QUANTUM PHYSICS AND THEOLOGY: JOHN POLKINGHORNE ON THOUGHT EXPERIMENTS

by Yiftach J. H. Fehige

Abstract. Thought experimentation is part of accepted scientific practice, and this makes it surprising that philosophers of science did not seriously engage with it for a very long time. The situation changed in the 1990s, resulting in a highly intriguing debate over thought experiments. Initially, the discussion focused mostly on thought experiments in physics, philosophy, and mathematics. Other disciplines have since become the subject of interest. Yet, nothing substantial has been said about the role of thought experiments in nonphilosophical theology. This paper discusses the role of thought experiments in Christian theology in comparison to their role in quantum physics, as mentioned by John Polkinghorne in *Quantum Physics and Theology*. We first look briefly at the history of the inquiry into thought experiments and then at Polkinghorne's remarks about the role of thought experimentation in quantum physics and Christian eschatology. To determine the actual importance of thought experiments in Christian theology a number of new examples are introduced in a third step. In the light of these examples, in a fourth step, we address the question of what it is that explains the cognitive efficacy of thought experiments in quantum physics and Christian theology.

Keywords: Augustine on human sexuality; James R. Brown; crucifixion; Einstein-Bohr debate; incarnation; intuition; ontological argument; John Polkinghorne; thought experiments

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The unity of knowledge and the unity of God are closely related. I believe in both. (Polkinghorne 1996, 47)

John Polkinghorne is one of the most important figures in the field of theology and science. He "has been called a first-generation scholar in the renewed dialogue between science and theology" (Hogan 2009, 559). Established as a theoretical physicist at Cambridge University, he left his chair in mathematical physics to become an Anglican priest. As a result he began to engage in Christian theology as it relates to the sciences, especially physics. This fortunate merger of science and Christian theology in one

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[*Zygon*, vol. 47, no. 2 (June 2012)]
 ISSN 0591-2385 *www.zygonjournal.org*

person has led to a significant number of stimulating contributions to the field. Among them is *Quantum Physics and Theology: An Unexpected Kinship* (in the following: QT; Polkinghorne 2007). The central claim of this thought-provoking essay is that Christology and quantum physics are methodologically close enough to claim a high degree of similarity between theology and science in the way each pursues truth. The differences between theology and science, argues Polkinghorne, are a function of the fact that they do not share a domain of inquiry. Broadly speaking, science investigates what we call nature, and theology deals with God, and "neither science nor theology should make the mistake of supposing that it can answer the other's proper question. Nevertheless, there has to be a consonance between the answers that each gives, if it is indeed the case that there is a fundamental unity of knowledge about the one world of created reality" (Polkinghorne 2006, 57). But in each case we arrive at those answers by reflecting on the "data" first to develop a theory. Polkinghorne speaks of a "bottom-up" instead of a "top-down" approach, and argues that theology and science are indistinguishable in this respect (Polkinghorne 1996, 35–42).

It attests to Polkinghorne's ingenuity that he brings into focus a practice common in theology and science that so far has not received the attention it probably deserves—namely, *thought experimentation*. In quantum physics and Christian theology, claims Polkinghorne, thought experiments are performed to explore concepts to achieve theoretical progress. Although ignored for a very long time in philosophy of science, thought experiments have received quite a bit of attention recently in this field. But thought experiments don't matter only in science. Philosophy would be severely impoverished without them. Other disciplines that make use of them include history, political science, and mathematics. According to Polkinghorne, Christian theology can be added to the list. The principal aim of this paper is to have a closer look at Polkinghorne's discussion of the practice of thought experimentation in QT, and thereby to deepen the conversation between theology and science in fruitful ways.

In what follows, we will first look at thought experiments as a topic of contemporary philosophy of science, because it is in this field that the practice of thought experimentation has come to prominence. What follows is a critical engagement with QT. The main points of QT will be summarized first, after which the role of thought experiments in quantum mechanics and Christian theology will be highlighted as characterized in QT. A closer examination of this characterization will follow. Its aim is to define more precisely the importance of thought experiments for Christian theology and to sketch a possible explanation for the evidential significance that Polkinghorne has assigned to the practice of thought experimentation in quantum physics and Christian theology. It will be argued that the main function of thought experiments is to assist investigators, both scientific

and theological, in accessing their intuitions. As such they play indeed a very important role in theology and science because in both domains cognitive progress is always also a function of intuitions.

Thought Experiments in Philosophy of Science

Many people know at least one of the famous thought experiments of quantum mechanics, be it Schrödinger's cat, Heisenberg's γ-ray microscope, or the Einstein-Podolsky-Rosen/EPR experiment (Brown [1991] 2011, 20–6). Thought experiments, generally speaking, are devices of the imagination, most often expressed in the form of narratives. They can serve various purposes. Some thought experiments are performed to entertain, others to illustrate, and yet others to teach. The most interesting, and also most debated, class of thought experiments includes those that serve the acquisition of knowledge—that is, they have evidential significance.

A thought experiment has evidential significance if and only if it contributes to the warrant of a proposition p, whereby it may give support to a theory T, which describes truthfully a certain general feature of the world. No experiment, and therefore no thought experiment, can be an *experimentum crucis,* for its evidential significance is a function of a particular metaphysical-epistemological framework that specifies what it is that counts as evidence (McAllister 1996). The evidential significance of a thought experiment does not result from a manipulation of the world, as is characteristic in real-world experiments. Therefore, the epistemological challenge posed by thought experiments of evidential significance is as intriguing as it is simple. They trigger the question as to how it is "that we seem able to learn about the world just by thinking" (Brown [1991] 2011, 203).

The practice of thought experimentation is probably as old as the human mind. Thought experiments have been recorded since the times of ancient Greek philosophy (Ierodiakonou 2005). It was the philosopher-scientist Hans-Christian Ørsted who introduced the term *thought experiment* in 1811 (Ørsted [1811]1920, 172). Eighty-six years later, Ernst Mach proposed the first classification of thought experiments and stated for the very first time the central epistemological puzzle posed by those thought experiments of evidential significance (Mach 1897). Given the contribution of Ørsted and Mach, and in the light of the widespread use of thought experiments in science, it is a surprising fact that in philosophy of science a serious investigation into thought experiments did not commence before the end of the 1980s. Since then, interest in the role of thought experiments in science, philosophy, and many other fields of inquiry has dramatically grown.

There can be little doubt that the recent explosion in the literature on thought experiments is because of the substantial and controversial work

of James R. Brown. Brown has proposed a Platonic account of thought experiments, first in 1986 (Brown 1986), and then most notably in Brown ([1991] 2011). Central to his Platonic account are three claims: (1) Laws of nature are about universals and their relationship to one another. (2) The universals in question are Platonic entities. (3) These Platonic entities are accessible by means of an intellectual perception that is comparable to, but quite different from, visual perception. All three claims are highly controversial. But this does not mean much in philosophy. One reading of "controversial" is that it is very stimulating. And this is exactly what Brown's account has been. It has triggered a debate over the use and nature of thought experiments that is ongoing.

To clarify Brown's central idea, it is by means of an intellectual perception that we peek into the realm of universals, the relations of which correspond to our laws of nature. In the case of Galileo's falling conjoined cannon balls of different weights, for example, one can just *see with the mind's eye* what the right law of motion is (Brown 1986, 9–10).

Brown's account of this piece of thought experimentation is as contested as his theory of thought experiments. That might not come as a surprise to anyone who finds Platonism itself highly implausible. What is surprising, however, is that the opposing view faces no less fierce opposition, according to which thought experiments are not facilitators for a Platonic perception but simply underdeveloped arguments (Bunzl 1996; Norton 2004; Williamson 2008, 179–207). This can be called the default view of thought experiments. What else do we do when conducting a thought experiment if not to perform a propositional line of reasoning? That such is the case is very likely because every thought experiment can be reconstructed as a well-ordered sequence of propositions that, if valid, obey the common rules of logic. Thus, there is no philosophical problem when it comes to thought experiments, unless we find fault with propositional reasoning in general. Not quite, claims the majority of participants in the discussion of thought experiments.

Although Brown's account is mostly rejected because of its commitment to a mysterious intellectual perception and to a realm of Platonic entities, the default view is mainly opposed on three grounds. First, every real-world experiment can be reconstructed as an argument. But nobody would argue that real-world experiments are just arguments. Such an identity thesis simply begs the epistemological question that emerges from the practice of thought experimentation. In the case of real-world experiments, some premises obtain from systematic manipulation in the domain of investigation. What is the equivalent in thought experimentation? Second, it can be shown that a thought experiment loses its evidential significance once it is reconstructed as a line of propositional reasoning (Gendler 1998). Third, counterexamples can be presented. Bishop (1999) has specified a counterexample in his discussion of Einstein's *clock-in-the-box* thought

experiment. A closer look at it can help to clarify the dynamics and challenges inherent in thought experimentation of evidential significance. In the discussion of Polkinghorne's views about thought experiment we will refer to the results of this clarification. At the same time the following in-depth discussion of the *clock-in-the-box* thought experiment provides the opportunity to demonstrate what a systematic treatment of a thought experiment requires. A systematic treatment of a thought experiment makes necessary far more work and space than an explorative treatment to which we will subject all other thought experiments that are discussed in this paper

Einstein entertained quite a number of thought experiments, most of which are very popular, although it is not quite clear what his actual views regarding thought experiments were (Brown [1991]2011, 152–75; Kühne 2005, 234–79). In his discussion of thought experiments as a common practice in theology and science, Polkinghorne (2005, 169–70) refers to those thought experiments that Einstein presented in discussions with Niels Bohr over the interpretation of quantum formalism as promoted by Bohr and others—and that has become known, quite misleadingly, as the "Copenhagen interpretation." The *clock-in-the-box* thought experiment is one of them. It is said that Bohr dealt with it until the last day of his life, and to this day the thought experiment is the subject of controversial discussions among physicists (see most recently Dieks and Lam 2008).

To recall the story as told by Bohr (1949, 224–30), Einstein presented his *clock-in-the-box* thought experiment at the sixth Solvay Conference in 1930. Its specific purpose is a matter of dispute. According to some, Einstein wanted to advance a statistical interpretation of the Heisenberg uncertainty relation for energy and time. Others think that Einstein presented an argument similar to the EPR (Einstein-Podolsky-Rosen) experiment to show that Bohr's interpretation of quantum formalism is incomplete. That is to say that the Heisenberg uncertainty relation for energy and time does not reflect what the world is actually like, and therefore fails to describe it properly. All that it states is a limitation of the way we can simultaneously measure energy and time of a photon. Again, others believe that Einstein aimed to show that Bohr's interpretation of quantum formalism is inconsistent. That is to say that the Heisenberg uncertainty relation for energy and time states what the world is like, and that Einstein meant to present a counterexample, showing that this is not true. In any case, the *clock-in-the-box* is obviously concerned with the *Heisenberg uncertainty relation with respect to energy and time of a photon*—that is, the claim that any attempt to measure an elementary's particle energy-variable to the highest degree of accuracy leads to an increasing uncertainty in being able to measure the particle's time-variable to the same equally high degree of accuracy.

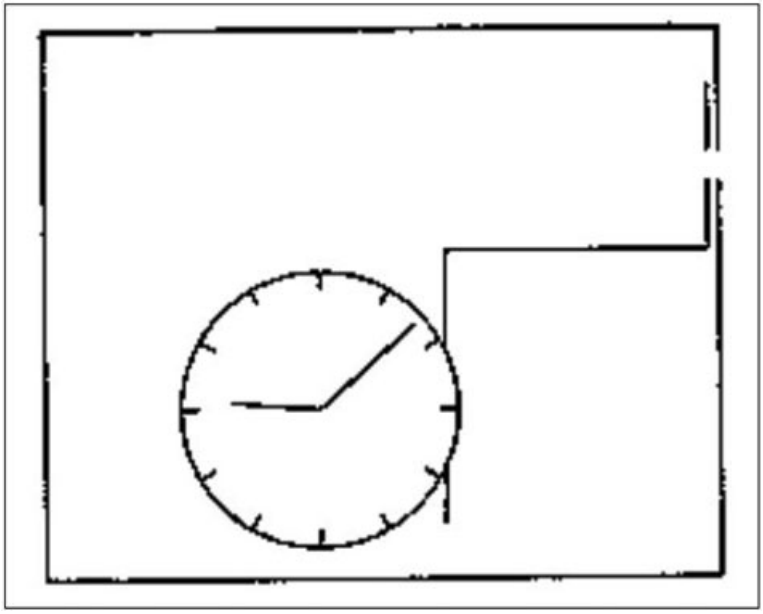

Figure 1. Bohr's Pseudo-Realistic Drawing of the Scenario in Einstein's Version of the *Clock-in-the-Box* (Bohr 1949, 225).

According to Bohr, Einstein imagined a box that contains radiation and is equipped with a shutter mechanism that is connected to a clock placed inside the box (Figure 1).

The clock can be set in such a way that the shutter opens at a very precise point in time, resulting in the escape of a photon. Measuring the weight of the box before and after the escape of the photon would allow us to determine precisely the difference in weight. Using the formalized equivalence of mass and energy ($E = mc^2$), we can thus determine the energy of the photon by a simple computation. Hence, the view that classical conjugate variables of a photon, like energy and time, cannot be measured with equal accuracy is called into question, and thus the Heisenberg uncertainty relation for energy and time.

Bohr confessed that Einstein's thought experiment caused him a sleepless night. But his answer to Einstein came the next morning. Bohr presented a version of the thought experiment that draws attention to the weighing mechanism. He imagines the box being held by springs from the top. Further, the box is equipped with a hitch at the bottom to hang the weights to determine the weight of the box (Figure 2).

What follows is that the box will be in motion, for two reasons. It will move when the photon leaves the box, causing a shift in the weight

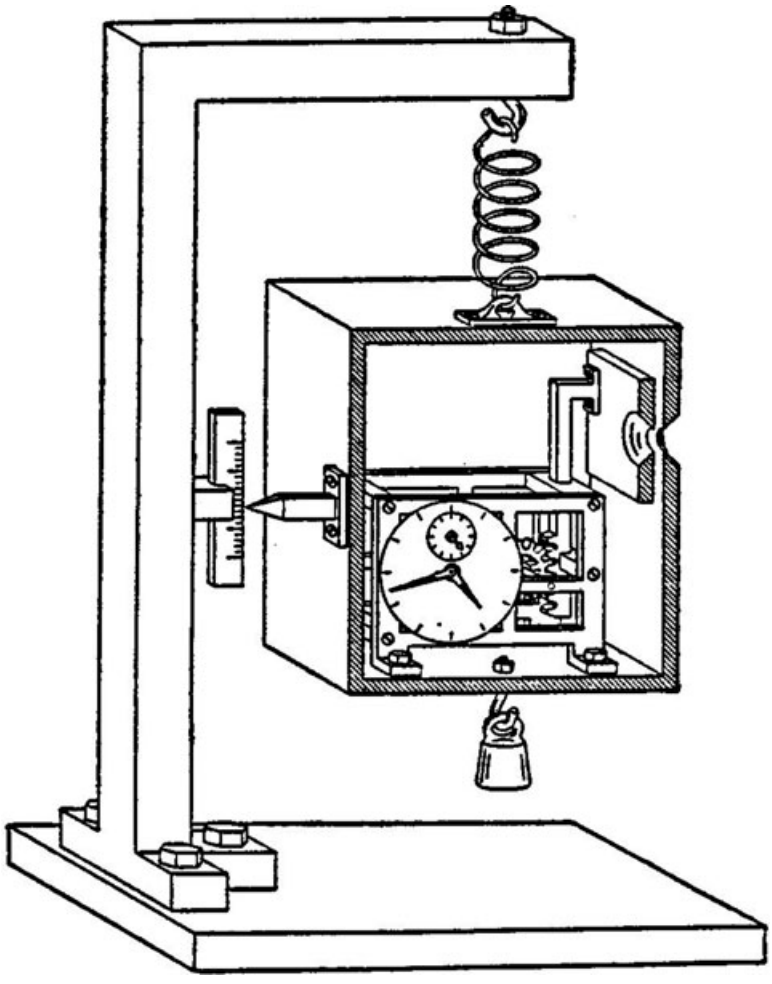

Figure 2. Bohr's Pseudo-Realistic Drawing of the Scenario in Einstein's Version of the *Clock-in-the-Box* (Bohr 1949, 227).

of the box. But it will also move when we try to determine the precise weight of the box (to determine the energy of the photon) because of the hanging of weights on the hitch at the bottom of the box. The resulting momentum of the box makes it hard to adjust the pointer, which is installed on the sidewall of the box that faces a scale. The scale is fixed on a frame that holds the springs and, via springs, also the box. When the box moves, it does so parallel to the scale. If the box gets heavier, the pointer moves downward along the scale; if the box gets lighter, it moves upward the scale. Because of the nature of the springs, the weighing process is more accurate

if more time is dedicated to the process of adjusting the scale and pointer. The faster the weighing process, the more inaccurate the determined weight difference and thus the energy of the photon. In addition, the more time it takes to weigh the box, the more inaccurate the reading of the clock will be, because the box moves in the direction of the gravitational force. This inaccuracy is taken by Bohr to be a consequence of the so-called redshift formula of Einstein's theory of general relativity, according to which a time measuring clock moving in the direction of gravitational force slows down.

Bohr's account as to what happened between Einstein and Bohr at the Solvay conference appeared in a volume dedicated and presented to Einstein. He had the chance to respond to Bohr's story, but decided not to. This is a surprise, because Bohr's reply is as flawed as Einstein's original argument, although it is a matter of controversy what exactly it is that is wrong with Bohr's reply. Some argue that no uncertainty relationship of energy and time can be inferred from Einstein's general theory of relativity, because it is deterministic. Nothing indeterministic can therefore come out of it. Others argue that Bohr's reply presupposes a deeper link between the general theory of relativity and quantum mechanics, a link that nobody has been able to spell out to this date. This missing link makes a unification of quantum mechanics and the general theory of relativity impossible. Again, others have objected that Bohr conflates the clocks that are involved in his reply. Einstein speaks about the time of the escape of the photon, and thus of the clock that is in the box. Bohr, however, speaks of the time it takes to weigh the box, and thus about a clock outside the box.

Whatever it is that is wrong with Bohr's reply, there is general agreement that it is wrong. Given this fact, it is thus as surprising that Einstein did not respond to Bohr's 1949 account of the event of 1930, as it is surprising that he accepted Bohr's response in 1930. In the literature we find basically two reasons why he didn't respond. First, in 1930 Einstein had already accepted Heisenberg's uncertainty principle, and therefore did not care anymore whether or not Bohr's reply could save it. Second, Einstein realized that the *clock-in-the-box* in his own version was flawed. This explains why he later developed the EPR experiment, proposing a different line of reasoning directed against the interpretation of quantum formalism that Bohr and others advanced.

Philosophically, the *clock-in-the-box*–based exchange between Einstein and Bohr is very intriguing. Much can be learned from it. According to Bishop (1999), the main lesson to take away for the study of thought experiments is that the default position is highly problematic. Defenders of the default view must and do describe the exchange between Einstein and Bohr as a transaction of two different arguments (Norton 2004b, 63–64). Given that thought experiments are claimed to be identical with arguments, and because Einstein's and Bohr's versions of the *clock-in-the-box* differ in their premises and conclusions, we have to say that

they exchanged two different arguments. But, objects Bishop (1999), such a reading is problematic, because it implies that Bohr simply ignored Einstein's original argument and just introduced a new one. How, then, could Bohr have come out as the winner of the debate, as it is commonly claimed? Don't we end up with a situation where one argument stands against another argument? A reading of the *clock-in-the-box*–based exchange between Einstein and Bohr along the lines of the default view of thought experiments is therefore epistemologically too costly, claims Bishop (1999). Einstein's declaration of "defeat" would not make much sense, assuming that he intended the *clock-in-the-box* in all seriousness to be an argument against the Heisenberg uncertainty relation for energy and time. To make this assumption seems justified in the light of Bohr's serious engagement with it. Given the fact that Bohr's reply is wrong and that Einstein probably realized this, too, he must have come to reject his initial argument on different grounds. But what was it, and how did Einstein realize it?

Thought experiments like the *clock-in-the-box* do not merely justify disagreement with the default view of thought experiments. They also illustrate quite nicely the general structure of thought experiments. We imagine a scenario S. In accordance with a particular aim, certain particulars of S are related to a target theory T. This can serve the purpose of gaining evidence in favor of or against a proposition p implied by T. S can be modified. Such a modification can undermine the conclusions regarding p that were drawn from the original version of S and lead to a rehabilitation of T, or the introduction of a new theory T'.

Furthermore, the *clock-in-the-box* and its controversial discussion make it plausible why thought experiments must be recognized from a historical perspective "as an occasionally potent tool for increasing man's understanding of nature" (Kuhn 1977, 240). From a pragmatic point of view one can add: "Thought experiment is part of accepted scientific practice" (Sorensen 1992, 19). This fact explains the ongoing struggle for a compromise between Brown's Platonism and the default view to account for thought experiments. A number of alternative accounts have been produced. Skepticism about thought experiments has remained a minority position. The majority view is that thought experiments are an indispensable tool of scientific creativity and that we need a better explanation for their cognitive efficacy than that offered by Brown's Platonism and by proponents of the default position.

The Unexpected Kinship of Quantum Mechanics and Theology

Consistent with his previous writings, in QT, Polkinghorne continues to argue for the compatibility of scientific and theological knowledge, and

he expresses once more his hope for a general theory of everything there is. That is to say, for Polkinghorne science and theology can be related for the sake of enhanced explanatory power regarding everything there is without revoking the integrity of either discipline. In QT, Polkinghorne is less interested in particular assertions to demonstrate the compatibility of science and theology so conceived. Instead, he focuses on more formal and methodological matters. Polkinghorne basically argues that quantum mechanics, as a representative scientific discipline, and Christology, as a representative discipline of Christian theology, are very similar in the way each pursues truth. That is why he speaks of a *kinship* between the two. More precisely, he sees "a cousinly relationship between the ways in which theology and science each pursue truth within the proper domains of their interpreted experience" (Polkinghorne 2007, 15). It is an *unexpected* kinship, however, insofar as theology is today widely conceived as cognitively meaningless, and in this sense commonly perceived as absolutely unrelated to science. In response to such a view, Polkinghorne offers an informed and thought-provoking dissection of the truth-seeking strategies employed in quantum mechanics and theology.

Polkinghorne does not play down the differences between theology and science. For example, he does not speak of siblings but of cousins, and explains their differences as a function of the different domains of inquiry—namely, *nature* versus *God*. Nevertheless, maintains Polkinghorne, a closer look at quantum mechanics and Christology reveals that theology and science are more similar than one might think. Generally speaking, both deal with interpreted experience and are therefore committed to what Polkinghorne calls "critical realism." That is to say that neither scientific nor theological knowledge is either merely a *neutral reflection* of the respective domain of inquiry or merely a *fabrication of the human mind*, but rather a mixture of both. According to Polkinghorne, quantum mechanics and Christian theology are two examples of a paradigm shift in the sense advanced by Kuhn (1996). In one case we have a shift from the Newtonian paradigm, and in the other case a shift from a Jewish to a trinitarian-incarnational monotheism. Each represents a moment of discontinuity in a continuous process of intellectual development—in one case in the context of the history of the physical sciences, and in the other case in the context of the history of revelation. Quantum physics and Christology themselves can also be characterized by the dialectic of continuity and discontinuity. In each case there is continuous deepening of the new paradigm, and this despite discontinued lines of reasoning.

In addition to these more general features, there are a number of more concrete similarities, and most of Polkinghorne's reflections in QT are dedicated to them. To name some examples, quantum mechanics is characterized by the puzzle of the particle-wave dualism and Christology by the doctrine of the God-Man. Furthermore, the period between

1900 and 1925 was a time of confusion in quantum physics, exactly like the first 500 years in church history. What quantum mechanics and Christology also have in common is a moment of mystery in the sense that each involves a commitment to fundamental statements that describe rather than explain central features of the domain of inquiry. The superposition principle "just had to be accepted as an article of quantum faith" (Polkinghorne 2007, 18). The equivalent in theology is the christological announcements of church councils that just had to be accepted as an article of religious faith. Of course, in neither case is the commitment irrational, Polkinghorne maintains. In general, he does not intend to promote fideism.

Another particular similarity is that quantum mechanics and Christian theology alike are both erected on solid experiential grounds, but are still burdened with perplexities. In one case there is the unresolved problem as to how the macro-physical realm with its nonprobabilistic physics emerges from the microphysical realm that is guided by probabilities. In the other case there is the well-known problem of how it can be that God incarnates but does not intervene in a way to end the "evil" in the world. Despite these perplexities, Polkinghorne states, quantum mechanics and Christology have proven to be theoretically highly fertile. This is not to deny that it is much more difficult to demonstrate theological progress, compared to progress in science. But, in Polkinghorne's view, this difficulty does not undermine the cousinly relationship between theology and science as it reveals itself upon a closer examination like his.

Polkinghorne develops a number of additional specific similarities from what he calls "conceptual exploration" that can lead scientists and theologians "to the formulation of ideas of wider generality" than a "direct systematisation of the basic evidence" can offer. These ideas have a "profound significance, aiming to offer more by way of understanding than simply an immediate matching with the particulars of experience." This way we come to see what actually "is going on" (Polkinghorne 2007, 73). It is in the context of his reflections on this dimension of "conceptual exploration" that he finds his way to the practice of thought experimentation (Polkinghorne 2007, 93 and 94).

Thought experiments are introduced as "toys of thought." In physics, they help to explore "possible schemas of thought." Using "highly simplified" and "idealized" situations, physicists "seek to gain insight into the nature of novel concepts." Thought experiments "had served to produce a useful clarification of quantum principles." Our excursion above into the exchange between Einstein and Bohr over the *clock-in-the-box* gives us a good idea of what Polkinghorne has in mind here.

The analogue in Christian theology, argues Polkinghorne, is thought experiments like those found in Revelation 21:1–4 and 22:1–5. In the case of these two examples of thought experimentation in Christian

theology, we can say that they serve to clarify eschatological concepts. Such thought experiments are necessary, because the world to come, as proclaimed in Christian faith, "is quite different from that of our present experience, and it is beyond the power of contemporary thinking to give an adequate description of it" (Polkinghorne 2007, 93–94). Thus, eschatological thought experiments are as indispensable as thought experiments in quantum physics. In both cases we seek knowledge that cannot be gained if we stay too close to the basic evidence provided by experience. In the case of eschatological thought experiments we seek to clarify *content* and *coherence* of the "world to come" as implied in Christian faith. Unlike in quantum physics such clarification will not reach more than a modest degree. The reason is that eschatology deals with matters that are to a much higher degree removed from the realm of experience, although not totally independent of it.

Polkinghorne is probably the first who has raised the issue of thought experiments in nonphilosophical theology. This is reason enough to have a closer look at his views of thought experiments. We will do so in what follows, and will begin by first discussing a number of thought experiments of Christian theology, including those introduced by Polkinghorne. In a second step we will then look at a promising way to explain the evidential significance that Polkinghorne ascribes to thought experiments in quantum physics and Christian theology.

Thought Experiments of Christian Theology

It is not self-evident that there should be thought experiments in Christian theology, because thought experimentation is not a common practice in every discipline. In chemistry, for example, we don't find thought experiments frequently employed (Snooks 2006). The same is true for anthropology. Thus, Polkinghorne's observation that Christian theology and quantum physics share the practice of thought experimentation is, by far, not trivial. As we have seen, Polkinghorne names two examples for thought experiments in Christian theology—namely, *the descent of the New Jerusalem as a bride* and *the river of life in the New Jerusalem.* It is worthwhile to have a closer look at them before we introduce some new examples.

The New Jerusalem. Revelation 21:1–4 and 22:1–5 are both part of the "grand finale"[1] of the last book of the Christian Bible (Reddish 2001, 401). The text unit of 21:1–22:5 depicts "God's ultimate plan for the world—a new creation in which evil and rebellion have no place." It is a "final spectacular scene of God's glorious kingdom." The central imagery is that of the New Jerusalem, the new heaven, and the new earth. Exposed is the "intimate communion with God and the lamb"—that is, with the

Father and the Son. 21:1–22:5 is basically a mixture of a vision and throne-speeches from God. It deals with the time when the world as we know it has come to an end.

The descent of the New Jerusalem as a bride: The first thought experiment identified by Polkinghorne is 21:1–4, which reports a *vision about the New Jerusalem* (see 22:8). "It is a proposed world, which through the imagination of reader or audience can become a horizon of possibilities open toward the 'reality of the possible' . . . a reality that as textual image is proposed as visionary direction for the responsible imaginative power of any human being" (Räpple 2004, 211–4). The seer is John, the self-identified author of Revelation (see 1:2), who claims for himself the authority of a prophet (see 22:9), receiving a revelation directly from Jesus. What John sees is the holy city, the New Jerusalem, as it comes down out of heaven by divine action, *because* the first heaven and the first earth have *passed away* or *passed by*. It is unclear if the text invites us to imagine the world, as we know it as *renewed* or as *completely replaced* (Trail 2006, 201). The New Jerusalem appears like a bride that is ready for her husband. Upon the arrival of this new city, a loud voice is heard, announcing the most important fact—namely, that God dwells now among humans. We are confronted with a world not yet experienced in which there is no sorrow, no death, no mourning, and no suffering. Thus, the reader is invited to imagine a world that is radically different from the world as we know it, and this in many of those respects that most fundamentally shape a human life. Despite this radical alterity of the imagined new world, the thought experiment is not completely detached from reality as we know it. For example, the metaphor of bride and husband establishes a "metaphorical play between the city and the human body. . . . Imagination becomes an act of empathy" (Räpple 2004, 224). This way the thought experiment remains grounded in the reality as we know it.

The river of life in the New Jerusalem: The second thought experiment identified by Polkinghorne is in 22:1–5, which, like 21:1–4, introduces a throne-speech of God. The vision is mainly *about the life-giving river* and *the tree of life*. There is an angel who was sent from Jesus (22:16) and who shows John a river of life-giving water, whose spring is mentioned by God in the preceding throne-speech (21:6). The river flows from the throne of Father and Son (Trail 2006, 228), either "through the middle of the street of the city" (Trail 2006, 229) of the New Jerusalem or "parallel to the street with a space in between" (Trail 2006, 229). We are invited to imagine trees of life growing on either side of the river. These trees give fruit every month of the year, or 12 kinds of fruit once each month of the year (Trail 2006, 230), and the leaves may be used as medicine for the nations in the sense that they "enhance the enjoyment of life in the city" (Trail 2006,

229). There is nothing anymore that is cursed by God (Trail 2006, 230), because now the throne of Father and Son is erected among God's people (Trail 2006, 231). The servants will worship God, while seeing his face (see Exodus 33:20; John 3:2). In most intimate communion with God they are firmly devoted to him (Trail 2006, 231). Day and night don't exist anymore (see also 21:23 and 25), nor are lamps or sun necessary any longer, because God will provide light. This is the way the servants of God will reign forever and ever.

Polkinghorne claims that the aim of these two eschatological thought experiments is to determine coherence and content of the Christian hope. In a sense this is trivial, because that is the aim of eschatology in general, and thus by definition also of eschatological thought experiments. The question arises, therefore, as to what the particular aim of the two thought experiments is. This question matters, because a thought experiment's identity depends on its particular aim (Krimsky 1973). This does not mean that thought experiments could not be *rethought* and *reperceived*, thereby receiving a new aim. On the contrary, they can be, and the *clock-in-the-box* thought experiment illustrates this fact very well. Bohr has turned it into a case in favor of Heisenberg's uncertainty relation for energy and time, contrary to Einstein's initial intention. What matters in our context is that each version of the *clock-in-the-box* in the debate between Einstein and Bohr had a particular aim. Generally, the aim guides the assessment of a thought experiment. One of the soft spots of Einstein's version of the *clock-in-the-box* thought experiment is that it remains unclear what exactly he intended to demonstrate by presenting a counterexample to the Heisenberg uncertainty relation for energy and time. Einstein's version of the *clock-in-the-box* did have a particular aim—namely, to refute the Heisenberg uncertainty relation for energy and time, but this aim remained too unspecific.

One difficulty in determining the particular aim of a thought experiment that is found in scripture, like Revelation 21:1–4 and 22:1–5, is that it requires serious exegetical work. Given the constraints of this paper, we cannot undertake such a task here. However, what can be done is to indicate the particular aim of these thought experiments. To that effect, we first shall have a closer look at the thought experiment of the descent of the New Jerusalem as a bride. We are particularly interested in the way in which the New Jerusalem is imagined as a city and a bride in order to read it as a thought experiment related to the problem of evil (Witherington 2003, 257 and 8; 266–8). First to note is that the text of 21:1–4 in its imagery is mainly indebted to Isaiah 54 and 61. The thought experiment is clearly based on Jewish scripture in this respect. Second, partly because of the status of Jerusalem in the Jewish scripture, a hope for a restoration of the actual city of Jerusalem was prevalent among the Jews of the time when the book of Revelation emerged. In a sense this Jewish hope is

part of the social setting of the thought experiment of 21:1–4. Third, instead of reaffirming such a hope, the author of Revelation imagines the consummation of all things, including the actual city of Jerusalem. This allows him to place the relationship between God and humans in the center of Christian hope. The relationship is described in a way that the positive-biblical connotations of Jerusalem are preserved, whereas the New Jerusalem is delocalized from the actual city of Jerusalem. Thereby, Christian hope is disconnected from Jewish hope, although not completely, of course, as Revelation remains indebted to the Jewish *apocalyptic* thinking of its day. Chapter 21:1–4 truly experiments in thought in this respect, because what we find here is a variation in the imagery of Jerusalem to address the problem of evil. Fourth, the author of 21:1–4 believes that evil has a very strong hold on the world, and reaffirms that evil is a problem for the Christian faith. In response to this problem, the New Jerusalem is imagined as free of evil, which is implied to be the result of a renewed relationship between God and humans. This relationship is different than it is in the actual world, and indicated is, therefore, a clear-cut with the old world in this respect. What is implied here is that a world free of evil will never be an accomplishment of humans. Such a world can come about only through "faithful witness, faithful worship, and faithful prayer . . . because they place matters in the hands of the only wise God who intends to work things out" (Witherington, 257). And he intends to do so, according to 21:1–4, by replacing or renewing this world, and not just by patching up the fallen world. In this sense the thought experiment takes on the features of a radical *apocalyptic scenario*. Thereby, the author of the text expresses a preference for a particular model of Christian hope. In other words, with respect to the specific problem of evil the thought experiment aims to support an apocalyptic model of Christian hope in preference to existing alternative eschatological models (for a discussion of these models see Kehl 1996, 114–24; 164–71; 232–7). This aim is partly realized through the variation of existing imagery with respect to Jerusalem.

As for the second thought experiment of the river of life, it is part of an "expansion of what was first mentioned in 21:2. John is using his interlocking rhetorical technique, first introducing a subject, then concluding the former subject, then continuing with the new subject" (Witherington 2003, 266). The new subject is the water of life. It is difficult to discern in what sense Polkinghorne sees here an independent thought experiment. But one could think of 22:1–5 in the context of Revelation 21–22 as a thought experiment with the principal aim of emphasizing that the New Jerusalem as a new creation "is not something brought into being by God from scratch, so to speak, but [that] it arises *ex vetere*, out of the redemption of the old" (Polkinghorne 2005, 173). The thought experiment achieves this aim through a variation of the imagery of Ezekiel 47:1–12, which is that part of Ezekiel's vision of a new Israel that includes

the flowing of healing water as it comes from the temple to sustain all life. Such healing water is required in the New Jerusalem because "the healing of the hearts and minds of people is seen to take much longer" than the healing of the body through the transformation of matter upon the descent of the New Jerusalem. John offers, as it were, an antiphysicalistic eschatology where the transformation of matter is only part of the redemption of the old.

Much more needs to and could be said about Polkinghorne's two thought experiments. But instead of digging yet deeper, we will shift our focus to additional, yet unnoticed examples of thought experimentation in Christian theology.

Sex in paradise. In Augustine we find quite a number of thought experiments. The one to be discussed now belongs to a *Christian theology of human sexuality*. Augustine felt compelled to perform the following thought experiment to test the consistency of his theological views about human sexuality (see *De Genesi Contra Manicheos* 1,19.30; 2.11.25, and *De Genesi Ad Litteram Libri Duodecim* 3,21.33; 9,3.6; 9,9.14; 9,10.16–18): Assuming that sexual intercourse, like mortality, is a consequence of the Fall, what kind of sexuality is it to which God commits Adam and Eve upon their creation by commanding them to procreate, if we imagine their body as similar to ours? This thought experiment matters to this day in the theological discussion over the meaning of human sexuality (Mailaender 2001).

The particular aim of the thought experiment is to clarify what the point of human sexuality in paradise is. Such clarification is necessary if one takes human nature at the time before the Fall as normative to derive a sexual ethics. When Augustine started to work on Genesis, he was convinced that sexual desire and thus sexual intercourse are a consequence of the Fall. But, if so, then we have to read God's command to procreate addressed to Adam and Eve in a different way than in terms of sexual intercourse. And this is what Augustine tries to do. He suggests that God meant a procreation in spirit, and thus speaks of children of the spirit instead of the flesh. Augustine's reading is understandable, because the immediate textual context does not mention the embodiment of Adam and Eve. The reading is challenged, however, once we reach the textual passage in Genesis that directs the attention to a kind of sexual dimorphism as it is implied by the creation of Eve. The text makes it clear that Eve is not just an Adam with a different name. Although the particular anatomical differences are not mentioned, the differences indicated in the text allow for the assumption that anatomically there is no difference between man and woman today and Adam and Eve. With this assumption in place, the question can arise as to what the meaning of the sexual dimorphism is if God's command to procreate addressed to Adam and Eve is to be

understood merely spiritually. Augustine suggests that the meaning of the sexual dimorphism has solely a symbolic purpose. He defines "children of the spirit" now as proper worship and argues that proper worship requires the obedient subordination of the woman to the man. This is said to represent that the man ought to be in obedient subordination to wisdom. And this in turn represents humanity's obedient subordination to Christ. In other words, the point of the sexual dimorphism is the proper symbolization of the divine cosmological order. So far, Augustine has been able to uphold his spiritual reading of the divine commandment to procreate addressed to Adam and Eve. But the fatal challenge to this reading emerges from a reflection on the fact that, according to the biblical text, Adam and Eve have been given food. Food, however, is only required by a mortal body. Mortality, however, is a consequence of the Fall. So, apparently there is desire for food in paradise. If so, it is questionable to assume that there was no sexual desire. Augustine realizes this, and changes his story once more. Now he assumes that there was a sexual desire in paradise. Still, in light of the assumption of original sin, for Augustine there must be an ontological difference in human sexuality before and after the Fall. Thus, he proposes to think of this difference in terms of the way in which sexual desire and reason relate. Before the Fall, sexual desire was well ordered as it was in alignment with reason. This is what has changed because of the Fall. A problem remains, however. Why would God create Adam and Eve sexually and command them to procreate if they are immortal? This is a problem if it is assumed that procreation is mainly a function of mortality. Augustine challenges this assumption and explains that procreation in paradise has two purposes—namely, to populate the earth and to add beauty to the world by increasing the number of beautiful humans.

As was mentioned at the beginning of this subsection, there are more thought experiments in Augustine (Fuhrer 2007). But this one is probably the most fantastic of his thought experiments, if not of Christian thought.

The nature of God's perfection. Everyone has heard of Anselm's ontological arguments for the existence of God as developed in chapter two and three of his *Proslogion* (Anselm 1998).[2] It is sufficient here to recall them in a simplified manner. One is a *reductio ad absurdum*. God as a perfect being, it is argued, cannot *not exist* without risking *a self-contradiction* in using competently the concept of God, because a perfect being that does not exist *is less perfect* than a perfect being that does exist. In its second version, the proof takes on the form of a modal-logical argument. An essentially perfect being like God exists necessarily, and such existence implies by logical necessity that an essentially perfect being exists in every possible world. Because it is conceivable that an essentially perfect being like God exists, God's existence is possible. Given this possibility it follows that God also exists necessarily in the actual world, because the actual world

is a realized possible world, and neither necessary existence nor essential perfection can change from world to world.

As popular as the ontological arguments are, their flaws are no less fatal. We don't have to recount the objections here, and will just assume that they cannot successfully prove God's existence. In other words, they fail as pieces of *philosophical* reasoning insofar as proofs for God's existence are part of philosophical theology. Yet, this cannot prevent us from reading them as successful thought experiments of Christian theology. To read Anselm's ontological arguments as thought experiments does not require us to challenge the historical fact that they were intended as a proof for God's existence. But there is no reason to assume that they can be read only as a proof for God's existence, and thus as pieces of philosophical reasoning.

Read as a thought experiment of Christian theology, the scenario remains the imagined nonexistence of God as a perfect being. But its aim is not to prove the existence of God but to clarify the nature of God insofar as God is a perfect being. In other words, the ontological argument as a thought experiment shows that "God exists *somehow* in some condition or other that is compatible with perfection" (Dombrowski 2006, 124). The point of the thought experiment is to indicate the need for specification with respect to the nature of God's perfection as it relates to God's conceivable, yet, in the context of Christian theology, impossible nonexistence. The idea is to read chapters 2 and 3 of Anselm's *Proslogion* in the context of the chapters that follow them, and not as a premise to these following chapters—that is, not as though these two chapters merely establish the existence of God, before God's nature is defined in the chapters that follow.

Divine perfection is crucial for Christian faith insofar as it seems that only a perfect being is worthy of worship. But what divine perfection means is not self-evident, and it is the task of Christian theology to develop a better understanding of it in response to scripture and the teaching of the church. The thought experiment of the imagined nonexistence of God can help to do that. For example, according to the reading of the *Proslogion* suggested here, Anselm does not assume that God is supremely intelligent to demonstrate that he cannot even be thought not to exist (Anselm 1998, 88). Instead, he comes to the conclusion that God can only be of supreme intelligence, because otherwise his conceivable nonexistence becomes possible, something to be avoided from the perspective of Christian faith and thus of theology. The central premise here is that the possibility of the nonexistence of God would place human intelligence above God's intelligence, because the human mind can produce a perfection that would be greater than God's if God lacked existence. Important to note is that there is an ambiguity here as far as the word "perfection" is concerned. It is used in two different ways. On the one hand, it individuates a particular feature of divine perfection, like

supreme intelligence. On the other hand, it is used as a placeholder in the sense of "in general unsurpassable and thus worthy of worship"—a legitimate assumption if the task is to define divine perfection instead of establishing the existence of a perfect being.

It is possible to read also the problem of theodicy as a thought experiment in a way similar to our appropriation of Anselm's ontological arguments. Again, it is not necessary to doubt that the most prevalent use of this problem is to develop a philosophical argument against God's existence as defined by classical theism (highlighting God's omniscience, omnipotence, and perfect goodness). Instead of challenging the existence of God as defined by classical theism, the imagined coexistence of God and evil raises questions that concern the nature of God's perfection. In Christian theology this thought experiment can serve to qualify why it is that God became incarnate. In the light of evil, one could argue, God's perfection is not sufficiently defined in terms of omnipotence and perfect goodness. The existence of evil helps Christian theology to realize that God is perfect in that God becomes incarnate to declare solidarity with humanity and to reveal the meaning of evil. Of course, this will and should not convince anyone who rightly claims that the existence of evil challenges the philosophical claim that God exists as defined by classical theism.

The same seems to be true with respect to the famous thought experiment that has us imagining God creating a stone which is too heavy for God to lift—something that is logically possible, and that God should, therefore, be able to do. If God can do so, then God is not omnipotent, because there is a stone God cannot lift. If God cannot create such a stone, then God is not omnipotent, because God is limited in the power to create. Philosophically, this thought experiment has been taken as a challenge to classical theism with respect to its assumption of divine omnipotence. In the context of Christian theology, however, this thought experiment can prove highly fertile, in that it triggers a theological discourse about the reasons why God will not do anything that limits God's omnipotence, like creating a stone that is too heavy for God to lift (Swinburne 1993, 153–66).

Incarnation and crucifixion. There are two further wonderful thought experiments in Christian theology which are closely related insofar as Christology and Soteriology are intertwined. One has us supposing that humans have not sinned. Its particular aim is to determine the theological significance of the incarnation. Let us call it the *incarnation thought experiment*. The other one requires us to suppose that Jesus did not die on the cross. Its particular aim is to determine the theological meaning of the crucifixion. Let us call it the *crucifixion thought experiment*. The two thought experiments are closely related insofar as one could argue, for example, that the point of the incarnation is redemption, and that

such redemption would have been impossible without the crucifixion. The two thought experiments are also similar in that they trigger the difficult question as to how to relate historical and theological evidence on matters of Christian faith. There is the risk in Christian theology either to ignore the historical facts and to engage in abstract theological reasoning, or to fall prey to a form of historicism where any kind of theological meaning of history evaporates (Swinburne 2003, 3). Thought experiments are an ideal tool to address this challenge in theological reflections on the incarnation and the crucifixion.

Irenaeus was the first to perform the *incarnation thought experiment*, and its original context was the debate over Docetism, according to which Christ has not taken on flesh and blood. If Christ had not taken on flesh and blood, argues Irenaeus in *Adversus Haereses* 5,14, then we would not have been saved, because there were humans of flesh and blood to be saved, and this required the incarnation of God in a human being of flesh and blood (Moiser 1973, 288). The incarnation thought experiment has produced basically three different views of the incarnation in the course of the history of Christian thought (Moiser 1973, 288–93). In each case the thought experimental scenario is slightly modified.

The so-called *Thomistic view* is that the redemption from sin is the point of the incarnation. Obviously, Thomas Aquinas was not the first to hold this view; Irenaeus shares it. But it came to prominence with Thomas, thus it is called the Thomistic view (for a most helpful analysis of it as presented in the *Summa* see Mostert 1978). The so-called *Scotist view* is that the incarnation is theologically independent of the Fall. John Duns Scotus emphasized the absolute primacy of Christ and argued that the incarnation is an end in itself—namely, to bring creation to its summit and perfection. In the twentieth-century theologians like Teilhard de Chardin and Karl Rahner defended this Scotist view. Francisco Suarez has tried to find middle ground between these two views, and he is the starting point for a third, much less influential, line of reasoning to determine the point of the incarnation. At the beginning of the world, God aimed for an incarnation for the sake of perfecting the creation. Yet, since the Fall, the incarnation is not sufficiently explained any longer unless its redemptive character is *also* taken into account. God knew that there would be a Fall, and that the already planned incarnation could be a way of providing redemption.

The *crucifixion thought experiment* underlies actually every Christian theology of the cross. It is justified to suppose that Jesus could have died in a different way than on the cross, and this for a number of reasons (for what immediately follows see Eire 2006, 119–37). To begin with, all the gospels imply that things could have gone differently. We learn through the gospels that the Roman procurator Pontius Pilate was eager to set Jesus free. It is safe to assume that the riots, if any, that might have resulted

from Pontius Pilate setting Jesus free could have been gotten under control by the Romans without much effort. So, Pontius Pilate did not want and did not have to crucify Jesus. Furthermore, the crucifixion as the central redemptive moment in the mission of Christ from the perspective of today's Christianity was the result of and not pregiven in the intense theological reflection on the life and death of Jesus Christ. The gospels make it very clear that Jesus and his mission was ambiguous and open to all sorts of interpretation. We learn through the gospels that Jesus constantly expresses frustration over the fact that no one seems to comprehend what he preaches. Related to this is that Jesus had no control over how others would interpret him or his mission. Some thought he was a prophet, and others believed he was Elijah redivivus. Furthermore, although Jesus predicted his own death, he contemplates the possibility of a different outcome when he prayed to the Father the night before his death on the cross. We also learn through the gospels that Jesus had limited knowledge about the course that his salvific work would take. Jesus predicted the coming of the kingdom of God and a radical transformation of the world. But he had to admit that only the Father knew when this would be. So, we do not have to assume that Jesus necessarily knew that he would have to die on the cross to bring about salvation and redemption. Finally, the New Testament includes a variety of interpretations of Jesus, his life and work. This is reflected in the pluralism in Christology in the early church. This in turn reflects the fact that Christianity is based on ambiguous historical narrative for its belief structure.

Given the legitimacy of the supposition of an uncrucified Jesus despite the significance of the cross in actual Christianity, we can follow Eire (2006) in comparing two scenarios, in both of which Jesus has been released by Pontius Pilate. In one scenario Jesus keeps spreading his message, covers more territory, remains a figure that is perceived in different ways, and very soon clashes again with the Roman authorities, and dies eventually a violent death of a different kind than by crucifixion. In the other scenario, the Romans protect Jesus because of his teaching, which emphasizes submission to earthly authorities. After his nonviolent death Jesus's religious teaching eventually gets integrated into Roman religious eclecticism. Each of the two scenarios requires a fleshing out by speculation that is based on historical facts, something we don't have to do here because Eire (2006) has done it quite eloquently. To state at least the result of the exercise of counterfactual history in Eire (2006): Without the cross Christianity as we know it would still have emerged as long as Jesus had died some kind of violent death. Without any violent death Christianity as we know it would not have come about. Instead, a Christianity would have developed that is better described as a "universalized Judaism." Such Judaism would have been influenced by Jesus's teaching but would not have produced something like the Chalcedonian formula.

The crucifixion thought experiment probably explains the wide variety of theological views of the crucifixion that have been proposed in the course of the history of Christian thought (Brondos 2001), although in many of them historical considerations often come short and soteriological reflections dominate. Many of the church fathers argued that the cross was necessary to overcome the power of evil. Others have favored the view that by means of the crucifixion, Jesus offered the satisfaction that humanity owed to God because of the Fall and that God could not have forgiven otherwise (Anselm). Again others proposed a third view—namely, that the crucifixion provided an example as to how to have full community with God, despite a fallen human nature (Abelard, Barth, Bultmann, Peter Knauer). Brondos (2001) argues that in all these views theology and history have not been properly related. He proposes therefore that in the light of historical data and theological reasons the cross does not stand for a violent death which must be deemed necessary from a theological point of view to bring about salvation. The crucifixion as such did not bring salvation but the faithfulness of Jesus unto death in carrying out his ministry for others. The fact that the crucifixion thought experiment can be used in the context of history, as in Eire (2006), and in theology as in Brondos (2001) affirms the interdisciplinary significance of thought experimentation that comes into focus with Polkinghorne's observation about the importance and cognitive efficacy of this practice in quantum physics and Christian theology. We will turn now to the question as to how to explain the evidential significance that some thought experiments in science and theology obviously have.

Explaining Thought Experimentation

Much has been written on thought experiments, and many accounts have been proposed to make sense of them (Kuhn 1977; Miščević 1992; Brown and Fehige 2010).

Given the constraints of a paper like this, it is impossible to do justice to the complexity that the debate on thought experiments has assumed. Fortunately, the principal aim of the following considerations does not require this. The point of this section is to sketch a possible way to account for the cognitive efficacy that Polkinghorne assigns to the practice of thought experimentation in quantum physics and Christian theology. To that effect it should be stressed first that Polkinghorne's claim about thought experimentation as a joint practice of theology and science is challenging, because not all the existing accounts of thought experiments allow for such a claim. For example, Bealer (1998, 207 and 208) has argued for a distinction between *physical* and *rational* intuitions, and against the idea of thought experiments involving rational intuitions. Therefore, there can be no thought experiments in mathematics, philosophy, or Christian

theology, because in these disciplines we deal with logical and metaphysical possibilities and thus with rational intuitions. There can be only scientific thought experiments because only here do we deal with physical intuitions. It is in favor of Polkinghorne's claim about thought experiments as a joint practice of theology and science that the phenomenology that justifies George Bealer's distinction between rational and physical intuitions is problematic. Bealer (1998, 208) claims that rational intuitions, unlike physical intuitions, are immutable. But this seems wrong. An example suffices to show why.

Arguably, everyone has had the intuition that there is a set of all sets, before acquiring some fundamental knowledge of set theory. There is a set of all elephants, the set of all books, of all journal papers, and so on. This probably explains why it is intuitively plausible for most people that there is a set of all sets. Yet, this intuition disappears once the many problems of such a universal set are internalized. Just think about the question whether or not the set of all sets contains itself. If it does, then it is not the set of all sets, because it is part of a larger set of sets. If it does not, then it is not the set of all sets, because it itself is a set. As a result of contemplating such paradoxes, the intuition disappears that there is a set of all sets. Because this is an instance of what Bealer (1998) calls a rational intuition, it is therefore hard to see that rational intuitions could be distinguished from physical intuitions in terms of immutability.

A promising alternative to account for thought experiments of evidential significance in terms of intuitions is to think of intuitions "as mental propositional attitudes which are accompanied by a strong feeling of certainty" (Brendel 2004, 96). They are an "inevitable but fallible and sometimes unreliable source of evidence" (Brendel 2004, 97). The idea is to follow empirical psychology in its judgment that "just by living we acquire intuitive expertise" (Myers 2004, 67). The ability to form mental propositional attitudes is innate. Particular mental attitudes are the result of engaging with the world. In my view, the degree of certainty C in the feeling that accompanies a particular mental attitude A regarding a proposition p depends on the *frequency by which* A and p are linked. This frequency is a function of the interactions with the natural and social environment, and in this sense context-dependent. Also, the more abstract the propositional content the greater the dependence on the social environment, because abstract entities are not part of the natural environment. The greater the dependence on the social environment, like a community of scholars, the more important it is to be part of that environment to share certain intuitions. For example, the more advanced the socialization into the community of logicians the lower C in the feeling that accompanies A regarding the proposition that "there is a set of all sets."

What follows is that the scenario of a thought experiment is progressively strengthened as those features relevant for linking A and p are depicted

more accurately and completely. Empirical psychology has identified a number of ways in which our ability to intuit can be misled, and thus produce misleading intuitions (Myers 2004; Bishop and Trout 2005). In such cases, *C* might be high but only because of a mismatch of *A* and *p*. *p* is entertained but in a way that *A* matches *p'* instead of *p.* This is basically what Bohr's objection to Einstein's *clock-in-the-box* scenario amounts to. The scenario is not accurately and completely depicted with respect to the way in which the weight of the box is determined. Once we add the missing information it becomes clear that our intuition has been misled by Einstein's scenario of the *clock-in-the-box*. Similarly, the incarnation thought experiment and crucifixion thought experiment require that the respective scenarios do justice to the relevant historical circumstances, among other relevant conditions.

What is even more interesting in the case of the *clock-in-the-box* is that Einstein's scenario challenged Bohr, despite the latter's commitment to the Heisenberg uncertainty relation for energy and time, and that Bohr's scenario challenged Einstein, despite the latter's skepticism about the Heisenberg uncertainty relation for energy and time. Facing Einstein's scenario of the *clock-in-the-box,* Bohr probably did not *believe* that the Heisenberg uncertainty relation for energy and time would not hold, and facing Bohr's version, Einstein probably did not *believe* that it would. To account for that, we can use the distinction between a proposition *p* and a belief *B. C* in the feeling that accompanies *A* regarding *p* can be quite high but still not establish *p* as *B.* A thought experiment might establish *p* by means of a high value for *C* in the feeling accompanying *A* regarding *p*, and yet not establish *p* as *B*. The likelihood that a thought experiment establishes *p* as *B* is increased as *p*'s tension with other relevant beliefs is decreased. A thought experiment is of overwhelming evidential significance if *p* is established as *B*, despite a strong tension between *p* and other beliefs held by a subject *S* that are relevant to *p.* The *clock-in-the-box* is not a thought experiment of overwhelming evidential significance. Yet, it is still of cognitive efficacy, because it establishes successfully intuitions that challenge beliefs relevant to *p,* and thereby renders them counterintuitive. Galileo's falling conjoined cannon balls of different weights, on the other hand, is of overwhelming evidential significance. If the Aristotelian is willing to accept Galileo's assumption that mechanics is about *phenomena* and not *natural occurrences* (for the importance of this assumption, see McAllister 1996), then the thought experiment establishes with overwhelming significance that all bodies fall at the same speed. Something comparable happens in Augustine's thought experiment on sex in paradise. It is of overwhelming evidential significance in that it establishes the belief that there must have been sex—similar to what we call sex today—in paradise. Consequently, Augustine revises his beliefs about

the nature of God's command to procreate addressed to Adam and Eve, and also his theory as to how the Fall has affected human sexuality. As these examples nicely illustrate, thought experiments of overwhelming evidential significance can induce *belief revisions*, because they introduce *p* as *B* and thereby a possible conflict in a set of beliefs of which *p* as *B* has become an element.

Nothing in what has been said so far will convince anyone who is skeptical about the cognitive efficacy of intuitions, and it was not intended to do so. Despite the skeptical objections, it is safe to assume that creativity in science and theology would be impossible without intuitions. This is not to deny that still much has to be done in philosophy to develop a theory of intuitions. Timothy Williamson's observation is still right that "philosophy has no agreed or even popular account of how intuition might work, no accepted explanation of the hoped-for correlation between our having an intuition that P and its being true that P" (Williamson 2004, 109). But this fact obviously does not necessarily speak in favor of the skeptic. In addition, in the present context, the above sketched account of thought experiments is meant as a suggestion as to how to clarify Polkinghorne's claim that thought experiments are cognitively useful in quantum physics and Christian theology.

The account sketched above can accommodate the claim that thought experiments matter in theology and science, because, like everywhere else, intuitions matter in both areas, especially when in comes to *theoretical creativity*. What thought experiments do is to trigger intuitions that are otherwise inaccessible. They are inaccessible, because they are unconscious in a non-Freudian sense (Wilson 2002, 1–66). Empirical psychology has come to state that we process a sophisticated and efficient set of nonconscious processes that are just indispensable for navigating our way through the world. The unconscious encompasses mental processes like intuition that are consciously inaccessible but nevertheless influence our judgments, feelings, and behavior. This is true in everyday life and scholarship. The human mind evolved in a way that it is "buzzing with influential happenings that are not reportedly conscious" (Myers 2004, 23). There is a "mushrooming mountain of evidence" indicating that "we have two minds—two ways of knowing" (Myers 2004, 51). Brown is right in this respect, and he gains additional support for his view that thought experimentation is all about intuitions from the fact that the majority of Nobel laureates implicate intuition in their success (Myers 2004, 61). But, contrary to what Brown's Platonism implies, the intuitive expertise is acquired through interactions with the natural and social environment. It is not due to a capability of the mind's eye.

The problem to which thought experimentation provides a solution is the inaccessibility of those intuitions that influence scientists and

theologians in their work. Introspection is not an option to access intuitions, because empirical studies have demonstrated that it is more a construction than a discovery (Wilson 2002, 159–81). This is not a useful method, therefore, if we are interested in what our intuitions really are. Empirical psychologists advise us therefore to observe our behavior or to keep a diary to detect what is going on unconsciously. Thought experimentation, as it were, is a way of "keeping a diary." Through thought experiments physicists and theologians alike are able to access intuitions that affect their theoretical work.

At this point we come to appreciate how appropriate it is that Polkinghorne has compared quantum physics and Christology in QT. In both quantum physics and Christology the subject matter under scrutiny has reached a degree of abstractness that makes intuitions to a high degree dependent on the social environment—that is, the community of physicists and Christian theologians. This explains why thought experiments have a limited scope in the sense that they do not necessarily speak to everyone, not even to every physicist or Christian theologian. The more abstract a subject matter is, the greater is the fragmentation of a community of scholars. It is different from fragmentation due to requirements in skills. Furthermore, the subject matter of quantum physics and Christian theology is odd in a similar way. The quantum world, as it were, and the divine reality are very different from the world as we know it in everyday life. Despite these commonalities, we should not forget, however, that there are important differences between theology and science. These must be reflected in a theory of thought experimentation, and Polkinghorne is the last person who would want to see anything else. He identifies four significant differences between theology and science (Polkinghorne 2007, 10–4). We will address them now one after the other and specify some of the implications of each for the sketched account of thought experimentation.

1 & 2. Foundational event, tradition, and church community. The first two of the four differences that Polkinghorne states can be put as follows: given a mind-independent reality R as the proper domain of investigation of either science or theology, a particular period of time t, direct accessibility D to R, and God's initiative I, then, unlike in science, in theology we have D to R only at t, and this depending on I. So, in the case of theology, D to R is not only a function of the nature of human cognition and technological equipment. There is a restriction on D emerging mainly from I. Polkinghorne speaks of D to R at t because of I as the foundational event of a religion. A foundational event is best defined as a class of state of affairs that is constitutive for a religion. In the case of Christianity, this is the history of Ancient Israel and the life, death, and resurrection of Jesus. In other words, the foundational event is the time of what is commonly called "original revelation." It has provided the "data" for Christian theology.

Christian theology cannot but revisit this foundational event in its exploration of divine reality, and it has to do so, because of *I*. For, the proper response to *I* is faith, and Christian theology is the systematic-methodological reflection of and on faith. Christian theology can revisit the foundational event only through an in-depth engagement with tradition and scripture, both of which are taken by the church as authentic reflections of the foundational event. Tradition and scripture have, therefore, continuing significance. The danger resulting from this hermeneutical situation for Christian theology is falling prey to habits of thought. That is to say that there is a stronger risk of theoretical stagnancy in theology than in science, because, disregarding limits of skills and technology, in science *D* to *R* is given at any time and independently of *I*.

Thought experiments can generally be of help in preventing theoretical stagnation. The eighteenth century philosopher-scientist Georg-Christoph Lichtenberg has emphasized this feature of thought experimentation. Under the strong influence of Kant's philosophy (Hermann 1974) he has expressed it as follows:

> For how long have the ingredients for gunpowder existed before gunpowder was invented? There is no natural aqua regis. If we rely only on the natural fore-ordering of the structures of the mind and reason, then many concepts will remain so stuck to other concepts, and will never be combined with others in the way that they should be. If only there were a procedure like decomposition in chemistry, where the elements swim around, lightly suspended, able to combine and recombine to form any product. But since such a procedure is not available, one has to join things together intentionally. One has to *experiment with ideas*. A convenient way to *experiment with thoughts* is to ask questions about particular things. . . .[3] (K308)

We don't have to commit ourselves to Lichtenberg's reading of the Kantian "natural fore-ordering of the structures of the mind and reason" to appreciate Lichtenberg's main point, which is that thought experiments can help in preventing or in overcoming theoretical stagnation. It is possible to read the "natural fore-ordering of the structures of the mind and reason" in the neo-Kantian sense of Friedman (2002). In this case, Lichtenberg's statement amounts to the claim that thought experiments in Christian theology can be of help to examine the metaphysical-epistemological framework that guides reflections on the foundational event, including those expressed in assertions of the Christian tradition and scripture. To a higher degree than in science, this framework can be reason for theoretical stagnancy. In a way similar to scientific progress via thought experimentation (McAllister 1996), thought experiments can be of assistance in theological progress, because they trigger intuitions that might conflict with or deepen and develop crucial elements of

this metaphysical-epistemological framework, and thus induce belief revisions.

For example, to imagine the New Jerusalem can facilitate the exposition and examination of the metaphysical-epistemological framework that contextualizes the Old-Testament imagery with respect to Jerusalem. The question can then arise what it is about Jerusalem that should shape Christian hope. Likewise, the thought experiment that has us imagining Jesus dying uncrucified triggers intuitions that render certain beliefs counterintuitive—for example, the belief that the crucifixion is more than a historical contingency—namely, that it is meant by divine will to be the climax of the incarnation, and this since God decided to create the world. One way of dealing with the challenges that result from the thought experiment with an uncrucified Jesus is to look into the metaphysical-epistemological framework that guides entrenched theories when assessing the "data" (Polkinghorne) of the original revelation, including the historical fact of the crucifixion. Such an examination brings into focus, for example, different readings of necessity as they pertain to an historical event like the crucifixion within the history of salvation, and the relationship between historical contingency and divine providence.

Our main concern here is not how to interpret Lichtenberg's views of thought experiments, but to appropriate his conviction that thought experiments can matter crucially when overcoming theoretical stagnation. This is an important point in our context, because the first two differences between theology and science that Polkinghorne highlights in QT imply that theology, compared to science, is to a higher degree susceptible to theoretical stagnation, because D to R is restricted to t, and this depending on I. Therefore, it seems that thought experiments are of greater importance in Christian theology than science.

3. Faith dependence. It is not only the case that D to R is restricted to t, and this depending on I. In addition, the occurrences related to D to R at t are not public and repeatable in the sense those occurrences are that are subject to scientific investigation. In other words, there is a greater *subjective* component in theology than in science. This seems to make thought experiments even more important in Christian theology than suggested by the first two differences between theology and science as highlighted by Polkinghorne. At this point we come to appreciate the importance of the fact that we find thought experiments in scripture. In reflecting upon the foundational event, scripture itself employs thought experiments (like the ones in Revelation) to expose and examine those intuitions that have guided the first followers of Jesus while facing the occurrences related to the life, death and resurrection of Jesus. In Polkinghorne's view, what scripture does is to collect and provide the data of the original revelation. In science, a sound methodology makes sure that intuitions do not exclusively guide real-world experiments when collecting data. But, of course, such a

methodology is not available when it comes to matters of faith. Thought experiments seem a very good way for the faithful to collect the data of the original revelation. To the extent that scripture is normative for Christian theology, thought experiments themselves become a normative practice for Christian scholarship in reflecting upon the thought experiment–based reflections of the early church in collecting the data of the original revelation as recorded in scripture.

4. Existential dimension. The subject matter of Christian theology affects human life to a higher degree than the reality scrutinized by science, claims Polkinghorne. Disregarding the more general problem whether or not all religious beliefs are the result of wishful thinking resulting from the challenges in living a human life, there is a serious specific challenge that emerges from a very intimate linkage in Christian theology between theoretical issues and a particular way of living a human life. This is to say that it is, by far, more difficult to detect bias in Christian theology than in science. Scientific and theological reasoning both can suffer from bias. But scientific methodology is more effective in avoiding bias. This is partly because of the fact that certain aspects of human life are just not dealt with. What follows from this regarding thought experimentation is that thought experiments always run the risk of reaffirming prejudice as they result from the way a particular faith community or denomination lives a Christian life. Living a Christian life in a certain way affects answers to a number of controversial theological questions. All too easily the scenarios of a thought experiment can be set up in a way that align to a particular form of living a Christian life so that only the desired intuitions are triggered.

The challenge posed by too strong a bias in thought experimentation emerging from the existential dimension of Christian theology is serious but not fatal. One can uphold the usefulness of thought experimentation in Christian theology, and this for at least two reasons. First, thought experiments very often initiate a debate over controversial issues without just giving up on a particular view or merely assuming a new position. In Christian theology, they might provide the only venue for exposing in an uncontroversial manner the link between a particular religious life-style and a certain theological view. Thought experiments are, as it were, noncommittal. Second, as the many thought experiments discussed demonstrate, there is always the option to modify a proposed scenario. Especially in ecumenical discussions, this might help to see where differences in theological position reflect differences in living a Christian life. Of course, thought experiments alone will not help to decide which is the better form of life. This would make too great demands on a method that is shared by physicists and theologians and hopefully will receive more attention in the future.

Conclusion

Given the centrality of Christian theology in the history of universities in the West, it is surprising to read that in the West theology today has become "a marginalized discipline in contemporary intellectual life" (Klemm and Klink 2003, 495).[4] In the words of Dawkins (2006, 57): "I have yet to see any good reason to suppose that theology . . . is a subject at all," which is perceived by some practicing scientists of Christian faith as an excellent example of the "ultra-Darwinist's" general inability to see "that theology might have its own richness and subtleties, and might—strange thought—actually tell us things about the world that are not only to our real advantage, but will never be revealed by science" (Conway Morris 2003, 316).

The dismissive attitude toward theology most likely explains the "fear that the prevailing outré thought experiments pull analytic philosophy in the direction of theology" (Peijnenburg and Atkinson 2007, 318). Such fear probably exists because theology is perceived as lacking so many of the features of science that elicit widespread approval and praise—most notably, the presence of a sound methodology. But, as the above discussion shows, thought experimentation is a practice common in quantum physics and Christian theology. That fact alone suggests that those who are skeptical about theology might want to reconsider their position. Eschewing theology could undermine a positive attitude toward thought experiments. Yet, although there might be a majority today who wish to avoid theology, apprehension about thought experiments is undeniably a minority position. Future discussions will have to determine how to resolve this tension, and thereby reconsider the relationship between theology and science.

Acknowledgment

I would like to thank two anonymous referees for extremely helpful comments.

Notes

1. Some commentaries include 19:11–20 to 20:15 in the "grand final" of the book, but still separate it from the unit of 21:1–22:5.

2. It is a matter of debate whether or not Anselm presented one or two arguments. I would like to remain neutral on this question, but merely speak of two arguments in light of the difference in logical form. This does not exclude the possibility that we are dealing with two parts of one and the same argument.

3. My own translation. For the original text, see Lichtenberg (1971), 453 and 454: "Wie lange haben nicht die Ingredienzen des Schießpulvers existiert vor dem Schießpulver? Ein natürliches aqua regis gibt es nicht. Wenn wir beim Nachdenken uns den natürlichen Fügungen der Verstandesformen und der Vernunft überlassen, so *kleben* die Begriffe oft zu sehr an andern, daß sie sich nicht mit denen vereinigen können, denen sie eigentlich zugehören. Wenn es doch da etwas gäbe, wie in der Chemie Auflösung, wo die einzelnen Teile leicht suspendiert schwimmen

und daher jedem Zuge folgen können. Da aber dieses nicht angeht, so muss man die Dinge vorsätzlich zusammen bringen. Man muss mit Ideen *experimentieren*. Ein bequemes Mittel mit Gedanken zu experimentieren ist, über einzelne Dinge Fragen aufzusetzen. . . ." Lichtenberg preferred to write in aphorisms. They are quoted by the letter assigned to a book—namely A-L—and the number of the aphorism within that book. So "K308" can be found in Book K, aphorism 308.

4. Ulrich Köpf has argued that such marginalization of theology has led to the birth of a "Theologische Wissenschaftstheorie" (a theological theory of science) in the 13th century. See Köpf (1974). Unlike "Fundamentaltheologie" (foundational theology) and "Theologische Erkenntnis- and Prinzipienlehre" (theological epistemology) the "Theologische Wissenschaftstheorie" responded to the particular objection that theology cannot be a "science" like the other two of the three medieval "speculative sciences"—namely "mathematics and natural philosophy" (Harris 2010, 25) because of considerable dissimilarities in aim, subject matter and method (Köpf 1974, 2).

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