10.2478/abcsj-2021-0005

Narrative Quantum Cosmology in Michael Frayn's *Copenhagen*

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Abstract
Twentieth-century drama has made the stage a site for reflecting on science. Michael Frayn's *Copenhagen*, considered by many as one of the most striking contributions to "science plays," portrays the elusive yet crucial short meeting of the two pillars of quantum physics, Niels Bohr and Werner Heisenberg, in the autumn of 1941. The play employs 'real' scientists as characters that recurrently refer to and explain their scientific ideas such as uncertainty and complementarity, recognized as the Copenhagen Interpretation. Adopting the approach of possible worlds theory, this article analyses the concept of 'possible worlds' as projected in *Copenhagen* in light of the idea that physics itself has proposed a proliferation of parallel universes (multiverse). In fact, our main thesis is that the play offers an alternate history and brings about a myriad of counterfactuals that are tested as "drafts."

Keywords: Michael Frayn's *Copenhagen*; possible worlds; quantum cosmology; parallel universes; alternate history; counterfactuals

Introduction: Science and Theater

In his influential article "Two Cultures" (1959), C.P. Snow expresses his discontent over the serious split between "science" and "the arts." "Those in the two cultures," Snow believes, "can't talk to each other," but it is

imperative that they engage in dialogue (16). He anticipates a "third culture" that would "be on speaking terms with the scientific one" (71). In a similar vein, Kirsten Shepherd-Barr points out that "the intersection of science and the stage may represent precisely the kind of "third culture" that Snow envisioned" (45). A surge of plays, such as Caryl Churchill's *A Number* (2002), Brian Friel's *Molly Sweeney* (1994), Tom Stoppard's *Arcadia* (1993), Timberlake Wertenbaker's *After Darwin* (1998) and Michael Frayn's *Copenhagen* (1998), among others, were successful in bridging the gap and unifying the two cultures, that is, in fusing "hard" sciences such as physics, chemistry, biology, with the humanities. Furthermore, in order to separate these works from science fiction, Carl Djerassi employs the term "science-in-fiction" or "science-in-theater" (ix). In other words, this genre is aptly incorporated in the subculture of scientists, since it has scientists as characters and their scientific ideas as the subject matter of science plays.

Another crucial aspect in science plays is, to put it in Shepherd-Barr's words, the "integration of form and content" (5). The setting and structure of the play sometimes mirrors the scientific ideas. For example, in *Hapgood* (1988), Stoppard applies the motion of subatomic particles in quantum mechanics to the way the actors move on the stage. Michael Frayn's *Copenhagen* depicts "the choreography of the actors' movements, apparently meant to evoke the supposed motions of electrons in Bohr's first atomic theory, [which] adds to the theatrical experience" (Holton 36). In a similar way, the staging techniques in Stoppard's *Arcadia* closely reflect tenets of chaos theory, the butterfly effect, in this case.

Frayn's *Copenhagen* has been commonly examined with regard to Niels Bohr and Werner Heisenberg's thought experiments in the Copenhagen Interpretation on the basis of ethical values in the humanities. Some critics objected to Frayn's misrepresenting the historical records. Katrine Antonsen, for instance, has expressed her doubts about what *Copenhagen* achieves: "Is it trying to help us to understand why the real, historical figure Heisenberg went to Copenhagen in 1941 and what he was trying to achieve, or is it using this event to explore more general issues about moral responsibility and its undecidability under certain circumstances?" (123). In line with that and considering many other

nuances, the present article draws on the under-researched area of cognitive narratology and possible worlds theory as applied to drama and elaborates on *Copenhagen* as a physics play dealing with quantum cosmology[i] or many-worlds cosmology. From a historiographical standpoint, Frayn's play offers an alternate history and, with particular emphasis on the epistemic possibilities, puts forth a myriad of counterfactuals that are tested as "drafts."

Parallel Universes and Possible Worlds in Narrative Theory: A Critical Survey

Before proceeding to an overview of parallel universes, the discussion would benefit from a brief overview of quantum mechanics. In quantum mechanics, the physicist grapples with the measurement of the behavior of subatomic particles. These particles, electrons, for instance, do not exist in the same fundamental way ordinary matter exists. Electrons sometimes follow one trajectory, sometimes another. In other words, they may jump from one position to another and exist in what is called superposition – essentially all possible versions of the particle at once. However, when we actually measure, or observe them, they express only one version of themselves.

The concept of parallel universes, also known as the "many-worlds interpretation in quantum physics," was developed as an alternative explanation to the Copenhagen interpretation of Schrödinger's cat[ii] proposed by Bohr and Heisenberg. In the Copenhagen interpretation, the observer's role is essential. In fact, the observer must open the door of the box to find out about the state of the cat, either dead or alive. Technically, the cat exists in a superposition of states until the door is opened, and it is the act of observation that makes the wave function collapse.

However, in the many-world interpretation advocated by Hugh Everett III, David Deutsch and Max Tegmark, Ryan holds that:

> all possibilities are realized simultaneously, and no collapse of the wave function needs to be postulated, because each observer witnesses only one possibility. In world 1 (or may be merely in consciousness 1), the cat is alive, and the observer sees a live cat; in world 2 (or consciousness 2), the

> cat is dead, and the observer sees a dead cat. Yet the opening of the door has no effect on the cat's state. ("Narrative/Science" 176)

According to this interpretation, the proliferation of possibilities, demarcated by wave function, are not merely possible, but they are "all actual phenomena taking place in different worlds. […] a theory of possible worlds which are all actual" (Ryan, "Parallel Universes" 639-640). This is literally what physicists call decoherence, wherein wave functions, after being split, follow distinct courses not merging or interacting again.

In narratology, the possible worlds theory stands as a counterpart of parallel universes. The main proponents of the PW approach to narrative are Umberto Eco (1984), Thomas Pavel (1986), Lubomír Doležel (1998), Ruth Ronen (1994), and Marie-Laure Ryan (1991). Umberto Eco designates the narrative text as a "machine for producing possible worlds" (246); accordingly, new worlds sprout in the narrative universe as long as the characters think, intend to do something, or make a decision. This bears similarity to the many-worlds interpretation of quantum physics in which parallel universes sprout in the multiverse every time a particle produces a wave function (Ryan, "Parallel Universes" 644).

The concept of "possible worlds" primarily stems from Gottfried Wilhelm Leibniz's concern with philosophical logic. Leibniz holds that there are "an infinity of possible worlds […] as thoughts in the mind of God," and among these worlds, only one is the actual world" (333-334). The Leibnizian concept of possible worlds was later utilized as a "convenient tool in building a semantic model for the modal operators of necessity and of possibility" (Ryan, *Possible Worlds* 16). Jaakko Hintikka, Saul Kripke, David Lewis, Alvin Plantinga, Nicholas Rescher are only a few names of distinguished analytic philosophers who have resolutely followed the assumption that "our actual world is surrounded by an infinity of other possible worlds" (Bradley and Swartz 2). Accordingly, the actual world is deemed to be the most credible one we inhabit. In the same vein, Saul Kripke proposes one of the most influential models, that is M-model or model structure in his 1963 "Semantical Considerations on Modal Logic." Pavel illustrates the model as follows:

> A model structure in Saul Kripke's sense is a logical construction consisting of a set K of elements, a well-designated member G of this set, and a relation R between the elements of the set. Under an interpretation influenced by Leibniz's notion of possible worlds, the set K may be viewed as a set of possible worlds, the privileged member G as the real world, and the relation R as the link between various worlds belonging to the system K and their possible alternatives within K. (44)

In this abstract theoretical model, Kripke, who is considered to be a stringent actualist,[iii] assumes that G as the actual world adheres to ontological commitment, but K, the possible worlds, does not follow the same rules; that is, possible worlds are not ontologically distinct. Kripke's notion of possible worlds could be summed up as follows: "A possible world isn't a distant country that we are coming across, or viewing through a telescope […] 'possible worlds' *are stipulated, not discovered* by powerful telescopes" (Pavel 44). In Kripke's view, possible worlds are abstract entities, hypothetical situations and, on the whole, not real, physical and ontologically committed.

Ryan points to two main theories of actuality that may emerge from Kripke's theoretical model. The first one is the absolutist view whose proponent Nicholas Rescher suggests that "the actual world differs in ontological status from merely possible ones in that this world alone presents an autonomous existence" (qtd. in Ryan, *Possible Worlds* 2). In this view, all other worlds are the products of mental activity: dreaming, imagining, foretelling, fearing, promising, or storytelling in fictional sense (qtd. in Ryan, *Possible Worlds* 2). The other interpretation is offered by the influential philosopher David Lewis and his modal realism[iv] that is thought as the most radical and extreme tendency in actualism. In Ruth Ronen's words, possible worlds or "modal possibilities we might stipulate, as well as the actual world, are equally realized in some logical space where they possess a physical existence" (22). Lewis proposes a different perspective when he argues that any possible world can be a concrete entity and is ontologically as well as spatio-temporally committed. Actual world in Lewis' definition is fundamentally premised upon the point of view of the speaker or "where the utterance is located" (qtd. in Ryan, *Possible Worlds*, 18); in other words, it is indexical. Hence, actual world has no privileged status and all the possible worlds are

equally actual from the given point of view, since actual world changes with point of view. However, Lewis here makes a distinction between "real" and "actual" on the grounds that all possible worlds are real in the sense that they exist independently of whether or not a member of actual world imagines them, but only one world can be actual from a given point of view (Ryan, *Possible Worlds* 2).

For Ryan, the indexical notion of actuality is of paramount importance. She maintains that "if fictional worlds were nothing more than nonactual possible worlds located at the periphery of the system of reality, we could not explain how the contrast actual/nonactual repeats itself, recursively, within fictional worlds" ("Parallel Universes" 646). In other words, while reading a narrative text, we need to make a distinction between the hard facts, the possible storyworlds, and what goes on in the minds of the characters. Ryan compares reading fictional universe with Kendall Walton's theory of art as "make-believe." Walton contemplates fictional representations as "continuous with children's game of make-believe," i.e. the pragmatics of pretense (*Possible Worlds* 2). Ryan proposes that "through their act of make-believe, readers, spectators, or players transport themselves in imagination from the world they regard as actual towards an alternative possible world – a virtual reality – which they regard as actual for the duration of their involvement in the text, game, or spectacle." She calls "this projection into a virtual body an imaginative recentering" ("Fictional Worlds" 251). Once the recentering occurs, and the reader becomes immersed and involved in a fictional narrative, everything within the fictional universe[v] (the characters and the world they live in) "momentarily takes the place of the actual world" (Ryan, *Possible Worlds* 21). The reader as a traveler to this "new system of actuality and possibility" explores not only "a new actual world, but a variety of APWs [alternative possible worlds] revolving around it" (Ryan, *Possible Worlds* 22).

Recentering, thus, can be deemed as an epistemological process by which readers imagine and, in part, accept as true that the textual actual world designated by a text does exist; for the extent of their reading, readers "recenter" or deictically "relocate" into that textual actual world (McIntyre 147). The inhabitants of the fictional worlds (universes), in

tandem with the readers, are molding the possible worlds under the aegis of the cognitive activities, and, as a consequence, the inhabitants' actual world is reverberated through their "knowledge and beliefs, corrected in their wishes, replaced by a new reality in their dream and hallucinations" (Ryan, *Possible Worlds* 22). "Through counterfactual thinking," as Ryan continues her argument, "they reflect on how things might have been, through plans and projections they contemplate things that still have a chance to be, and through the act of making up fictional stories they recenter their universe into what is for them a second order, and for us a third order, system of reality" (*Possible Worlds* 22). Ryan refers here to readers' experiencing a variety of APWs, which stand for the satellite worlds that are revolving around the actual world of the fiction and belong to the fictional characters. Overall, any of these APWs may be placed at the center of the textual universe, hence, the world of reference. The APWs are as follows: in the knowledge world or K-world, the reader accesses knowledge, beliefs, and ignorance of the characters within the fictional universe; Obligation world or O-world is a "system of commitment and prohibition defined by social rules and moral principles" on the grounds that there always exists the authorial power (Ryan, *Possible Worlds* 116); in the wish world or W-world, the key word is "desire"; I-world is another private world that gears towards plans and intentions (Ryan, *Possible Worlds* 123); in F-universes, a type of private sphere within the narrative universe, the reader deals with what the characters in the story create within their minds in the TAW such as dreams, hallucinations, fantasies, and fictional stories (Ryan, *Possible Worlds* 119).[vi]

Parallel universes in physics, conversely, are not concerned with the contrast between the actual or the nonactual since within parallel universes "all objects exist in the same ontological mode—mode of actuality" (Ryan, "Parallel Universes" 651). This means that they are not organized based on modal system, nor do they follow up Lewis' notion of indexicalism. In other words, "all probabilities are simultaneously realized in some world" (Ryan, "Parallel Universes" 651). Similarly, from a narratological perspective, modeling a narrative text as a tree with branches as parallel universe, "the branches are kept neatly separate, the

worlds they represent will 'decohere'," and also the characters will not interact with each other as they do in a network (Ryan, "Parallel Universes" 654). However, in the fully integrated "multiverse narrative" or quantum cosmology based on the possible worlds theory, "characters either travel physically from branch to branch or know with certainty that other branches exist objectively. This knowledge affects their behavior and consequently alters the history of their own universe" (Ryan, "Parallel Universes" 656).

One type of the story based on narrative quantum cosmology is alternate- (or counterfactual-) historical narrative. It "creates a world whose evolution, following a certain event, diverges from what we [the readers] regard as actual history" (Ryan, "Parallel Universes" 657). Actually, the narrative text offers some alternative realities or counterfactuals, "what-ifs" in a postmodernist sense, and, in Doležel's words, "postmodern historical fiction generally cultivates ontological experiments in that it freely transforms entities of historical worlds into fictional entities (and vice versa) by playing with the category 'historical fact'" (*Possible Worlds of Fiction* 105).

Copenhagen: Counterfactual Historical Narrative

Copenhagen premiered at the Royal National Theatre in London, in May 1998, and on Broadway at the Royal Theatre in New York, in April 2000. It became a great success in London and received numerous positive reviews from both theater commentators and the wider public. Though containing rather complex ideas related to quantum mechanics, the play has become immensely popular.

Frayn deploys the genre of "forking path narratives"[vii] in dramaturgy that also encompasses ontological pluralism. By the same token, as a distinct type in postmodern poetics, the forking path narrative contests "historical and narrative continuity and closure" (Hutcheon 12). From a cognitive standpoint, *Copenhagen*, in an anti-illusionist fashion, and through its anticlosure or open-ended narrative, provokes the reader to dynamically get involved in the interpretation of the different alternate viewpoints offered by the characters so as to fill in the gaps of historical

records. The counterfactuals or alternate histories projected in the play act as possible worlds, which merge, as Ryan observes: the play "takes interference between its constituent worlds to turn a fiction with a multiverse cosmology into a cohesive narrative" ("Parallel Universes" 655). For the sake of elaboration, Ryan also opts for meta-textualism, a strategy through which the characters do not "lead parallel lives; rather, these lives are different drafts of a novel in progress, different developments that the author is contemplating" ("Parallel Universes" 670). The metafictional comments passed by the characters to break the fictional illusion consolidate this strategy in *Copenhagen*.

One of the inherent properties of counterfactual historical narratives is that they are logically impossible worlds explicitly incommensurate with modern physics – quantum mechanics –wherein nature often appears to be integrated with the logically impossible. Ryan maintains that "texts such as nonsense rhymes, surrealistic poems, the theater of the absurd, or postmodernist fiction may liberate their universe from the principle of noncontradiction" (*Possible Worlds* 32). In the same vein, Ruth Ronen further explains the notion of logical impossibility: "Although logically inconsistent states of affairs are not restricted to specific literary periods or genres, with postmodernism, impossibilities, in the logical sense, have become a central poetic device, which shows that contradictions in themselves do not collapse the coherence of a fictional world" (55).

In *Copenhagen*, Frayn does not describe the setting in the usual sense, nor does he give the reader the extradialogic stage directions. In London and New York, the play was performed in a circular stage, in a Beckettian manner, with three chairs as the only props. Three historical figures, the Danish physicist Niels Bohr, his wife Margrethe Bohr, and the German Physicist Werner Heisenberg in the primary fictional world or the framing story as the central TAW of the play, "lingering like ghosts," come back from the world of the dead, "looking for the answers they never found in life," so as to re-live and reconstruct the autumn of 1941 (Frayn 3). In addition, the play generally operates as a postmodern detective narrative universe that, in this context, following the Uncertainty Principle, fails to satisfy the W-world of the three characters, particularly in the case of Margrethe who aims to resolve an enigmatic ambience

(within T/AW) which "stems from an incomplete K-world with well-defined areas of indeterminacy" (Ryan, *Possible Worlds* 121). Heisenberg, then working for Hitler's war effort and under Gestapo surveillance, visits the Bohrs in the Nazi-occupied Copenhagen. Talking in private and more freely, Heisenberg and Bohr go for a walk but return soon, with Bohr in a state of anger, and Heisenberg leaving abruptly, hence, the complete dissolution of their friendship. In other words, what the three characters strive to come up with is that not only "the past becomes the present inside [their] head[s]" as memories, but also, they enact that specific event physically. Nicholas Ruddick believes that the three characters "have the ontological status of revenants, though they dress realistically and behave onstage as if they were still alive" (130). Actually, the characters are both alive and dead simultaneously in violation of the principles of non-contradiction and the excluded middle, hence the boundaries between the real and the unreal are transgressed.

In *Copenhagen*, by means of summoning these ghosts and by perpetually restaging the history (Ruddick 132), Frayn seeks to find answers for the vexed questions posed concerning the private talk between Bohr and Heisenberg. Each time a question arises, another draft is presented and a new possible world is generated along with it, which makes it difficult for the audience to distinguish between history and fiction. In point of fact, by the title of the play, Frayn does not refer directly to a real city in historical time and space, but "alludes to the more abstract concern: to offer an interpretation of what happened in Copenhagen in 1941 from a perspective that has been determined—or made indeterminate—by the Copenhagen Interpretation" (Ruddick 130). In other words, Frayn "incarnates" Heisenberg's Uncertainty Principle as a fictional representation in a metaphoric way. In the same manner, Victoria Stewart contends that "Frayn's use of Heisenberg's principle of uncertainty ultimately reveals that this plurality of possibilities has to replace any search for a definitive answer" (302). Considering Ryan's strategy of virtualization, such possible worlds are speculations and it would be worthwhile to seek for the reasons as alternative realities so as to fill in the gap of an indeterminate T/AW. There is a scarcity of historical records linked with the event. Given the failure of the German

atomic research program in advancing an atomic bomb for Hitler, the meeting might have led to some blurred consequences of World War II (non/actualized possible worlds), whether this failure was due to the conflicts of the O-world, that is the moral responsibilities of the scientists who held that to be armed with such a weapon was ethically intolerable or the failure was merely due to scientific deficiencies.

Copenhagen is clearly indebted to the Brechtian technique to create the alienation effect. All the three characters "resemble actors in rehearsal trying to get inside their roles" (King 151). When the reader immerses in the play, s/he perceives the physicists on stage as if they were real-life individuals and not represented characters embodied by actors. In fact, Heisenberg, at the beginning of the play and in an anti-illusionist and self-referential manner, informs the audience that he has tried hard to explain to many, "to interrogators and intelligence officers, to journalists and historians," what exactly occurred in Copenhagen in 1941, but to no avail, that he hopes that his "one more attempt," this time on stage, would put an end to uncertainties (Frayn 4). During the conversation between Bohr and Margrethe, Heisenberg continues to provide a general background prior to that specific day in 1941. Sometimes his monologue is interwoven with Bohr and his wife's talk; at the beginning of one such monologue, Heisenberg's K-world not only conflicts with historical facts but also challenges Margrethe's K-world. Heisenberg's memory in this scene does not prove reliable, but Margrethe intervenes to correct him:

> **Heisenberg** September, 1941. For years I had it down in my memory as October.
> **Margrethe** September. The end of September.
> **Bohr** A curious sort of diary memory is.
> **Heisenberg** You open the pages, and all the neat headings and tidy jottings dissolve around you. (6)

Elsewhere, before they formally meet each other, they answer each other's questions on stage. This time the conflict arises between Margrethe and Bohr's K-worlds as Margrethe thinks it is better that Bohr and Heisenberg talk privately; however, Bohr claims he has "nothing to hide":

> **Margrethe** You could go for another of your walks together.

> **Heisenberg** Shall I be able to suggest a walk?
> **Bohr** I don't think we shall be going for any walks. Whatever he has to say he can say where everyone can hear it. (10)

Thus, together with the audience, they "open the pages" of the diary memory and, by stepping through it, are recentered into September 1941. This is exactly a "switch between two radically district worlds," which Ryan defines as "ontological metalepsis"[viii] (*Avatars* 207). It turns out to be logically impossible because, through an entanglement of the diegetic levels, all three characters, throughout the play, and repeatedly, exist in more than one ontologically distinct world simultaneously while the center changes each time, hence a polycentered narrative universe. In the case of *Copenhagen*, the interaction between the same characters in different worlds render an ontological entity different from physics' multiverse. Unlike Henrik Ibsen's realistic plays, for instance, in *Copenhagen* there are no definite boundaries to separate the spaces that the audience/reader has to cognitively construct/map. Thus, Heisenberg starts the embedded plot from the Copenhagen railway station: "here I am, getting off the night train from Berlin," then, he goes to "Bohr's workplace, the Institute for Theoretical Physics," for a conference and later he arrives at "the Bohr's house at Ny-Carlsberg" (Frayn 6; 7; 10). There are also the places they choose to go for a walk such as "Faelled Park" and "Elsinore." Actually, these are the instances what we would call "fantastic narrative spaces" (Amani et al). As mentioned earlier, the circular stage also "disrupts the reader's comfortable notion of space as a positivist objective reality" in support of the concept of space as socially deliberated, as constructed and conventional (García 7-8). The stage, apart from the storyworld it depicts, turns into a scientific universe itself that projects the central tenets in quantum mechanics. The stage becomes an atom and the characters revolve around it like electrons. As long as one possible world, particularly through one of the characters, is generated on stage, the audience is required to reflect upon it.

There are several drafts as counterfactuals projected to answer the question why Heisenberg came to Copenhagen. As a narrative quantum cosmology, within each draft, a substantial number of worlds are generated at every moment, contrasting with those multiverse

cosmologies in which the sprouting of worlds is attributable to isolated events. To put it in terms of the principles of possible-worlds theory, out of an F-universe, another F-universe (actually, memories, both personal and collective) is brought forth. Bohr and Heisenberg (and sometimes Margrethe) are recentered to a kind of "collective" F-universe. Having remembered the same incident in the past, both/all of them contribute to the recentering and shift in the TAW of the play; Bohr and Margrethe's recollection of their lost children is an instance set out by Heisenberg:

> **Margrethe** The same bright things. The same dark things. Back and back they come.
> **[…]**
> **Bohr** She's thinking about Christian and Harald.
> **Heisenberg** The two lost boys. Harald […] And Christian. The firstborn. The eldest son.
> **Bohr** And once again I see those same few moments that I see every day.
> **Heisenberg** Those short moments on the boat, when the tiller slams over in the heavy sea, and Christian is falling. […] Those long moments in the water. […] When he's struggling towards the lifebuoy.
> **Bohr** So near to touching it.
> **Margrethe** I'm at Tisvilde. I look up from my work. There's Niels in the doorway, silently watching me. He turns his head away, and I know at once what's happened. (29-30)

As it appears, they are immersed into a memory, temporarily the other TAW of the play, about the drowning of Christian, Bohr's son, while they were sailing in a boat. Heisenberg is aware of what Margrethe and Bohr are thinking about; in other words, they are aware of each other's K-worlds. Hence, as they resume the conversation, each of them contributes to the telling of Christian's story.

In the first alternate historical draft, based on some evidence, the audience may come to the conclusion, that Heisenberg's purpose (his I-world) in meeting Bohr was to work on a bomb for Hitler. Heisenberg was working at the time on fission trying to build a reactor for Nazis to develop their nuclear program:

> **Heisenberg** A reactor! That's what we were trying to build! A machine to produce power! To generate electricity, to drive ships!
> **Bohr** You didn't say anything about a reactor.

Heisenberg I didn't say anything about anything! Not in so many words. I couldn't! I'd no idea how much could be overheard. How much you'd repeat to others.
Bohr But then I asked you if you actually thought that uranium fission could be used for the construction of weapons.
Heisenberg Ah! It's coming back!
Bohr And I clearly remember what you replied.
Heisenberg I said I now knew that it could be.
Bohr This is what really horrified me. (36-37)

Likewise, Heisenberg adds: "If we could build a reactor we could build bombs. That's what had brought me to Copenhagen. But none of this could I say. And at this point you stopped listening. The bomb had already gone off inside your head. I realised we were heading back towards the house. Our walk was over. Our one chance to talk had gone forever" (37-38). Heisenberg's W-world and O-World are in conflict with the T/AW of the play since what he plans to achieve is a transgression of social roles and principles, a catastrophe for AW.

In another version, Heisenberg mentions that he came to Copenhagen, since he was in control of the reactor and the nuclear program, hoping that the Nazis could not produce the nuclear weapon without plutonium; if the meeting ended in failure, Kurt Diebner, Hitler's supporter, would take control over it. Consequently, Heisenberg also wishes to find out about the Americans' program: I "simply want to know if there is one. Some hint. Some clue. I've just betrayed my country and risked my life to warn you of the German programme" (42). He refers to Oppenheimer (the well-known American physicist who later helped the Americans to produce the bomb and drop it on Hiroshima) who said "it was his one regret. That they hadn't produced the bomb in time to use on Germany" (43).

In the two versions mentioned above, the audience/reader experiences some slight changes: in the first draft, at the beginning, Bohr acts coldly towards Heisenberg; however, in the second version, as he finds that Heisenberg's W-world was to stop producing nuclear weapon, Bohr resumes their father-son-like relationship. Furthermore, in the second version, the audience's attitude towards Bohr may partly change

since he participated in the American nuclear program which led to the production of the Hiroshima bomb.

The other draft draws the audience's attention to Bohr and Heisenberg and their thought experiments in the Copenhagen interpretation. It is noteworthy to mention that in this version, Margrethe acts beyond being a simple observer and passes comments on the events and memories. One of the groundbreaking thought experiments in the play is the Uncertainty Principle. This thought experiment, a nonfictional universe in itself, has been framed into a narrative universe (Heisenberg's F-universe), when, at night, he walks around Faelled Park and thinks about what Bohr could see, if he "train[s] a telescope on me from the mountains of Norway":

> You'd see me by the street lamps on the Blegdamsvej, then nothing as I vanished into the darkness, then another glimpse of me as I passed the lamp post in front of the bandstand […] Not a continuous track but a series of glimpses – a series of collisions between the passing electron[s]. (68)

The passage thrusts the audience/reader into the world of indeterminacy/uncertainty. Heisenberg, as an electron, cannot be simply spotted in one specific place and the viewer has only glimpses of his presence in different spots. He further concretizes his theory by referring to Bohr's trip to Leiden in 1925:

> What did Margrethe see of that, at home here in Copenhagen? A picture postcard from Hamburg, perhaps. Then one from Leiden. One from Göttingen. One from Berlin. Because what we see in the cloud chamber are not even the collisions themselves, but the water droplets that condense around them, as big as cities around a traveller – no, vastly bigger still, relatively – complete countries – Germany . . . Holland . . . Germany again. There is no track, there are no precise addresses; only a vague list of countries visited. (68)

This is how one's K-world misrepresents the T/AW, assuming that it is possible to have certain knowledge about their quests. In this case, one can come to the conclusion that the metaphor also effectively performs the role of possible world. This echoes Paul Ricoeur's idea of "mimesis," which does not hold as a copy of the real world. However, he believes that "[i]f we continue to translate mimesis by 'imitation', we have to

understand something completely contrary to a copy of some preexisting reality and speak instead of a creative imitation" (*Time* 45). He also replaces mimesis with metaphor, stating that "metaphor is the rhetorical process by which discourse unleashes the power that certain fictions have to re-describe reality" (*The Rule* 5). More precisely, metaphors create reality or constitute possible worlds rather than simply represent/imitate reality.

Furthermore, in the draft embedded in Margrethe's K-world, Heisenberg's purpose in coming to Copenhagen was to flaunt his position in the Nazis' nuclear program. Margrethe also contends that the reason why Heisenberg did not help the Nazis produce the nuclear bomb was that he was afraid of "what would happen if the Nazis committed huge resources and [he] failed to deliver the bombs" (76). Similarly, the last, or the other collision, in Margrethe's words, is rather more elaborate, inasmuch as it is a totally metafictional one. Bohr, who is opposed to the AW, does not get angry: "Let's suppose for a moment that I don't go flying off into the night. Let's see what happens if instead I remember the paternal role I'm supposed to play. If I stop, and control my anger, and turn to him. And ask him why" (91). Bohr adds a fictional embedded plot to that famous short conversation:

> **Bohr** Why are you confident that it's going to be so reassuringly difficult to build a bomb with 235? Is it because you've done the calculation?
> **Heisenberg** The calculation?
> **Bohr** Of the diffusion in 235. No. It's because you haven't calculated it. You haven't considered calculating it. You hadn't consciously realised there was a calculation to be made.
> **Heisenberg** And of course now I have realised. In fact it wouldn't be all that difficult. (91)

Thus, in this world, Heisenberg is projected as a hero whose O-world is satisfied in T/AW because he misrepresents his K-world so as not to calculate the diffusion in 235 necessary to produce the atomic bomb.

Conclusions

The present study has looked into Frayn's *Copenhagen* from a cognitive narratological perspective through the lens of the possible worlds theory. *Copenhagen* is a "physics play" that appealingly holds a dialogue with humanities. As a quantum mechanics play, it formally offers the many-worlds interpretation by dramatizing the analysis of thought experiments by the physicists of the Copenhagen Interpretation. To some extent, the many-worlds interpretation, parallel universes or many-worlds cosmology (quantum cosmology) is compatible with the possible worlds theory in narratology. Thus, we opt for "narrative quantum cosmology" to illustrate the role of alternate historical counterfactuals, mixing fact and fiction, as possible worlds in *Copenhagen*. Frayn's objective by presenting a proliferation of possible worlds appears to be productive because it acts as an incentive for the audience/reader to consider various viewpoints and address ethical questions. Taking the scarcity of historical records pertaining to a specific event in 1941 as paradigmatic, Frayn examines the uncertainties that human beings experience in life. However, what makes Frayn's reflection on a common philosophical theme uncannily compelling is his masterful way of creating parallels between the components of his dramatic/ dramaturgical world, and that of the scientific/philosophical notions it addresses, thus, viscerally reflecting how human life and knowledge are the matters of projecting many possible worlds.

Notes:

[i] We have to note that not all quantum physicists, Heisenberg and Bohr among others, endorse many-worlds interpretations or many-worlds cosmology.

[ii] For a short comprehensible description of quantum mechanics and the equation of Schrödinger's Cat, see Ryan (2011). Ryan delineates the Schrödinger's equation as follows:

> Schrödinger developed an equation that describes the quantum state of a system as a wave that evolves over time. Because the exact behavior of subatomic particles is unpredictable, Schrödinger's equation has been interpreted as representing a set of probabilities concerning the position of particles, rather than assigning them a precise location. When Schrödinger worked out the mathematical steps necessary to apply the equation to

> reality, he found out that they included an imaginary number. This could mean that electrons exist in a superposition of states, simultaneously occupying all the positions predicted by the equation. Schrödinger's cat is consequently both dead and alive, since the nuclear reaction that releases a poison meant to kill him both occurs and does not occur. (5)

[iii] Doležel (1998) hints at two different tendencies in logical semantics of possible worlds, on the grounds that possible worlds do not require ontological commitment: possibilism and actualism (13). He adds that for possibilism, the actual world does not have a different status within the set of possible worlds, while for actualism the actual world is "a standpoint outside the system of possible worlds from which judgments of actuality which are not world related may be made" (13).

[iv] See Ronen's (1994) discussion of three basic views on the validity of talking about possible states of affairs and about the actuality of these alternative worlds: (1) modal realism, (2) moderate realism, and (3) anti-realism.

[v] Ryan's use of universe here is significant because it differs to a great extent from the one in physics. Ryan considers a narrative text a narrative universe with textual actual world and multiple possible worlds.

[vi] The notion of "recentering" in this case takes place for the character as well as the reader since F-Universes itself has a new system with a new TAW at the center and the APWs or F-worlds surrounding it.

[vii] See Bordwell (2001). Bordwell holds that Borges' "Garden of Forking Paths" stands as a "conceit" that comprises "its counterpart in quantum mechanics." Borges' story is an epitome of parallel universes in that the reader encounters an infinite proliferation of possible worlds "each as real as the one we apparently know" (88):

> In all fictions, each time a man meets diverse alternatives, he chooses one and eliminates the others; in the work of the virtually-impossible-to disentangle Ts'ui Pen, the character chooses-simultaneously-all of them. He creates, thereby, several futures, several times, which proliferate and multiply themselves. In Ts'ui Pen's novel, all the outcomes in fact occur: each is the starting point for further bifurcations. Once in a while, the Paths of that labyrinth converge: for example, you come to this house, but in one of the possible pasts you are my enemy, in another my friend. (qtd. in Bordwell 88)

[viii] Ryan believes that "in a narrative work, ontological levels will become entangled when an existent belongs to two or more levels at the same time, or when an existent migrates from one level to the next, causing two separate environments to blend" (*Avatars* 207).

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