Masters of Theory: Cambridge and the Rise of Mathematical Physics

Andrew Warwick
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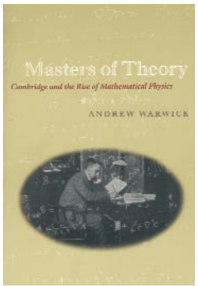
In *Masters of Theory: Cambridge and the Rise of Mathematical Physics*, Andrew Warwick, a senior lecturer in the history of science at Imperial College London, focuses on the development of a community of University of Cambridge mathematical physicists during the 19th and early 20th centuries. Except for two case studies, Warwick's attention in the book is not on research but on the methods of teaching at the university, the kind of mathematics taught, and, through that training, the emergence of a group of researchers united by standards and expectations developed while they were students.



The training at the university was intense. It entailed three years of instruction in mathematical and physical principles, accompanied by practice in using those principles to solve technical problems of growing difficulty as quickly as possible. The prize was the position of First Wrangler in the Cambridge Mathematical Tripos, a grueling examination, held over several days, in which mathematical problems of increasing sophistication were posed. Grading depended on accuracy and the number of questions answered at each stage in the examination. A student's place in the honor role determined reputation and career possibilities. This was a contest of national importance.

This method of training was unique to Cambridge and, as Warwick argues, grew out of the particular social circumstances in the university. It led to a community of researchers who shared common problems, standards, and methods. To put meat on this argument, Warwick investigates the research that emerged from James Maxwell's *Treatise on Electricity and Magnetism*. It took a decade for Cambridge mathematicians to understand Maxwell's physical ideas and mathematics and incorporate them into their teaching and questions for the Tripos examination. By 1900, that research had gone far beyond Maxwell's equations to include work on an electrodynamic foundation for physics. In many ways, the direction paralleled the research done contemporaneously in Europe. The unique training at Cambridge led to a style of research that generated increasingly complex mathematical problems. Yet the physics was not stagnant; the relativity of motion was recognized and explored. In the early 20th century, some researchers saw the ether as doubtful or superfluous.

This nuanced account of the beginning of relativity theory leads Warwick to present a bold new interpretation of the reception of Albert Einstein's papers on relativity. Warwick contends that physicists need to set aside the idea that physics was in crisis or moribund around 1900. Einstein cannot be seen as an isolated genius but as a young theoretician who, in 1905, contributed to the flourishing field of electrodynamics. In Cambridge, reactions to his denial of the ether were negative, not from conservatism but from Einstein's lack of demonstration—experimental or mathematical—of the idea's plausibility. No one saw his arguments on relative motion as extraordinary. It was not until Hermann Minkowski reworked Einstein's ideas in 1909 that the term "theory" of relativity entered physicists' vocabulary.

Einstein's work on general relativity was not appreciated until after 1916 (partly because of World War I) through Willem de Sitter's interpretation. The grounds of the theory and the debate then shifted from electrodynamics to astronomy, a shift that presented Cambridge mathematicians with difficulties. The mathematics of general relativity was not part of the Tripos and, in general, not known to most theoretical physicists. The efforts of astrophysicist Arthur Stanley Eddington significantly changed mathematics and physics at Cambridge. Because of Eddington's report on general relativity and astronomy in 1918, his books on general relativity, and his courses, the mathematics and physics of general relativity entered into Cambridge's curriculum and thus into the Tripos examination.

Teaching was central to the creation of the Cambridge group and, Warwick contends, to any research community, whether local, national, or global. Thus Warwick's work is of interest to physicists and historians. He introduces the sobering example of specialties disappearing, not because they were destroyed by new theories but because no one taught them anymore and their subject matter no longer appeared on examination papers. Teaching creates research fields and is the glue that keeps physics together. A decline in teaching will signal the decline of the discipline and profession itself. It is also a sobering thought, as Warwick points out, that the riches of our common heritage will disappear not through destruction from without but through neglect from within.

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Principles of the Quantum Control of Molecular Processes

Moshe Shapiro and Paul Brumer
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The field of quantum control has a long history. In the early 1970s, it was thought that tunable lasers, those novel coherent light sources, might be able to break molecular bonds selectively and thus enable radically new methods for chemistry. Unfortunately, molecules are remarkably adept at quickly redistributing any applied laser energy among many modes of internal motion, so the laser acts more like a blowtorch than a surgical scalpel on the atomic scale. Mode-selective chemistry was a failure.

But in the mid-1980s, the field began a remarkable revival that continues today. Two different methods were proposed independently at that time to overcome the intramolecular vibrational redistribution problem. Both methods were based on laser-coherence improvements that made it possible for scientists to control optical phase over a broad spectral range. These two control protocols are known in the field by the names of their originators: Paul Brumer and Moshe Shapiro, for the Brumer–Shapiro scheme, and David Tannor and Stuart Rice, for the Tannor–Rice scheme. Together with continued improvements in lasers, optical pulse shaping, and calculation techniques, these two methods have rejuvenated quantum control of molecules to the point where the topic has generated hundreds of papers, dozens of active groups, and several international conferences. Now, Shapiro and Brumer have written a textbook, *Principles of the Quantum Control of Molecular Processes*, that is intended to educate