General relativity in the mathematics department

Research into general relativity has been carried out in the mathematics department almost continuously since 1922. Between then and about 1985, when the theoretical physics research group in the department was changing its emphasis, at least 18 members of the teaching staff worked on general relativity. In that time staff, students, post-docs and visitors made many important contributions of which only a selected few will be outlined here. More information is available in a journal essay which includes a comprehensive account of relativity in the department.

The sixth professor George Jeffery, at King's from 1922 to 1924, initiated research and teaching of general relativity in the mathematics department. His pioneering relativity work included research, a seminal set of translations still in print, and a book based on his lectures to King's students. Later he would make a key contribution to the study of plane gravitational waves, a topic about which there was much subsequent confusion. Relativity was only one of the areas Jeffery studied and this was also the case for George Temple, the eighth professor here from 1932 to 1953. The first member of the department to concentrate almost entirely on cosmology and general relativity was George McVittie, a reader from 1936 to 1948. In cosmology, where his most notable work was done, his studies were noted for their pioneering development of methods for relating theory and observation; many are still used. McVittie's student at Queen Mary College, Clive Kilmister, became an assistant lecturer here in 1950. In 1954 Kilmister, who worked in various areas of applied mathematics, including general relativity, founded, with Geoffrey Stephenson, the London relativity seminar. It ran at King's until about 1980.

The tenth professor, from 1954 until 1971, Hermann Bondi, arrived at King's to replace Temple and formed the first modern general relativity research group in the UK. Early members of the group included Kilmister and Bondi's former student Felix Pirani, appointed to a lectureship in 1955. The group rapidly became a major international centre, attracting as visitors all the major figures in the field. It was one of a small number of groups, world-wide, that revitalized the subject after the second world war. Over the years members of the group investigated many different aspects of general relativity, but probably the two best known ones are gravitational waves, predicted by Albert Einstein in 1916, and classical and quantum aspects of black holes.

In the 1950s and 1960s Bondi, Pirani and other group members removed doubts, held by some leading researchers including Einstein himself, about gravitational waves. They produced ground breaking research on relativity and gravitational radiation. In particular they showed unambiguously that general relativity predicted the existence of gravitational waves and the transfer of energy by gravitational radiation. In addition, Pirani's research is acknowledged to have influenced the construction of gravitational wave detectors. Decades later, on 14 September 2015, the first direct detection of a gravitational wave signal, from the inward spiral and merger of two black holes, was made by the LIGO observatories.

Major discoveries such as those of quasars and pulsars in the late 1950s and the 1960s were accompanied by the development of new theoretical frameworks by people like Roger Penrose and Stephen Hawking. Their work enabled the gravitational collapse of massive bodies, and the formation of black holes and space-time singularities, to be more fruitfully investigated. Penrose was a post-doc in Bondi's group from 1961 to 1963 and made highly

original contributions to radiation theory then. His research at that time was cited when he was one of those awarded the 2020 Nobel prize in physics.

Research related to black holes became the leading feature of work at King's in much of the 1970s. David Robinson, who arrived in 1970, and Paul Davies, here from 1972 until 1980, both came to King's as lecturers. Together with their collaborators and students they made pioneering contributions in this area. The former's work resulted in major advances in the proofs of the uniqueness of the Schwarzschild and Kerr black holes and other equilibrium black hole solutions of Einstein's gravitational field equations. The latter's work included seminal research on the theory of quantum fields propagating in curved background space-times such as black hole space-times.

The 1970s also saw substantial investigations of general relativity and quantization led by Chris Isham, who was a reader from 1973 until 1976. In time research on fundamental physics incorporating gravity came to centre on the study of supersymmetry, string theory, M-theory and related areas.