

## The Scientist as Byronic Hero: Michael Frayn's *Copenhagen*

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It is both strange and exciting in a postmodern world to find science and scientists becoming the touchstone of popular culture. There was a time when the movies featured various "mad scientists" such as Dr. Frankenstein, or there were romantic biographies of heroes of science such as Madame Curie or Louis Pasteur journeying to truth, or brilliant servants of progress like Alexander Graham Bell with the popular singer Don Ameche in appropriate period costume. Fifty years ago science was amusing and tolerable; it was far enough in the past or made your milk safer to drink or gave you a telephone. Later there were mad science works in the form of science fiction where in films like *2001, A Space Odyssey* the mad scientist becomes a mad computer. But of late science has become more real, more mainstream as it were. Oh, I know there have been odd instances of the phenomenon in the past such as the WPA Theatre's production of  $E=MC^2$  and the ultimate canonization of St. Einstein, and all that pop romance quality of the NASA program. But now science is truly a metaphor for human life, or—as the playwright Michael Frayn and others are now confounding the two—the state of being human and the scientific method have now become inseparable so that great scientists like great poets can suffer as Byronic heroes trapped in their own human condition.

Not that scientists are entirely enamored with the idea. There is still the ideal of the scientist as passionate puritan, a person so devoted to intellectual ideals and "the truth" that no mere humanist concern could swerve the scientist from his righteous path. While most of my colleagues in the sciences would publicly deny being attracted to such a mantle, it is there for the wearing and that is another issue which Frayn deals with in his play, *Copenhagen*.

*Copenhagen* opened over three years ago in London to enormous critical acclaim and strong audience interest. It premiered on Broadway in April of 2000 to equal critical and audience excitement. When one realizes that Broadway is usually occupied by musicals and light comedies, Frayn's achievement becomes all the more impressive. And when we realize that the subject matter of *Copenhagen* is a visit between two theoretical physicists the achievement is astonishing.

The play is set in September, 1941 when Werner Heisenberg, the articulator of the "uncertainty principle," came to visit his mentor, Neils Bohr, the propagator of the so-called Copenhagen Interpretation. World War Two was in its second year, and the two men were on opposite sides. The meeting was fraught with danger and embarrassment. It ended abruptly, and even to this day there are heated discussions of what actually transpired. Several books and many articles have

considered what might have been discussed.<sup>1</sup> At the center of the debate is the atomic bomb. Heisenberg was working on German projects in atomic fission. Whether he was working on an atomic bomb is not clear even to this day. After the war, in order to save his reputation as a scientist-hero and to put the best face on his relation to the NAZI's, Heisenberg always argued that he had miscalculated the critical mass of U235 needed to construct a bomb. Though never actually saying so, he let stand the assumption that he deliberately miscalculated in order not to provide the bomb to the NAZI's. Some have argued that so great a mathematician could hardly have miscalculated. Others, pointing out the failure of other great physicists, including Neils Bohr, to arrive at a correct calculation, argue that Heisenberg may well be telling it the way it was. Frayn comes now, a half century later, to explore this issue among others.

Like science itself, the play does not allow extraneous matter on the bench. There are only three characters: Heisenberg, Neils Bohr and Bohr's wife, Margrethe. The stage is bare except for three chairs. The play takes place in the present, after all three characters are dead. They return to re-live the events and they re-live them not once but several times, in several different fields as in an Einsteinian universe, and in several forms of relationships between the three as in a quantum universe. What is intriguing is Frayn's manner of structuring the play itself as a model of the famous two-slit experiment or even, since the characters are already dead, as a working example of Shrodinger's famous cat in a lead box.

At the opening Bohr and his wife speculate about why Heisenberg had asked for a visit, and why, after all these many years of being dead, the visit or what was said matters to them. It matters, of course, because of the issue of the scientist as contemporary hero and of the scientist as passionate puritan. Even as they talk, Heisenberg chats with the audience.

. . . there are only two things the world remembers about me. One is the uncertainty principle and the other is my mysterious visit to Neils Bohr in Copenhagen in 1931. Everyone understands uncertainty or thinks he does. No one understands my trip to Copenhagen. Time and again I've explained it. To Bohr himself and Margrethe. To interrogators and intelligence officers, to journalists and historians. The more I've explained it, the deeper the uncertainty has become. Well, I shall be happy to make one more attempt. Now we're all dead and gone . . . so what was Bohr? . . . the father of us all. Modern atomic physics began when Bohr realized that quantum theory applied to matter as well as energy.

Inside the house Bohr chats with his wife.

BOHR: When you think that he first came to work with me in 1924...and in just over a year he had invented quantum mechanics.

MARGRETHE: It came out of his work with you.

BOHR: Another year or so and he'd got uncertainty.

MARGRETHE: And you'd done complementarity.

BOHR: We'd argued them both out together.

HEISENBERG (outside the house). We did most of our best work together.

BOHR: Heisenberg usually led the way.

HEISENBERG: Bohr made sense out of it.

BOHR: We operated like a business.

HEISENBERG. Chairman and managing director.

MARGRETHE: Father and son.

Exposition is taken care of, and it is done so in what I might call a “sub-atomic” manner, in that each of the nuclei on stage is demonstrating an entirely different spin. Nils and Margrethe are dead but spinning in the Denmark of 1941, even though they are disagreeing and thus have antagonistic spins. Heisenberg, on the other hand, is spinning in the universe also inhabited by the audience of the 21<sup>st</sup> century. This is what is exciting about Frayn’s play. First Bohr and his wife list some of the scientific problems he and Heisenberg had worked on together, and then Heisenberg demonstrates the thought process behind “uncertainty” and the “measurement issue.”

HEISENBERG: First of all there is the official visit to Bohr’s work place, The Institute of Theoretical Physics, with an awkward lunch in the old familiar canteen. No chance to talk to Bohr, of course. Is he even present? There’s Rosenthal . . . Peterson, I think . . . Christian Moller, almost certainly. It’s like being in a dream. At the head of the table—is that Bohr? I turn to look, and it’s Bohr, it’s Rosenthal, it’s Moller, it’s whomever I appoint to be there . . .

This is the first wave function of Heisenberg-in-the-ghost-house-of-the-Bohr’s. That wave function collapses and another function follows almost immediately as Heisenberg announces to the audience that he is approaching the Bohr residence.

HEISENBERG: What am I feeling? Fear, certainly—the touch of fear that one always feels for a teacher, an employer, a parent. Much worse, fear about what I have to say. About how to express it. How to broach it in the first place. Worse fears about what will happen if I fail.

MARGRETHE: It's not something to do with the war?

BOHR: Heisenberg is a theoretical physicist. I don't think anyone yet has discovered a way you can use theoretical physics to kill people.

MARGRETHE: It couldn't be something about fission?

BOHR: Fission? Why should he want to talk to me about fission?

MARGRETHE: Because you're working on it.

BOHR: Heisenberg isn't.

MARGRETHE: Isn't he? Everyone else in the world seems to be and you are the acknowledged authority.

BOHR: He hasn't published on fission.

MARGRETHE: But if the Germans were developing some kind of weapon based on nuclear fission—

BOHR: My love, no one is going to develop a weapon based on nuclear fission.

MARGRETHE: But if the Germans were trying to, Heisenberg would be involved.

BOHR: There's no shortage of good German physicists.

MARGRETHE: There's no shortage of good German physicists in America.

BOHR: The Jews have gone obviously.

Then Heisenberg makes his public proposition.

HEISENBERG: I don't suppose you could ever come to Germany?

MARGRETHE: The boy's an idiot.

HEISENBERG: I was simply going to say that I have my old ski hut at Bayrischell. So if by chance . . .

BOHR: Perhaps Margrethe would be kind enough to sew a yellow star on my old ski jacket.

Heisenberg apologizes and the two physicists go on to discuss Germany's lack of cyclotrons, and then Bohr observes that the Germans always turned their backs on theoretical physics because so many of its practitioners were Jewish. Margrethe cautions them to talk about physics, not politics to which Bohr replies:

“The two are sometimes difficult to keep apart.” Enter the first hint of Byronic agony.

As they argue the old camaraderie of colleagues who respect one another and who do not resent an intellectual jab fest begins to emerge. Heisenberg recalls their ski trips. “What about those games of poker in the ski-hut . . . you once cleaned us all out! . . . with a non-existent straight! We’re all mathematicians—we’re all counting the cards—we’re 90% certain he hasn’t got anything. But he goes on raising us. This insane confidence. Until our faith in mathematical probability begins to waiver, and one by one we all throw our cards in.” Bohr laughs and says: “I thought I had a straight. I misread the cards. I bluffed myself.”

Heisenberg is also laughing. “You were insanely competitive.” Bohr observes that Heisenberg engaged in his own competitiveness. Everything Heisenberg did, even skiing down to get provisions became a contest. “You were down in ten minutes of course . . . At the speed you were going you were up against the uncertainty relationship. If you knew where you were when you got down, you didn’t know how fast you’d got there. If you knew how fast you were going, you didn’t know you were down.” “I certainly didn’t stop to think about it,” replies Heisenberg. Bohr quickly retorts: “not to criticize, but that’s what might be criticized about your science.” “I usually got there all the same,” says Heisenberg. Bohr reminds him that “you never cared what you destroyed on the way though. As long as the mathematics worked out you were satisfied.” Heisenberg shrugs. “if something works it works.” “But,” says Bohr, “the question is always, what does the mathematics mean in plain language? What are the philosophical implications?” Heisenberg chuckles. “I always knew you’d be picking your way step-by-step down the slope behind me, digging all the capsized meanings and implications out of the snow.”

MARGRETHE: The faster you ski the sooner you’re across the cracks and crevasses.

HEISENBERG: The faster you ski the better you think.

BOHR: Not to disagree but that is most . . . most interesting.

HEISENBERG: By which you mean it’s nonsense. But it’s not nonsense. Decisions make themselves when you’re coming downhill at 70 kilometers an hour. Suddenly there’s the edge of nothingness in front of you. Swerve left? Swerve right? Or think about it and die. In your head you swerve both ways. . . .

MARGRETHE: Like that particle . . . the one you said goes through two slits at the same time . . . Or Schroedinger’s wretched cat.

HEISENBERG: That’s alive and dead at the same time.

Until the experiment is over, this is the point, until the sealed

chamber is open, the abyss detoured; and it turns out the particle  
has met itself again, the cat's dead.

MARGRETHE: And you're alive.

HEISENBERG: The swerve itself was the decision.

Now we have thoroughly mixed the issues of the scientist as hero, as passionate pilgrim and the scientist as humanist, and Frayn has us hooked. And then finally the scientist-humanist as agonized soul. "I was formed by nature to be a mathematically curious entity," remarks Bohr. "Not one but half of two." To which Heisenberg adds, "Mathematics becomes very odd when you apply it to people. One plus one can add up to so many different sums . . ."

Ah ha, now we will entertain the question of just what Heisenberg is up to—saving his country or like Pasteur saving the "good guys." To save his country he need only remain a "pure scientist," but to save the "good guys" he will have to become a humanist. In which role will he emerge as the scientist-hero? He asks Neils to take a walk with him as they once did when they worked out the Copenhagen Interpretation.

They leave the stage, but quickly they are back. Bohr is obviously upset. Heisenberg leaves, the field dissolves. Neils and Margrethe, once again ghosts, review the problems of the play. Heisenberg re-enters the field.

MARGRETHE: What did Heisenberg tell Neils—what did Neils reply? The person who wanted to know most of all was Heisenberg himself.

BOHR: The conversation went wrong almost as it did before.

MARGRETHE: You couldn't even agree on where you walked that night.

HEISENBERG: Faelled Park, of course. Where we went so often in the old days...I can still see the drift of autumn leaves under the street lamps.

BOHR: Yes because you remember it as October!

MARGRETHE: And it was September.

BOHR: No fallen leaves.

MARGRETHE: And it was 1941. No street lamps.

BOHR: I thought we got no further than my study.

HEISENBERG: We must have been outside! What I was going to say was treasonable. If I'd been overheard, I'd have been executed. I remember it absolutely clearly because my life was at stake. I chose my words very carefully. I simply asked you if as a physicist one had the moral right to work on the practical application of atomic energy. Yes?

BOHR: I don't recall.

HEISENBERG: You don't recall because you immediately became alarmed.

BOHR: I was horrified.

HEISENBERG: . . . and you jumped to the conclusion that I was trying to provide Hitler with nuclear weapons.

BOHR: And you were.

HEISENBERG: No, a reactor . . . to generate electricity, to drive ships!

BOHR: But then I asked you if you actually thought that uranium fission could be used for the construction of weapons.

HEISENBERG: I said that I now knew it could be.

BOHR: That is what really horrified me.

HEISENBERG: If we could build a reactor we could build bombs. That's what brought me to Copenhagen. But none of this could I say. At this point you stopped listening. The bomb had already gone off inside your head . . . Our one chance to talk was gone forever.

The act then ends with another reliving of the 1941 meeting—seemingly as proof that it did happen, but the meeting this time will have other aspects, just as the scientist at his bench repeats his experiment and adds other variables. But unlike science, these variables turn to the humanities for an answer. Heisenberg argues that Germany is his country, and he must help his country. He points out that his love of his country is not unlike Bohr's love of Denmark for whom he aided the Americans to create a bomb. What is right and what is wrong? When does patriotism go too far, when does it become treason? The first act ends with Margrethe's observation: "From these two heads the future will emerge. Which cities will be destroyed, and which will survive. Who will die and who will live. Which world will go down to obliteration and which will triumph."

As the second act begins, we have introduced the variable of the early relationship of Bohr to Heisenberg. This time the German scientist comes to Copenhagen as a graduate student in 1924. Bohr and Heisenberg relive the student-mentor relationship as they go through the discoveries they made together working in Bohr's lab. Suddenly, as it is with a master teacher and his or her best graduate student, they were friends and colleagues. Bohr exclaims, "three years of bracing, northern springtime . . . At the end of which we had uncertainty . . . we had complementarity . . . we had the whole Copenhagen Interpretation." But Heisenberg had his problems. He protests he had trouble understanding matrix calculus. He says that he was betrayed by Bohr, who at one point rejected Schrodinger and wave mechanics and then "turned coat." Bohr went on a skiing vacation and

Heisenberg remained in Copenhagen and perfected the uncertainty principle, which I best understand as the universe is composed of the world of potential and the world of actuality, with the two joined by the act of measurement, so that the measurer and the thing measured form a unified whole in which there is no certainty of boundaries.<sup>2</sup> Now we have the full and complex issue of the play: If Bohr measures or evaluates what a German scientist did it will contain uncertainties, and if the German scientist, Heisenberg, measures what he did, that measurement will contain other uncertainties. Bohr makes this point but it is Margrethe who draws the ultimate conclusion: If it's Heisenberg at the center of the universe then the one bit of the universe he can't see is Heisenberg. . . . So it's no good asking him why he came to Copenhagen in 1941. He doesn't know." Or as David Merman puts it: "The moon really isn't there if you don't look at it"<sup>3</sup>

Margrethe, however, is willing to look at the moon. She points out that the Uncertainty Principle and its Copenhagen Interpretation—that says that all measurement must be seen in the context of the measurement situation (complementarity) and that all measurement is done by a human measurer so that the universe, as far as quantum physics is concerned, is anthropocentric—is entirely humanist in quality. There is no room for a believer in a contextual universe to adhere to universal principles such as those proclaimed the NAZI's. And so much for the concept of the scientist as passionate puritan. The Copenhagen interpretation has returned us to classical Greek humanism, put the human at the center of the universe where man is the measure (and measurer) of all things.

It is at this point that Heisenberg as humanist puts the question: does one as a physicist have the moral right to work on the exploitation of energy? Bohr, still the puritan, is horrified and dashes off into the night, collapsing the wave function for the two. Margrethe sums it up: "That was the last and greatest demand Heisenberg made upon his friendship with you. To be understood when he couldn't understand himself. And that was the last and greatest act of friendship for Heisenberg that you performed in return. To leave him misunderstood."

But there is yet one more reliving, one more *pas de trois* for the trio to perform in an altered field. In this final field Bohr proposes "to see what happens if I do not go flying off into the night."

HEISENBERG: Meanwhile you were going on from Sweden to Los Alamos.

BOHR: To play my small part in the deaths of a hundred thousand people . . . whereas you, my dear Heisenberg, never managed to contribute to the death of a single solitary person in all your life. Heisenberg, I have to say that if people are measured strictly in terms of observable quantities—

HEISENBERG: Then we would have a strange new quantum



ethics. There would be a place in heaven for me and another for the SS man I met on the way home.

Now we have it: a postmodern ethic that confounds science with humanism, that makes of Heisenberg as much a hero of science, albeit something of a Byronic hero, as Bohr. For all things must be understood as complementary, as uncertain even as we evaluate them. Goodbye to the passionate puritan, the scientist as shining hero, and even the “mad scientist”. Hello to the postmodern condition. The moon isn’t there if YOU don’t look at it.

## Notes

1. Quite a body of literature deals with the Heisenberg-Bohr issue. Among the more interesting are: Jeremy Bernstein, *Hitler's Uranium Club, The Secret Recordings at Farm Hall* (Woodbury, New York: American Institute of Physics, 1996); David Cassidy, *The Life and Science of Werner Heisenberg* (New York: Knopf, 1996); Werner Heisenberg, *Physics and Philosophy* (New York: Penguin, 1958); Paul Lawrence Rose, *Heisenberg and the Atomic Bomb Project* (Berkeley: U of California P, 1998). It should be noted here that the Bohr family became concerned about the talk and controversy surrounding the play that they released in early February, 2002, 11 unpublished documents that related to the Bohr-Heisenberg meeting. In an interview in the *New York Times*, February 9, 2002, Michael Frayn discussed the documents, but stated that they were not sufficiently informative enough for him to consider changing anything in his play. Several conferences on the play have been held in Denmark and throughout the world. There is a very popular web site for the play.

2. Several popular studies of late have made the whole issue of quantum mechanics more accessible to the educated non-scientist. Among the more informative are: John Casti, *Paradigms Lost* (New York: Avon Books, 1989); Murray Glen-Mann, *The Quark and The Jaguar* (New York: Freeman, 1994); Brian Green, *The Elegant Universe* (New York: Random House, Inc., 1999); Stephen W. Hawkins, *A Brief History of Time* (New York: Bantam Books, 1988).

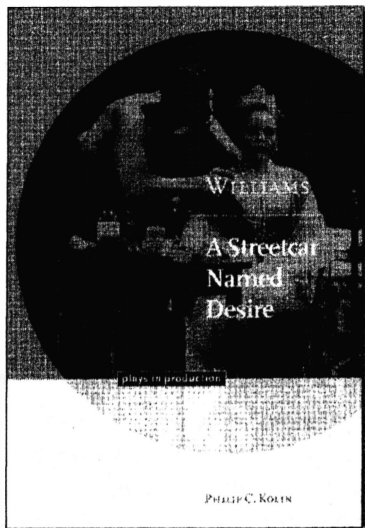
3. David Merman, quoted in John L. Casti, *Paradigms Lost* (New York: Avon Books, 1989) 433.

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### **Table of Contents:**

List of illustrations; General preface; Preface; Acknowledgements; 1. A Streetcar Named Desire—The Broadway premiere and beyond; 2. Streetcar on the world stage: the national premieres, 1948–1953; 3. Streetcar revivals on the English-language stage; 4. Recasting the players: expanding and radicalizing the Streetcar script; 5. Streetcar in other media; Selective production chronology; Notes; Selective bibliography of criticism of Streetcar; Index.

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