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Closed Theories, Falsificationism and Non-Cumulative Progress

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Abstract. It is argued that scientific progress occurs not with the cumulative growth of knowledge or when theories get closer to the truth but with discovering new domains and new theories that fit these domains. This horizontal view on the direction of scientific progress (in contrast to vertical, when we aim to get from here to the abstract and ephemeral truth) allows avoiding traditional objections posed by the incommensurability thesis and pessimistic induction, namely, that radical theory changes leave no room for progress. According to this perspective, the discovery of quantum mechanics as a new field of inquiry is a progress in itself, since this discovery had opened up a new distinctive domain of physics and a new theory that fits this domain. While some perspectives on scientific progress maintain that there is a need for correspondence between competing theories, we shift the emphasis from correspondence towards the discovery of new domains and new theories that apply to those domains. This approach allows overcoming the problem of theoretical discontinuity after scientific revolutions. Correspondence between theories is an important but not necessary condition for progress, while the falsifiability of theories as a means of demonstrating the boundaries of old theories and domains and beginnings of the new domains and theories (instead of being merely a means of refutation) is a necessary condition.
Keywords: scientific progress, correspondence principle, closed theories, discovery, theory

Uždaros teorijos, falsifikacionizmas ir nekumuliatyvi pažanga

Santrauka. Esama nuomonės, kad mokslo pažanga vyksta ne kumuliatyviai augant žinojimui ar mokslo teorijoms artėjant prie tiesos, o atrandant naujas sritis ir naujas toms sritims tinkančias teorijas. Toks horizontalus žvilgsnis į mokslo pažangą (priešingai nei vertikalusis, kai siekiama iš pradžios taško pasiekti abstrakčią ir efemerišką tiesą) leidžia išvengti įprastų prieštaravimų kylančių iš nebendramatiškumo tezės ir pesimistinės indukcijos, t.y., iš nuostatos, kad radikalūs teorijos pokyčiai užkerta kelią pažangai. Remiantis šia perspektyva, kvantinės mechanikos kaip naujos tyrimų srities atradimas yra savaime pažangus, nes atveria naują, atskirą fizikos sritį ir pasiūlo naują teoriją, tinkančią šiai sričiai. Nors kai kurios koncepcijos pripažįsta, kad turėtų būti tam tikras atitikimas tarp besivaržančių teorijų, straipsnyje teikiama daugiau dėmesio ne atitikimui, o naujų sričių ir joms taikomų teorijų atradimui. Tokia prieiga suteikia galimybę įveikti teorinio tęstinumo problemą, atsirandančią po mokslinių revoliucijų. Atitikimas tarp teorijų yra svarbi bet nebūtina pažangos sąlyga; tuo tarpu teorijų falsifikuojamumas kaip būdas pademonstruoti senųjų teorijų ribas ir naujųjų teorijų sritis bei jų pradžią yra būtina mokslo pažangos sąlyga.
Pagrindiniai žodžiai: mokslo pažanga, atitikimo principas, uždaros teorijos, atradimas, teorija

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Introduction

Scientific progress, rationality and the scientific status of a theory change, as well as the development in scientific inquiry, are central aspects of the philosophy of science that philosophers need to demonstrate and prove that these features are really present in scientific practice. It is however still not evident that these virtues can be assigned to science and many different conceptions have been offered on what scientific progress and rationality are about and how not to confuse it with mere change (Niiniluoto 1984).

All most popular realist's conceptions of scientific progress imply a continuity of reference between successful theories when the successor theory appear to be "a correction and improvement of its predecessor" (Doppelt 2005: 1085) and retains at least structurally previous theory as a special case (Bokulich and Bokulich 2005). Together with the problem of Popperian falsificationism, which faces a range of objections from Duhem-Quine to Lakatos, a continuity of reference faces too strong objections and counter evidences from the history of science to accept them as criteria of progress (Jones and Perry 1982). Progress should be found and traced not in the process of transition from one theory to another but it is more reasonable to confirm the progress when new domains of science emerge and new theories for these domains developed even when no correspondence between these domains and theories exist. For this concept of scientific progress, we should revisit the notion of falsifiability and reduce our demands for this tool so that the task of falsification is to recognize and mark the boundaries of existing theories and placed where new domains and theories can be found. Refutation in this case is desirable but not necessary condition for theories and scientists who use them. This account of scientific progress and falsification allows escaping; for example, Kuhn's objection against the impossibility of objective, rational and progressive choice between incommensurable theories and paradigms, since we can go beyond old and new paradigms which explain the same phenomena (Kuhn 1962). We can trace the progress beyond this paradigm replacement and see the progress as an emergence of new paradigm or theory that emerge as a result of attempts to explain new classes of phenomena and new areas of nature. This same account can also resist realists' overoptimistic view on the science as approximation to the truth (Popper 1963; Niiniluoto 2015) and partly avoid antirealists' claims about the absence of progress since our best theories are likely to be false. In other words, we can move beyond to objections against the possibility of scientific progress: the one that rejects the possibility of progress and rationality since there is no continuity in science (Kuhnian incommensurability) and the one that rejects the progress and rationality since the fact of false but successful theories gives no reason to see progress as a cumulative approximation towards the truth.

The paper is structured as follows. First, we review and discuss the notion of correspondence in the philosophy of science literature with special attention to its different meanings and important in scientific progress debates. Second, we discuss the concept of falsification, review various objections against this statement as the criterion of progress and rationality and suggest the weaker formulation of falsifiability as the concept that doesn't require falsified theories to be necessarily refuted. The next section discusses the most popular theories of scientific progress and various objections against them. Finally, the last section develops a new account of scientific progress based on our weaker formulation of falsifiability, discoveries of new domains of science and new theories for them and where correspondence between theories is neither a sufficient nor necessary condition for scientific progress.

Correspondence and Continuity in Theory Change

The correspondence principle in its various forms has one common ground in philosophy of science as its main aim is to demonstrate the evidence of progressive nature in theory change (Krajewski 1977; Aksom et al. 2020). Niels Bohr's generalization of Classical Mechanics by means of correspondence principle demonstrated the continuity and survival of theoretical knowledge in change from Classical Mechanics to Quantum Mechanics (Jammer 1966). Correspondence principle epitomizes a belief in continuity between Classical and Quantum Mechanics that "classical mechanics must somehow emerge from quantum mechanics—that a classical limit of quantum mechanics must exist" (Bowman 2005: 605). Bohr attempted to minimize the radicalness of departure from classical mechanics and show that "quantum mechanics should be a theory that departs as little as possible from classical mechanics" (Bokulich and Bokulich 2005: 349; Klein 2012; Allori and Zanghì 2009). According to this principle, classical mechanics are to be regarded as a limiting case of quantum mechanics. Thus, the Shrodinger wave equitation for quantum mechanics passes into the classical Hamilton-Jacobi equation $\hbar \rightarrow 0$ so that the equation $pq - qp = h$ passes into the classical $pq = qp$ (Rosen 1964; Bokulich 2014). At the same time there exist problems with complete and nonconflicting transition from classical to quantum and vice versa (see Allori and Zanghi 2009).

Worrall's Structural Realism is another type of correspondence principle which was a response to pessimistic induction (Psillos 1999) by means of offering a tradeoff between scientific realism and antirealists' rejection of unobservable entities and continuity (Psillos 1995). Structural realism hopes to save the qualitative nature of theory change and resist the argument about the radical discontinuity between theories during scientific revolutions by claiming that there is continuity in the mathematical structure of mature scientific theories through theory change. According to structural realists, even though ontology may be lost in transition, it is the logic form or structure that survives. The knowledge on the relationship between phenomena survives even after scientific revolutions.

Correspondence principle culminates in Heinz Post's heuristic principle as his interpretation of theory change not only required retaining some key elements and structures of predecessor theory but also maintained that a new theory should incorporate and explain the success of the theory it supersedes (Radder 1991). In particular, Post argued that

> "the requirement that any acceptable new theory L should account for the success of its predecessor S by "degenerating" into that theory under those conditions under which S has been well confirmed by tests" (Post 1971: 228).

In this paper we will show that establishing the boundaries or existing theories by means of falsification, maintaining them as limited but closed theories, and discovering new domains of science are more important indicators of progress than correspondence and continuity. Although, in particular, Bohr's generalization of classical mechanics to quantum domain aims at retaining the former theory as a valid and empirical adequate in its limited domain of application, this approach also puts forward an optimistic view on theory change as one "unbroken, continuous development" (Bokulich and Bokulich 2005: 349). It is an attractive but not necessary condition for scientific progress. Moreover, as it has been already noted by both working scientists and philosophers, the link between the two theories is not so evident.

The Possibility of Falsification and Its Role in Scientific Progress

One of the cornerstones of the philosophy of science in the last century is a concept of falsification which Sir Karl Popper put forward in order to solve the problem of demarcation, induction and scientific progress. For Popper, falsifiability of theories allows solving all these problems and plays central role in scientific progress (Kelly and Glymour 1989). Falsification for him is the very instrument which allows recognizing progress and rationality, as in natural selection, when theories compete against each other in order to better explain and predict the same phenomena or account for more phenomena. If accepting the impossibility of ever verifying theories, we can nevertheless falsify and refute them, which, in turn, ensures the progressive growth of science – verisimilitude.

Popper's falsificationism belongs to the few philosophical concepts that working scientists acknowledge and agree with. But their appreciation does not go beyond pure admittance that falsifiability is a virtue that any theory should have in order to accept this theory as scientific. Being in principle open for empirical tests and falsification is not the same as being open for refutation and replacement. Working scientists are not willing to reject once-accepted theories when they are confronted with empirical anomalies. As Millman summarized, Kuhn, Lakatos, Feyerabend and some other prominent philosophers of science doubted that scientists would discard theories based on any observations. Specifically, "a theory may be contradicted by plain and unambiguous facts and yet, since such facts have often themselves proved to be defective and capable of rejection, a theory refuted by such facts may be retained even though scientists do not know how to challenge the refuting facts" (Millman 1990: 23). In particular, Lakatos starts his "research programs" argumentation from acknowledging the clash between a theory of falsifiability and reality of everyday puzzle-solving reality of scientific conduct:

"Popper ignores the remarkable tenacity of scientific theories. Scientists have thick skins. They do not abandon a theory merely because facts contradict it. They normally either invent some rescue hypothesis to explain what they then call a mere anomaly or, if they cannot explain the anomaly, they ignore it, and direct their attention to other problems. Note that scientists talk about anomalies, recalcitrant instances, not refutations. Had Popper ever asked a Newtonian scientist under what experimental conditions he would abandon

Newtonian theory, some Newtonian scientists would have been exactly as nonplussed as are some Marxists" (Lakatos 1976: 207).

From the point of view of the philosophy of science, as Lakatos (1974) claimed, one neither can tell when certain theory is true nor identify when theory is false. Neither confirmations nor refutations have any epistemic value whatsoever because neither can be learned from experience (Lakatos 1974).

A scientific theory is more than a sum of observations and facts. Theories are not derived from observations directly. It is the theory which decides and specifies in advance what one can observe, while scientists conduct experiments because they expect to see what the theory described and then "interpret" their findings through the lenses of theory. Moreover, good theories are counterintuitive. because they recognize those patterns and phenomena that can't be inferred from experience. As conjectures and guesses (Popper 1962), theories go far beyond observations and they cannot be refuted on the basis of what is observable. We know many facts from theories and the primacy of theory over observations does not give us legitimate reason to refute a theory on the basis of facts that are, in turn, derived from theory. Putting forward a theory requires an intellectual jump that prevents refutation.

There is a common pattern in all objections against falsifiability: they all attack the idea of ultimate refutation. As such, they attack Popper's method of conjectures and refutation which he considered as the way science can progress. For Popper, this strong version of falsifiability is necessary in order to solve the problems of demarcation and induction and for him these two problems were of primary importance while the criterion of scientific progress is subordinated to them. When critics of falsificationism say that "scientists actually do not follow the methodology of falsificationism" (Böhme 1980) they require refutations as a demonstration that science can learn from its mistakes (Popper 1963).

But should we limit our view on the progress and rationality of science and scientific knowledge only in those situations when theories compete against each other in attempt to explain the same kind of phenomena? Traditionally many philosophers of science used to claim that it is impossible to find the correspondence after new theory has replaced its predecessor in explaining the same kind of phenomena. And as such, should we take falsification only as a tool for refutation? We suggest the weaker formulation and demand for falsificationism in order to escape previous objections that had been based on the claims about the impossibility or ignorance of refutation and for the purpose of formulating alternative account of scientific progress. In our view, the very notion of progress can be extended beyond the competition between theories in the same domain and falsification can and should be reconsidered as a tool for marking the boundaries of theories and understanding where new domains of science can be found. For example, it was enough for physicists in the beginning of the XX century to find the limits of classical mechanics in order to understand where new physics can be discovered and new theory for this new domain developed. Falsification in this case doesn't function as a means of theory refutation and progress here is not restricted by and/or defined as an abandonment of falsified theory and its replacement within the new one.

In our view the more modest version of falsifiability is enough if our main purpose is to define the key ingredient of scientific progress, that is, we aim in this paper to demonstrate why science is rational and progressive and not to tell science from non-science. For this specific purpose we don't need to distinguish between induction and validation on the one hand, and falsification and refutation on the other. We need only to show that falsification is necessary aspect of distinguishing the limits of old domain of science and the beginning of new domains.

Is Progress Possible without Correspondence?

The question of what constitutes scientific progress and whether it is possible at all is that problem of philosophy of science where Popper's concept of falsifiability and Kuhn's incommensurability thesis intersect and contradict with each other (Davies 2013):

> "If there is discontinuity of reference between theories, there may be no scientific progress in the sense of increase of truth about a common domain of entities. In sum, the incommensurability thesis is controversial because it throws doubt upon the rationality of scientific theory choice, as well as the progressive character of scientific theory change" (Sankey 2009: 196).

This problem, in fact, is among several others that reject the view on scientific progress as a rational choice between competing theories. And incommensurability as a direct consequence of those cases where no correspondence between theories can be found should motivate both realists and antirealists looking for the criteria of scientific progress somewhere beyond the continuity and accumulation in the shift of structure or content of competing theories. In other words, this means one needs to accept this as an epistemic constraint (Psillos 1995) and abandon attempts to link scientific progress with 1) correspondence principle and 2) falsificationism as a means of choosing between theories and refutation.

Another problem that the realist concept of scientific progress faces is with the notion of truth and, specifically, the link between the success of theories and truth of these theories. "The concept of scientific success is central to the most favored defenses of scientific realism" (Harker 2012: 80) but success itself, as antirealists show, is not the same as (approximate) truth (Laudan 1981), progress and rationality (Kuhn 1962; Popper 1963). Success, according to antirealists, can't be explained by truth and, beyond this, we can't make correspondence principle solely responsible for progress as there are theories that were found completely false without referring to anything in real world and new theories after revolutions have nothing at common with them at all. This forces us to find more modest and justified criterion of progress and rationality. We have no reasons to believe in truthlikeness of theories or that there is accumulation and growth of knowledge when new theory substitutes the old one. Although realists use to save correspondence principle in their defense strategies, we need to set the bar lower and don't assume that by saving the correspondence principle we save the evidence and offer a criterion of scientific progress.

For this purpose, let's cut down unjustified assumptions. First, we have no reason to believe that current and future theories will not be discarded in the same manner as their predecessors. Second, we can't accept the view that progress is ensured when scientists choose between theories by means of refuting falsified ones and approximating to the truth through refutations. In the first case this conception fails due to the pessimistic induction and in this case because falsificationism doesn't work. Third, we have no reason to believe that mathematical structure of theories will be retained and not discarded in the same way as theoretical ontology of those past theories which didn't survive revolutions. Together, such concepts of progress as an approximation to the truth, (structural) correspondence, falsifications and refutations meet too strong objections to take them as basic and load-resisting components in any theory of scientific progress.

Let's assume that mathematical structure retainment is a constant, and these changes have never yet occurred during theory change. But we can't be sure that this will not happen in the future. And in the case of scientific discoveries we need to adopt a different epistemological attitude. Discovery of a new domain of science is itself an evidence of progress; quantum physics and relativity theories discovered new worlds and dimensions we could have not imagine about before these revolutions occurred. There is no logic of scientific discovery but the fact of discovery speaks in support of scientific progress and discovery is in fact the most reliable evidence of scientific progress. And even if there will be no more such discoveries at all and everything is already discovered, as physicists in the late XIX century claimed, there is still a criterion which we can follow in order to recognize when science progresses. And we can even accept that discovery without logic is a miracle but it is a kind of miracle that happens only when scientific inquiry functions and the fact that these "miracles" happen doesn't prevent us from acknowledging them as scientific progress.

Closed Theories and Non-Cumulative Progress

Heisenberg's closed theories view gets us closer to the notion of scientific progress without correspondence and cumulative theory change than any other conception. Heisenberg defines a closed theory as that which is "perfectly accurate within its domain" and "correct for all time" (Heisenberg 1972 [1983]. They are absolutely valid in the sense that there is no room for further improvements: minor changes cannot improve closed theories while major changes give us radically new theories (Weinert 1994). Heisenberg didn't claim closed theories must be true but he explained why they should not be considered false. Instead, empirically adequate (if using van Fraassen's words) theories are not universal but limited in their range of applicability:

> "Newtonian mechanics is a limited description of nature and in that limited field it is perfectly accurate. All attempts to improve Newtonian mechanics are just fruitless. But you come to parts of physics where the concepts of Newtonian physics do not apply. You just cannot do anything with these words. Then you have to go for something new" (Heisenberg in Bokulich 2004).

Heisenberg's view allows overcoming the problem of incommensurability and discontinuity of theory-change; scientific progress, according to this approach, consists in developing and using such closed theories in instrumentalist manner. The most important point in Heisenberg's approach is its ability to escape pessimistic induction: the limitation of closed theory does not mean it is false. Rather, it has exhausted its range of applicability and new theories simply will approach new domains of phenomena. Closed theories view, therefore, 1) resists radical form of pessimistic induction which treats past, present and future theories as false and 2) explains why there is a discontinuity in theory change and how progress can be saved in this situation. In particular, the aim of physics is not getting closer to the truth by conjectures and refutations or within problem-solving activity, but to establish closed theories (Weinert 1994).

This claim is too strong and overoptimistic due to a strict possibility of closed theories being rejected as completely false and non-referring (Böhme 1980; Weinert 1994). Again, neither realists, nor structural realists can be sure that someday the correspondence and accumulation will not be interrupted. Similarly, Heisenberg had no reason to be sure that closed theory will not be completely and ultimately rejected as a result of, for example, an invention of new unconceived methods or data. As such, we need to adopt less radical form of closed theories model and save only those features that help to build a non-contradicting and justifiable concept of scientific progress.

Another problem with this concept is that it leaves no room for falsifiability and correspondence. Karl Popper saw a direct conflict and incompatibility between the notion of closed theories and the notion of falsifiability in favor of the later as neither theory should be accepted as a final and the one that in principle can be justified. Moreover, when talking about falsification, he maintained that theory, according to this instrumentalist view, will simply be revisited in terms of its range of applicability instead of being refuted and replaced with a better one (Popper 1963).

To find a middle way between these two positions means toning down both claims. Falsification doesn't imply refutations, and closed systems should be accepted only in terms of discovering new domains of sciences.

The methodology of closed theories allows discovering new areas of nature and experience. Even though we can't be confident about the impossibility of radically changing or abandoning the self-proclaimed closed theories, when they discovered new areas of nature these episodes in science can be accepted as progressive. These theories can be soon even rejected (hypothetically), but progress definitely took place when new parts of nature, new parts of physics or any other science (Bokulich 2006) had been discovered. The progress of the transition between Classical physics and Quantum physics and Relativity theory consisted not so much in some kind of verisimilitude, structural correspondence or problem-solving but in discovering new areas of nature, new areas of experience. Put differently, this discovery of new domain of science is an integral part of future revolutions while we can suggest that there can be no approximation to the truth or structural retainment. General relativity theory predicted that distinct regions of space-time are so deformed that they form objects called black holes. Predictions of this theory have been confirmed in numerous highly sensitive experiments (Patton, 2020) and new tests seem to be performed not so much to falsify this theory but to test its boundaries and find out where new theories and regions of universe begin. When the existence of gravitational waves was confirmed by the LIGO collaboration in 2015, the scientific community indeed had little doubts that general relativity is true. Gravitational wave detection became a breakthrough of the decade rather because a new phenomenon had been confirmed. Together with confirming the existence of black holes, such a discovery offers something more that corroboration. First, we see here how mathematical theory claims what should exist despite being unobservable. Second, it is a power of this theory that simultaneously discovers the new domain of nature but delineates its own boundaries by mapping the new region of universe – the event horizon, where new laws of physics are probably to be found. Together with the discovery of a quantum world, this episode in science can be counted as scientific progress despite the two fundamental and most successful theories in modern science that directly contradict each other and do not respond to any attempts of unification. Even if it would be discovered that General Relativity cannot explain phenomena beyond the event horizon, it does not mean this theory is wrong. It is more plausible explanation that GR delineated its range of applicability and suggested the need for new theories that would be responsible for new regions of nature. Alternatively, instead of being refuted, GR and some other theory (at the moment, Quantum Mechanics is the major candidate) will be unified in order to explain new domains where both theories are silent when applied alone.

Finally, String Theory emerged out of attempts to extend general relativity made by Theodor Kaluza in 1919. His approach allowed entering a new domain of nature, which was previously unknown, because one had to assume the existence of additional dimensions. The limits of both Maxwell equations for the electromagnetic fields and Einstein field equation were overcome by introducing a fifth dimension which, in turn, allowed him to unify these two fundamental forces – gravity and magnetism (Smolin 2006). This historical case best illustrates the inability of falsificationism and Popper's criteria of progress to direct and predict the nature of scientific conduct and theoretical advances. The String Theory that nowadays occupies a central place in physics is built on this assumption about additional dimensions.

Conclusion

It was suggested that given the numerous attacks the concept of falsification perceives and those shortcomings that these attacks reveal, it is more reasonable to reduce the role of falsificationism in epistemology and, simultaneously, find its distinctive role in scientific practice, which can ensure that the latest is progressive. Therefore, we have argued that attention in the scientific progress and demarcation problem debates should be shifted from falsification/verification and truth/false towards the notion of scientific progress as new phenomena and scientific area discoveries. The concept of Heisenberg's closed theories contributes to this view as it allows recognizing the central role which transition between old and new domains of physics and other sciences plays in scientific progress and rationality.

On the one hand, this is a pessimistic epistemology, since it reduces our beliefs about what can be accepted as scientific progress. On the other hand, it is more optimistic than the pessimistic induction, because the later adopts the view that, probably, by induction, we have never been progressive, as theories of today and tomorrow can have nothing to do with the progress just as past false theories did. In our approach, we take a discovery of new areas of phenomena as a progress itself which can't be undermined.

For Kuhn, progress to be assigned to the level of paradigms but the notion of incommensurability doesn't allow progress to be possible. To avoid incommensurability we need to tone down the expectations and beliefs about the progress and take it on the level of theories and discoveries.

Successful reference of central terms between theories is necessary condition for realist account of scientific progress but it is enough to demand falsifiability as a demonstration of progress as an isolation of old theories and approaching new ones in the instrumentalist version defended in this paper.

We have no reason to accept the concept of scientific progress as a cumulative theory change and mobilize the notion of truth. The problem the progress-as-continuity has with a radical discontinuity at the theoretical level of scientific theories is reinforced with the problems with falsification, incommensurability and pessimistic induction. All these problems by and large preclude the possibility of developing and defending the concept of scientific progress as a theory change that retains continuity between theories (paradigms) or getting closer to the truth and, at best, invite us to be agnostics concerning this form of progress and rationality.

What remains is the possibility to use falsificationism as a tool not for theory refutation but for delineating the boundaries of old scientific areas and theories and recognizing the new territories and domains of phenomena. At the same time, the closed theories view allows taking discoveries as a central component in the scientific progress and accepting in as the one that can satisfy the minimal requirement for scientific episode to be progressive.

This view is motivated by what Laudan called "a difference between wanting to believe something and having good reasons for believing it" (1981: 48) as it has been developed from the same epistemic attitude. Claiming that scientific progress is cumulative process which takes place during theory change transitions is as unjustifiable as realists' claims about the link between success and truth.

References:

Aksom, H., Zhylinska, O., Gaidai, T., 2020. Can Institutional Theory be Refuted, Replaced or Modified? *International Journal of Organizational Analysis* 28 (1): 135-159, https://doi.org/10.1108/ijoa-02-2019-1666.

Allori, V., Zanghì, N., 2009. On The Classical Limit of Quantum Mechanics. *Foundations of Physics 39* (1): 20-32, https://doi.org/10.1007/s10701-008-9259-4.

Böhme, G., 1980. On the Possibility of 'Closed Theories'. *Studies in History and Philosophy of Science Part A 11* (2): 163-172, https://doi.org/10.1016/0039-3681(80)90022-9.

Bokulich, A., 2004. Open or Closed? Dirac, Heisenberg, and the Relation Between Classical and Quantum Mechanics. *Studies in History and Philosophy of Modern Physics* (35): 377–396, https://doi.org/10.1016/j.shpsb.2003.11.002.

Bokulich, P., Bokulich, A., 2005. Niels Bohr's Generalization of Classical Mechanics. Foundations of Physics 35 (1): 347–371, https://doi.org/10.1007/s10701-004-1979-5.

Bowman, G. E., 2005. On the Classical Limit in Bohm's Theory. *Foundations of Physics 35* (4): 605-625.

Davies, A., 2013. Kuhn on Incommensurability and Theory Choice. *Studies in History and Philosophy of Science Part A 44* (4): 571-579.

Doppelt, G., 2005. Empirical Success or Explanatory Success: What Does Current Scientific Realism Need to Explain? *Philosophy of Science 72* (5): 1076-1087, https://doi.org/10.1086/508958.

Jones, G., Perry, C., 1982. Popper, Induction and Falsification. *Erkenntnis 18* (1): 97-104, https://doi.org/10.1007/bf00179245.

Jammer, M., 1966. *The Conceptual Development of Quantum Mechanics*. McGraw Hill Book Co, New York, NY.

Harker, D., 2012. How to Split a Theory: Defending Selective Realism and Convergence Without Proximity. *The British Journal for the Philosophy of Science 64* (1): 79-106, https://doi.org/10.1093/bjps/axr059.

Heisenberg, W., 1972 [1983]. *The Correctness-Criteria for Closed Theories in Physics*. In: W. Heisenberg (Ed.), Encounters with Einstein: And other Essays on People, Places, and Particles. Princeton, NJ: Princeton University Press.

Kelly, K. T., Glymour, C., 1989. Convergence to the Truth and Nothing but the Truth. *Philosophy of Science 56* (2): 185-220, https://doi.org/10.1086/289483.

Klein, U., 2012. What is the Limit $\hbar \rightarrow 0$ of Quantum Theory? *American Journal of Physics 80* (11): 1009-1016.

Krajewski, W., 1977. *Correspondence Principle and Growth of Science*. Dordrecht: Reidel.

Kuhn, T., 1962. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Lakatos, I., 1974. The Role of Crucial Experiments in Science. *Studies in History and Philosophy of Science Part A 4* (4): 309-325.

Lakatos, I., 1976. *Falsification and the Methodology of Scientific Research Programmes*. In: S. Harding (Ed.), Can Theories be Refuted?: Essays on the Duhem-Quine Thesis. Berlin: Springer.

Laudan, L., 1981. A Confutation of Convergent Realism. *Philosophy of science 48* (1): 19-49, https://doi.org/10.1086/288975.

Millman, A. B., 1990. Falsification and Grünbaum's Duhemian Theses. *Synthese 82* (1): 23-52, https://doi.org/10.1007/bf00413668.

Niiniluoto, I., 1984. Is Science Progressive? Dordrecht: D. Reidel.

Patton, L., 2020. Expanding Theory Testing in General Relativity: LIGO and Parametrized Theories. *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics 69* (1): 142-153, https://doi.org/10.1016/j.shpsb.2020.01.001.

Popper, K. R., 1963. *Conjectures and Refutations: The Growth of Scientific Knowledge*. London: Hutchinson.

Post, H. R., 1971. Correspondence, Invariance and Heuristics: In Praise of Conservative Induction. *Studies in History and Philosophy of Science Part A 2* (3): 213-255, https://doi.org/10.1016/0039-3681(71)90042-2.

Psillos, S., 1995. Is Structural Realism the Best of Both Worlds? *Dialectica 49* (1): 15-46.

Psillos, S., 1999. *Scientific realism: How Science Tracks Truth*. London; New York: Routledge.

Radder, H., 1991. Heuristics and the Generalized Correspondence Principle. *The British Journal for the Philosophy of Science 42* (2): 195-226.

Rosen, N., 1964. The Relation Between Classical and Quantum Mechanics. *American Journal of Physics 32* (8): 597-600, https://doi.org/10.1119/1.1970870.

Sankey, H., 2009. Scientific Realism and the Semantic Incommensurability Thesis. *Studies in History and Philosophy of Science Part A 40* (2): 196-202, https://doi.org/10.1016/j.shpsa.2009.03.007.

Smolin, L., 2006. *The Trouble with Physics*. Boston, MA: Houghton Mifflin.

Weinert, F., 1994. The Correspondence Principle and the Closure of Theories. *Erkenntnis 40* (3): 303-323.