Research Topics

MAX PLANCK INSTITUTE FOR THE HISTORY OF SCIENCE

OCTOBER 2015

The Renewal of Einstein's Theory of Relativity in the Post-War Era

By Alexander Blum

In November 1915, Albert Einstein published his theory of gravitation, thus attaining international renown which was to last unfailingly until the present day, long after his death. The history of his general theory of relativity, however, took a different course. It lost its appeal in the 1920s and did not experience a resurgence until the mid-1950s. Researchers at the Max Planck Institute for the History of Science have traced this surprising development.

In 2015, the general theory of relativity will be 100 years old. In November 2015, Albert Einstein gave weekly lectures to the Prussian Academy of Sciences in which he set out the fundamental field equations of his new theory and explained its application to the precession of the perihelion of Mercury.

Four years later, one of the basic predictions of the theory – the bending of light in the gravitational field of the sun – was impressively confirmed by a solar eclipse expedition on the island of Principe, which was led by Arthur S. Eddington. Einstein became, almost overnight, an international celebrity, and has been regarded as the epitome of the brilliant scientist ever since.

This unparalleled success story is often recounted and has been researched in great detail. Less well known is the subsequent history of the general theory of relativity which – in contrast to its sensational beginnings – took a somewhat surprising turn. Historian of Science Jean Eisenstaedt has shown that after the initial hype, interest in and research into the theory ebbed into a "low-watermark period". This phase lasted from roughly the mid-1920s to the mid-1950s.

The low point was followed by a vigorous resurgence of interest, which physicist Clifford Will describes as the "renaissance" of the general relativity theory: Until then, the theory was used mainly to calculate minute corrections to the predictions of the Newtonian gravitational theory within our solar system. Now it became important for describing distant celestial bodies as well.

Their unexpected properties could be explained with the help of concepts newly derived from the theory: for example, the model of a black hole – an astronomical object with a gravitational field so strong that not even light can escape it.

The general theory of relativity returned to centre stage in the 1960s and 1970s. A half century after Einstein's triumph, researchers who dealt with this theory and with black holes became the new superstars of physics – foremost among them the British physicist Stephen Hawking.

With the aim of studying these historical dynamics, Department I of the Max Planck Institute for the History of Science has established a Working Group in which historians of modern physics and international experts in general relativity and its history are combining their efforts. This work – partly in preparation for a major conference that is to be held on the occasion of the theory's centennial in November (together with the Albert Einstein Institute in Potsdam-Golm) – is currently in full swing, and the project will present first results in the upcoming issue of *Isis* (authors: Alexander Blum, Roberto Lalli, Jürgen Renn).

Figure 1: The image of a distant galaxy is distorted into a so-called Einstein Ring, due to the gravitational lensing effect, first predicted by Einstein himself on the basis of his general theory of relativity; Wikimedia Commons.

These results have already shed light on the above-mentioned decline and subsequent resurgence of general relativity. The changed conditions for the sciences – and specifically physics – after World War II and during the Cold War are of course a major factor. After physicists had demonstrated their importance to national security by building the atomic bomb, a great deal of money flowed into physics research in the post-war years, and the number of young physics graduates surged on an unprecedented scale.

At the same time, technologies developed during the war opened up whole new fields of research. For example, methods developed in radar research to detect radio waves were now used to observe celestial bodies that did not happen to emit radiation in the spectral range perceived by the human eye, giving rise to the field of radio astronomy. In the early 1960s, the new field of study provided proof of distant star-like objects whose properties differ fundamentally from those of our sun: Despite being billions of light-years away, these quasars, as they became known, emit such powerful radiation that they can be detected by radio telescopes. In the context of general relativity, they were soon interpreted as black holes in the making.

However, it was by no means certain that research into general relativity could benefit

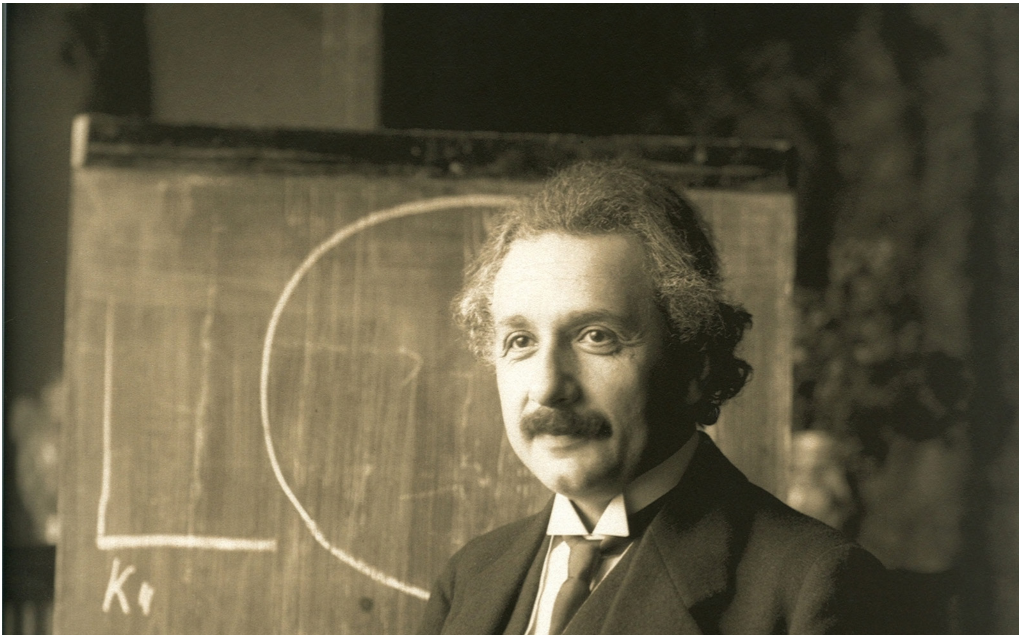

Figure 2: Albert Einstein in Vienna (1921); Wikimedia Commons.

from the boom in physics. Around 1950, general relativity was regarded as a highly esoteric and unproductive field. Nor could it have benefited directly from new astronomical observations, since new theoretical concepts to explain those observations had already been worked out in the late 1950s and early 1960s. In order to benefit from these developments, physicists first had to re-invent the general relativity theory.

During the decades of neglect, the general relativity theory was essentially a field of mathematical and philosophical interest: Remote from concrete physical questions and highly complex in structure, the Einstein field equations provided a fertile field of activity for mathematicians.

At the same time, with its novel concept of curved spacetime, the theory formed the basis for experiments for elaborating a unified theory of the whole of physics or a theory that could explain the development of the universe as a whole (cosmology). However, these early experiments were driven principally by fundamental philosophical questions and had little to do with mainstream physics research.

That all began to change in the 1950s: New mobility made it easier for international scientists to meet who, until that time, were working in relative isolation on peripheral problems of physics relating to general relativity. A key event was a conference in Bern in 1955, which proved to be a starting point for the establishment of an international community of physicists who call themselves "relativists".

The conference was held on the occasion of the 50th anniversary of the special theory of relativity. Of course, Albert Einstein was invited as a guest of honour. His death several months before the conference was taken as a sign by the participants that it was now up to them to continue the Einstein tradition.

To a certain extent, the institutionalisation of this community in subsequent years – through regular conferences, specialist journals and a lively exchange of young scientists between the far-flung centres of this research – followed the model of established subdisciplines of physics, such as nuclear physics. However, in comparison to nuclear physicists, the general relativity and gravitation community had to invent itself from scratch to a much greater extent. For this reason, it was a pioneer in the field of international networking.

In order to create such a community, physicists first had to formulate common questions. In the process, an increased number of physical questions came to the fore. One example is the calculation and possible proof of the existence of gravitational waves; another, the nature of gravitational fields of very dense, massive stars.

Figure 3: This nearly perfect sphere was used in the Gravity Probe B satellite experiment to test the curvature of spacetime near earth, as predicted by the general theory of relativity. Here it is seen refracting an image of that theory's inventor; Wikimedia Commons.

These questions brought relativists in contact with other subdisciplines of physics, as such dense objects could be – and in fact had to be – described using nuclear physics methods. The relativists developed the theoretical concepts which, in the wake of astronomical discoveries in the early 1960s, impressively established the general relativity theory as an empirical physical theory with an unexpected scope of applications – a status that has been consolidated in the intervening 50 years.

Alexander Blum has been a Research Scholar at the MPIWG since May 2010
(ablum@mpiwg-berlin.mpg.de)

The full version of this feature and more research topics are accessible at the Institute's website ("News/Feature Stories").