an accelerated system 'sees' the transformed vacuum as black-body radiation at a finite temperature.)

The editors have managed to put together a book honouring John Bell written by people who are not only world-class physicists themselves, but who are all people one would refer to as *Menschen* — people of great humanity. This makes the book an especially fitting tribute to a man whose humanity was an intrinsic part of his greatness. ■

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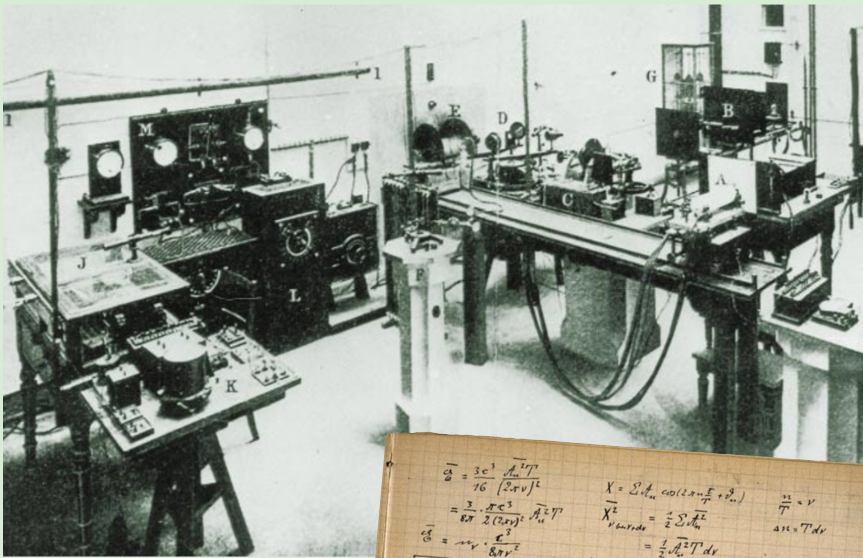
Relics of the quantum century



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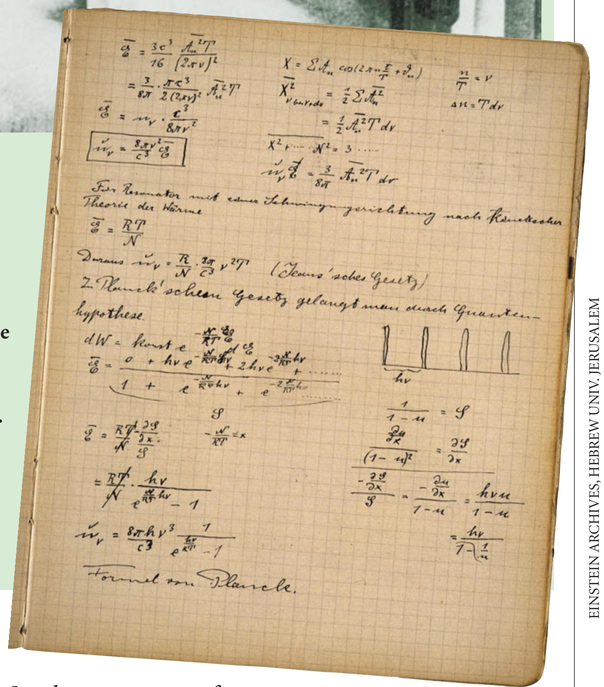

EINSTEIN ARCHIVES, HEBREW UNIV. JERUSALEM

Until 15 February 2001, visitors to Berlin's Staatsbibliothek am Kulturforum can see an exhibition of artefacts connected with quantum physics. These include a reconstruction of Max Planck's laboratory of 1895 (above), where the germ of quantum theory took root, and a page from Einstein's 'Zurich notebook', dating from around 1911. Einstein was trying to convince his colleagues that Planck's law was a break from classical physics. Shrödinger's cat was unavailable for public appearances.

Observing the astronomer

Henry Norris Russell: Dean of American Astronomers
by David H. DeVorkin
Princeton University Press: 2000. 499 pp. £30, $49.50

Dorrit Hoffleit

More than any other American astronomer, Henry Norris Russell (1877–1957) believed that observational astronomy was only of use if it was directed specifically at solving problems concerned with the constitution and evolution of the stars. For, before 1920, so little was known about atomic theory that progress in interpreting stellar spectra was extremely erratic. David DeVorkin has carried out a remarkably thorough search into both Russell's family life and his scientific accomplishments.

Russell's father was a Presbyterian minister, and Henry grew up with strong religious principles. However, when he married Lucy Cole, an Episcopalian, the couple attended the Presbyterian and the Episcopal churches on alternate Sundays. They had four children, three girls and a boy. The two eldest were twin girls, of whom one was seriously handicapped with cerebral palsy. Whenever his wife fell ill, Russell was greatly concerned lest he should be left to look after their small children alone. He himself was always in frail health.

Russell's nervously active mind sometimes led him astray in his ideas about stellar composition and evolution, but his conclusions were always reasonable given the knowledge of the laws of physics at the time. This biography shows how theories once considered logical may later be discredited when newer laws of physics are discovered.

Russell was the most brilliant student under the astronomer Charles Young at Princeton. For his PhD he studied the light curves of Algol-type eclipsing binaries — two stars revolving around one another — as a means of determining the masses of the component stars. Only by using the gravitational effects of the stars on one another could their masses be determined; the masses of single stars could not be worked out.

After he had obtained his PhD, Russell spent some time with Arthur Hinks in Cambridge, England, determining the parallaxes, or distances, of stars. From these and the apparent magnitudes, or relative brightnesses, of the stars, he determined their absolute magnitudes — how bright they would look if all were at the same standard distance. This work confirmed and improved upon the earlier important discovery by the Danish astronomer Ejnar Hertzsprung that stars of the same colour, or spectral class, do not all have the same intrinsic luminosity. From these results Russell developed an attractive theory for the evolution of stars that was accepted for many years. It was finally abandoned when, after more was known about the properties of atoms, it was found that the stars Russell assumed to be the oldest turned out to be the youngest.

Russell was an excellent adviser to graduate students, but he had no great interest in teaching undergraduate astronomy. As

AIP

Top of the heap: Russell was a domineering personality whose "word was law" in US astronomy.

director of the Princeton Observatory, he delegated undergraduate teaching to two able assistants, Raymond Dugan and John Stewart, who also collaborated with him on a revision of Young's manual, *Astronomy*, the first revisions to which were published in 1926–27, and final revisions in 1945.

In 1900 Russell was asked to write monthly articles for *Scientific American*, a task he enjoyed for 42 years. These articles were written with the scientifically minded layperson in mind, but otherwise, Russell paid little attention to popularizing astronomy. In fact, he disapproved of the considerable time Harlow Shapley spent on public education during his directorship of the Harvard Observatory, even though such efforts helped in the necessary fund-raising. Russell also criticized Shapley — his former best graduate student at Princeton — for continuing his predecessor Edward Pickering's "factory" type observational programmes. These programmes were aimed at producing photometric and spectroscopic catalogues, whereas Russell believed observational programmes should be directed at solving specific theoretical problems in astrophysics.

In testing his own theories, Russell was not interested in making telescopic observations himself. Instead, he got permission to examine the collection of spectroscopic plates at the Harvard College Observatory.

US astronomer George Hale had consulted Russell about suitable programmes for the telescopes he built at the Mount Wilson Observatory above the Los Angeles basin. Russell was consequently a welcome visitor at Mount Wilson, and soon persuaded the Princeton administration to give him an annual three months leave of absence to spend there. He also made frequent visits to Harvard. Indeed, Russell seems to have been attempting to direct the research at all three observatories. At Harvard he tried to steer Shapley into concentrating on the fields of astrophysics with which he himself was most concerned. Although Shapley obviously felt that in any controversy over the composition or evolution of stars, his mentor Russell could not be wrong, he still pursued the topics that most interested himself — the structure of the Milky Way and the distributions in space of external galaxies — subjects to which Russell paid little heed.

The first graduate student to obtain a PhD in astronomy at Harvard or Radcliffe was the British woman Cecilia Payne. In her 1925 thesis she correctly identified hydrogen as the most prevalent atom in the stars. Russell objected that her conclusion could not be correct because he had worked out that the composition of the stars, especially that of the Sun, was the same as the more metallic composition of the Earth's crust. Payne was forced to water down her thesis by saying that there must be a mistake in her analysis because her conclusion differed from then prevalent beliefs. She said of Russell: "His word was law. If a piece of work received his imprimatur, it could be published; if not, it must be set aside and its author had a hard row to hoe." In 1929, from an examination of Mount Wilson spectra, Russell himself reached Payne's conclusion about the prevalence of hydrogen. And in 1934, when Russell was considering whom he should be training as his successor on his retirement in 1943, he lamented that the best-qualified person, "alas, is a woman" — meaning Payne.

After Russell's son-in-law, Frank Edmondson, obtained his PhD at Harvard, Russell got him an offer of a research position at the University of Virginia. Edmondson declined, preferring a position at his undergraduate University of Indiana, where he would be in line for the directorship of the observatory. Russell strongly disapproved, stating that administration is anathema to good research. But, like Shapley, Edmondson followed his own inclination, and returned to Indiana.

In his final chapter, "Russell's Universe", DeVorkin comments that Russell "helped transform American astrophysics into a wholly physical discipline. Establishing this framework, more than any one discovery or application that bears his name, is Russell's greatest legacy to astronomy." Yet DeVorkin continues, "much of his work was not really his own, not new ... he typically seized upon the incomplete work of others and tried to confirm or refute it".

This comprehensive biography should be of interest not only to historians of science and students of astronomy, but also to psychologists who might enjoy analysing this brilliant, domineering personality. ■

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