Enigma variations on the nuclear stage

Copenhagen
A play by Michael Frayn
Performed at the National Theatre, London
Methuen: 1998. 128pp. £6.99 (pbk)

Michael Berry

ROYAL NATIONAL THEATRE/CONRAD BLAKEMORE

Meeting of minds: Burke (left), Kestelman and Marsh succeed in the fusion of science and drama.

In *Copenhagen*, Michael Frayn re-creates one of the more mysterious episodes of the Second World War, when Werner Heisenberg travelled to German-occupied Denmark in 1941 to visit his fellow physicist Niels Bohr. Why did he go there?

Historians — as well as the protagonists themselves, with their faulty and shifting memories — have long puzzled over Heisenberg's motives. Did he seek to enlist Bohr's assistance in developing a German nuclear bomb? Was he pumping Bohr for information about a possible parallel programme by the Allies? Was he alerting Bohr to the existence of the German programme, in the hope that Bohr would provoke the Allies to accelerate their own programme? Was he seeking a reason to delay, or even sabotage, the German nuclear effort? And why did the German programme fail? Was it through rivalry and division of resources between competing teams, or because a crucial neutron diffusion rate was wrongly assumed instead of being calculated?

In the play, these possibilities are explored in detail and with sensitivity, concentrating on the contrapuntal relationship between the two physicists' personalities, their careers, and their scientific styles. Bohr, 16 years Heisenberg's senior, initiated the modern theory of the atom in 1913, with his proposal that the energies of electrons in atoms are restricted by quantum rules similar to those that Planck and Einstein had applied to light. This was not only bold but outrageous, because it had no basis in theoretical physics — indeed, it flatly contradicted the established 'classical' physics of the day.

Twelve astonishing years followed, in which the most intense concentration of scientific effort was devoted to the search for the fundamental quantum theory underlying Bohr's atom. An important centre of that research was Bohr's newly established institute in Copenhagen. He imported a stream of brilliant young physicists, and sought unremittingly to uncover the physical significance of their theories and formalisms. This led him into philosophy, and to his principle of complementarity. His style was slow, tentative, almost inarticulate, repeatedly redrafting his papers in the hope of reaching a version that matched what he was groping for.

Heisenberg, competitive, insecure, barely into his twenties when he went to Copenhagen, was instantaneous in his responses, diamond-hard in the precision of his thought. He occupied himself with mathematical formalism rather than wordy interpretations. It was he who reached the first consistent quantum mechanics: spare, algebraic, a landscape alien to theoretical physicists yet capable of reproducing all the hitherto baffling experimental observations on atoms. Complementing Bohr's complementarity was Heisenberg's uncertainty principle, a precise statement of the limits within which a particle's position and motion can be known.

The structure of the play mirrors these contrasts. Bohr appears mumbling, reflective, but with a simple goodness ("I don't think anyone has yet discovered a way you can use theoretical physics to kill people") and clear moral insight; Heisenberg, swift-tongued but morally ambiguous. The 1941 meeting is repeatedly re-enacted and revisited, echoing Bohr's repeated redraftings, in attempts to get at what really happened. As each dilemma gets focused on, another recedes, vague, into a mist.

Underlying the momentous events that followed the Copenhagen encounter are facts about atomic nuclei, understandable only in terms of quantum physics. Frayn does a splendid job of explaining these subtle and tricky matters, in some detail yet without technicalities. Through the exchanges of the protagonists, we get clear accounts of fission, the production of nuclei, chain reactions (where the play as staged corrects an arithmetic error in the published version), the important distinction between slow and fast neutrons, diffusion rates, and quantum uncertainty and interference.

On a stage bare but for three chairs, our attention is gripped and held by three actors: Bohr, played by David Burke, Heisenberg by Matthew Marsh, and Bohr's wife Margrethe by Sara Kestelman. Margrethe is the chorus, mercilessly exposing Heisenberg's evasions and Bohr's good-natured, even fatherly, indulgence towards his former colleague. Marsh and Burke bring out beautifully the obvious affection between the two very different men, strained to the utmost by the excruciatingly hard times — and not helped by Heisenberg's clumsy invitation to the Bohrs to make use of his ski-hut in Bavaria, apparently forgetting that Bohr was half-Jewish.

With *Copenhagen*, Frayn helps to create a genre, alongside Tom Stoppard, with *Hapgood*, inspired by quantum mechanics, and *Arcadia*, based on chaology, and Mike Maran, with *Surely You're Joking, Mr Feynman*, about that unique and colourful physicist. This acceptance of science as a legitimate subject for dramatization, rather than something separate and technical, is both welcome and overdue. In human culture, as with nuclei, fusion is more powerful than fission but harder to achieve. □

Michael Berry is in the Physics Department, University of Bristol, Bristol BS8 1TL, UK.

Myths that won't die

Frankenstein's Footsteps: Science, Genetics and Popular Culture
by Jon Turney
Yale University Press: 1998. 320pp. £19.95, $30

Roslynn Haynes

"What terrified me will terrify others", wrote Mary Shelley of the nightmare that allegedly provided the inspiration for *Frankenstein*. Nearly two centuries later her words remain uncomfortably prescient. The name of her protagonist and the image of his Monster are ever available as shorthand to evoke the whole package of emotional reactions to perceived hubris — from guilty fascination to fear and