Gravity and General Relativity at KCL

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1 The study of gravity at KCL

Research on gravity has been carried out at King's since the nineteenth century. James Clerk Maxwell considered, and rejected, an approach to Newtonian gravity similar to his field theory formulation of electromagnetism published in 1865. Subsequently much work was carried out at King's, at various times, on both Newtonian gravity and general relativity. In the twentieth century most of this research was carried out in the Mathematics Department but there was also activity in the Physics Department. This note is a forerunner of an article on the history of research into gravity at King's, from Maxwell until about 1980, which will focus primarily on the work in the Mathematics Department during the period discussed below.

2 Research in the Mathematics Department

Between the 1950's and the 1970's general relativity, the theory of gravitation formulated by Albert Einstein in 1915, was transformed into its modern form. Research carried out in the King's College Mathematics Department during this period made a major contribution to this advance.

At the end of the second world war research in general relativity was at a low ebb. Predicted deviations from Newton's theory of gravity were so small, and difficult to measure, that there was virtually no experimental work being done in the field and it had little contact with the rest of theoretical physics. However by the time Einstein died in 1955 things were changing. The formation of a small number of significant research groups, in Europe and the United States, was taking place, and there would soon be a renaissance of the subject. One of these groups was based in the Mathematics Department of King's College London. At various times throughout the 1920's, 30's and 40's some research on gravitation had been undertaken in the Department by individuals like George Jeffery, George Temple and George McVittie, but Hermann Bondi built a modern research group, the first in the United Kingdom devoted to the study of gravitational physics.

Bondi came to King's from Cambridge in 1954 as the professor of applied mathematics. He quickly brought his former student Felix Pirani over from Dublin. Together with Clive Kilmister, who was already at King's, they formed the nucleus of the new group. Generously supported by the U.S. Air Force's Aerospace Research Laboratories it rapidly became a leading international centre, attracting all the major figures in the field as short or long term visitors. Over the years members of the group investigated many different aspects of general relativity, but probably the two best known ones are gravitational radiation and topics related to black holes.

In 1916 Einstein had predicted the existence of gravitational waves. Subsequently he became uncertain about the physical significance of his results. Surprisingly, doubts about gravitational radiation were still widespread in the 1950's and Bondi was not immune from them. However in the late 1950's and early 1960's Bondi, Pirani, students and visitors at King's made major breakthroughs. These demonstrated, unambiguously, how general relativity predicted the existence of gravitational waves and the transfer of energy by gravitational radiation. Today a number of big experiments are attempting to detect gravitational radiation directly, and to add it to electromagnetic radiation as a tool for investigating the Universe.

During the second half of the 1960's Bondi was increasingly involved in non-University activities such as defence related work, and looking at the need for a London flood barrier. His report on the latter led to the Thames Barrier being sited in its current location. In 1967 he was appointed Director-General of the European Space Research Organization. Although he retained his professorship and connection with the College for many years this appointment marked the beginning of his career as a full-time public servant. By that time major discoveries, such as the microwave background radiation and quasars, followed in 1967 by the observation of pulsars, had broadened interest in general relativity and relativistic astrophysics. Fortunately, new theoretical insights into the global structure of space-time had been emerging. Many were due to Roger Penrose, and later, Stephen Hawking. Penrose was a postdoctoral researcher in the relativity group in the early sixties and even then he was using modern mathematical tools in a highly original way. The new ideas provided a framework within which gravitational radiation, astrophysical dynamics and the gravitational collapse of massive objects to form black holes could be fruitfully investigated. The lively King's relativity seminars, short conferences and post-graduate relativity lectures regularly attracted students, such as Hawking, and researchers from all over the country and abroad.

Research related to black holes was the leading feature of the group's work on general relativity in the 1970's. Paul Davies and I came to King's in the early seventies and worked with collaborators and students to make pioneering contributions to the investigation of classical and quantum aspects of the theory of black holes. Davies' research activities resulted in seminal contributions to the theory of quantum fields propagating in curved background space-times, including black hole space-times. Mine led to major advances in the proofs of the uniqueness of equilibrium black hole solutions of Einstein's gravitational field equations.

As the 1970's progressed it became clear that, although many interesting and difficult problems remained, there was now a good conceptual and technical understanding of the classical theory of general relativity and research interest in quantum gravity increased. Chris Isham came in 1973, and for some years he and his students studied general relativity and quantization in the Department.

Over the years the research focus in the Department shifted and investigations of fundamental physics incorporating gravity now centre on the study of supersymmetry, string theory, M-theory and related areas.