On how *Epistemological Letters* changed the foundations of quantum mechanics[1]

[To appear in *Oxford Handbook of History of Interpretations and Foundations of Quantum Mechanics* (forthcoming)]

It is not an exaggeration to say that the 1970s marked the beginning of a new era in the foundation of quantum mechanics. These were the years when physicists and philosophers interested in the foundations of physics started to actively engage with the conceptual and empirical implications of the Bell inequality, published in 1964. Among other things, the first experiments designed to test whether quantum mechanics violated the inequality in question were carried out during these years, two journals —*Foundations of Physics* and *Epistemological Letters*— dedicated to the foundations of physics were created, and for the first time since its creation, the "International School of Physics 'Enrico Fermi'" dedicated its theme to the foundations of quantum mechanics (see Freire (2004)). Although all this is well-known, not much has been said about the exact ways that *Epistemological Letters*, in particular, helped the foundations of quantum mechanics consolidate as an important and respectable scientific discipline. And this is precisely the subject of the present paper.

As I will argue here, at least four features of *Epistemological Letters* encouraged the foundations of quantum mechanics to flourish during a time when the discipline itself was not very

[1] Some fragments of this work are based on an unpublished document co-written with Don Howard that can be found at https://curate.nd.edu/show/nz805x2535c (Accessed August 4, 2020).

well respected by the broader physics community: one, the kind of interdisciplinary research *Epistemological Letters* and the institution behind it so insistently encouraged; second, and related, their efforts for reaching out to anybody interested in the foundations of quantum mechanics, regardless of their department, position, or "academic status"; third, the fact that the journal explicitly promoted the informal confrontation of ideas; fourth, and more obviously, its very high quality—some of the most important papers on the foundations of quantum mechanics were first published in *Epistemological Letters.*

The structure of this paper goes as follows. First, in section 1, I will offer a brief historical overview of physics as a discipline in the 1960s and 1970s, mostly focused on the American context. Then, in section 2, I will discuss the creation of the Association Ferdinand Gonseth and the Institut de la Méthode, which sponsored the publication of *Epistemological Letters*. Finally, in section 3, I show why exactly *Epistemological Letters*, much more than any other publication of the time (including *Foundations of Physics*), so significantly impacted the foundations of quantum mechanics.

1. Historical Context

I will approach this brief historical context from three different but complementary perspectives: from the point of view of the physics textbooks and classrooms of the time, from the first-person perspective of Clauser who was an important figure in the foundations of quantum mechanics during the 1970s, and from the position of physics journals that were published during this period.

Throughout World War II and the Cold War, physics in America was greatly shaped by military demands. Physics was the field that received the most the federal funds destined to war

needs by recently founded agencies such as N.D.C.R and N.S.F (Kevles 1995). And of course, physics would play a crucial role in the war itself, with, for example, the development of the radar and the atomic bomb (atomic bombs would continue to be developed throughout the Cold War). In part because of its rapidly expanding budget and because of the widespread public recognition of its contribution to the war effort, physics became a very attractive career choice in American society. Consequently, after World War II graduate-level enrollments in physics increased twice as quickly in the United States as all other disciplines combined (Kaiser 2011, p. 17). The United States was producing three times as many PhDs in physics as it did in prewar times, and this number would become six times as many after Sputnik (Kaiser 2011, p. 17). As Kaiser (2007) shows, this massive increase in enrollment significantly influenced the way quantum mechanics was taught. As advanced physics classrooms started to hold more than a hundred students, professors teaching quantum mechanics had less time to deal with interpretative questions. They had less time to read (and hence assign) student essays on issues such as the meaning of the uncertainty principle or the notion of probability in the theory. By comparing lecture notes from graduate-level courses on quantum mechanics across the United States in the 50s, Kaiser (2007, p. 30) shows that classes with an average of 13 students included five times this kind of philosophical material as compared to classes with an average class size of 40 students. In short, as one professor says in 1956, "the philosophical issues raised by quantum mechanics ... the student never has a chance to gauge their depths" (Kaiser 2011, p. 18).

The decrease in the time dedicated towards interpretative issues was also reflected in the textbooks that professors and students used during this period. For example, one of the most popular textbooks of the time, *Quantum Mechanics* by Leonard Schiff, placed a particularly strong emphasis on calculations, which kept the students busy while avoiding discussions centered on

more philosophical issues. This was just one instance of a more general pattern. Whereas textbooks on quantum mechanics before the second world war used to have a fair amount of essay prompts (in some cases near a quarter of all the problems), by 1960, questions dealing with interpretative issues shrunk to just about 10 percent among all problems in most textbooks (Kaiser 2007, p. 32).

In short, after the World War II and during the Cold War, the number of physicists in the United States increased exponentially and this fact, when combined with the specific military needs, made teaching and research in quantum mechanics much more pragmatically orientated than before —as evidenced by the materials covered in textbooks and lectures. This rather pragmatic orientation of the discipline—the commonly deemed "shut up and calculate" attitude—meant that students learning quantum mechanics had little to no exposure to the more philosophical questions and debates on interpretations that some of the main fathers of quantum mechanics had intensely discussed just a few decades earlier. It also meant, as we will see now, that those physicists in the early moments of their careers who were interested in pursuing more foundational questions faced a strong opposition by the dominant academic physics culture of the time.

In his paper Notes on Early History of Bells Theorem," John Clauser offers a first-person perspective on what the academic life of quantum physics was like in 1960s America. To better appreciate Clauser's remarks, it is pertinent to say a couple of things about what was going on with the foundations of quantum mechanics at that particular moment. In 1964, when Clauser was a graduate student at Columbia, John Bell published his paper "On the Einstein-Podolsky-Rosen paradox". In this work, Bell proved that, for a certain class of correlation measurements between previously interacting elementary particles, such as the polarization correlation between two photons from a two-stage atomic decay, the predictions of any local hidden variable theory would have to satisfy an inequality – now known as the Bell inequality – that is violated by the predictions

made by standard quantum mechanics (Bell 1964). Bell was motivated by his interest in non-local hidden variable theories, such as the one that David Bohm proposed in 1952 (Bohm 1952). Bell believed that (non-local) hidden variable theories were a more conceptually satisfying theoretical framework than that afforded by orthodox quantum mechanics, mainly because of that curious loss of separate real physical states of previously interacting particles that Albert Einstein once famously derogated as spooky action-at-a-distance" [spukhafte Fernwirkung"] (Einstein to Max Born, 3 March 1947; Einstein, Born, and Born 1969, 215). But Bell s motivations notwithstanding, Bell s theorem pointed the way to direct experimental tests of entanglement for the first time.

In its original form, Bell s theorem was not ready for the laboratory because it made several idealized, unphysical assumptions about such crucial details as detector and polarizer efficiencies. That shortcoming was remedied when, in 1969, Abner Shimony (more on him later) along with John Clauser, Michael Horne, and Richard Holt, rederived the theorem in a form more apt to actual experiments (Clauser, Horne, Shimony, Holt 1969). The CHSH theorem, as it is now often dubbed, opened the door to the decades-long, still ongoing series of experimental tests of Bell s theorem that have proven, one and again, results consistent with quantum mechanics and against local-hidden variable theories. By bringing an apparently abstract result from the foundations of quantum mechanics to the lab, Clauser and Shimony not only helped the foundations of quantum mechanics take a big step closer towards "acceptance" as a legit scientific discipline, but they would also initiate a new era in quantum optics (for an excellent review of the origins of this collaboration between quantum optics and foundations of quantum mechanics, see Freire 2006).

Clauser, who was interested in the foundations of quantum mechanics since he was a graduate student, recalls this period with great disappointment:

> Any open inquiry into the wonders and peculiarities of quantum mechanics and quantum entanglement that went outside of a rigorous party line" [the party line of shut up and calculate"] was then virtually prohibited by the existence of various religious stigmas and social pressures, that taken together, amounted to an evangelical crusade against such thinking. As a result of this evangelism, *much of the early important work on Bell s Theorem was published only in an underground" newspaper, whose circulation was limited to members of a quantum-subculture", and that probably cannot be found in most physics libraries* [my emphasis]. (Clauser 2002, p. 62)

The "underground" newspaper Clauser is referring to here is *Epistemological Letters* (we will come back to it in section 3). Clauser offers different examples to illustrate this so called party line" that heavily hindered any work on the foundations of physics from being produced. For the sake of brevity, I will focus on two examples. First, when he was a graduate student at Columbia, Clauser asked Prof. Bob Serber for his opinion of Bell s theorem and on whether or not it was important to conduct an experiment to test if quantum mechanics violated the inequality. Serber responded, Well that [Bell s Theorem prediction] might be worth pointing out in a letter to the editor, but no decent experimentalist would ever go to the effort of actually trying to measure it with that in mind!" (Clauser 2002, p. 71). Thankfully, Clauser did not follow this advice too closely.

Second, Clauser recalls his professors advising him that if he wanted to have a successful career, he needed to avoid all interpretative questions:

> Any physicist who openly criticized or even seriously questioned these foundations (or predictions) was immediately branded as a quack". Quacks naturally found it difficult to find decent jobs within the profession ... Any student who questioned the theory s foundations, or, God forbid, considered studying the associated problems as a legitimate pursuit in physics was sternly advised that he would ruin his career by doing so. I was given this advice as a student on many occasions by many famous physicists on my faculty at Columbia. (Clauser 2002, pp. 72-73)

Obviously, Clauser does not have the fondest memories of the physics academic culture of the time in question, and we can easily imagine that he would have had a much more positive experience had he been lucky enough to work with physicists such as Eugene Wigner, David Bohm, or Bell himself, who were some of the rare examples of prominent physicists interested in the foundations of quantum mechanics. It is also worth pointing out that the popularity of the "shut up and calculate" attitude that Clauser alludes to in these passages was not the only reason that physicists interested in foundational questions faced challenges during this time period. As the Cold War was cooling down in the late 1960s, federal funding designated for physics research was dramatically cut, causing the enrollment rates to half in just five years (Kaiser 2011, p. 22). This sudden loss of funds, together with the surge in physics graduates from previous years, created a rather dire job market environment. In the mid-1960s there were more physics jobs than graduates, but in 1971 there were 1053 applicants competing for just 53 jobs (Kaiser 2011, p. 23). This would only exacerbate the pressure felt by young physicists such as Clauser who were

interested in studying the foundations of quantum mechanics. Naturally, the scarce job market and reduced federal funding were not going to be dedicated towards investigating questions that most of the physics community of the time did not take very seriously.

Besides textbooks, lectures, and the testimonials of figures like Clauser, there is another angle through which we can explore how the pragmatic character of the physics of the time limited research in the foundations of quantum mechanics. After WWII, because of the pragmatism of the period as well as a natural consequence of the increasing specialization of physics and academic disciplines in general, it became more difficult to find physics journals willing to publish works on this topic. There is an obvious reason to this: the foundations of quantum mechanics has always been an example of an interdisciplinary area that calls for a tight collaboration between physics and philosophy. Einstein's "Quantum Mechanics and Reality" (1948), where he puts forward one of his clearest versions of the incompleteness argument, is an illustrative example of why an interplay between philosophy and physics is essential when addressing foundational questions in quantum mechanics. These more philosophical reflections on quantum mechanical issues were at the same time too removed and "too interdisciplinary" for the pragmatic style of the physics in the post-WWII period.

It is not a coincidence that it was in *Dialectica*, a prestigious philosophy journal initially created by Ferdinand Gonseth, Paul Bernays and Gaston Bachelard in 1946 that is still active, where Einstein's "Quantum Mechanics and Reality" paper was published for an issue dedicated to Bohr's complementarity, and whose participants included figures such as Bohr, de Broglie, and Heisenberg. To this very day, that special issue of *Dialetica* stands as one of the most important published symposia on the foundations of quantum mechanics. The contributions of Bohr (1948) and Einstein (1948), especially, having become classics. Somewhat ironically, a philosophy

journal was more open to continuing the debates by the founding fathers of quantum mechanics than the physics journals of the time, and this would become even more the case during the 1950s and 1960s. For instance, Clauser recalls that Samuel Goudsmit, the editor of the prestigious *Physical Review* from 1958 to 1974, enclosed a policy statement recommending the rejection of any article on the foundations of quantum mechanics unless they were mathematically based *and* gave new quantitative experimental predictions" (Clauser 2002, p. 72). Surely, none of the pieces by Bohr, Einstein, Heisenberg, or de Broglie published in the special issue of *Dialectica*, and probably not even the EPR paper, would have been accepted in *Physical Review* under this policy.

As a response to this mixture of pragmatism and hyper-specialization, three physics journals relevant to our story were created in the 1960s and early 1970s.[2] On the one hand, we find the short-lived journal *Physics*, which only ran for four volumes between 1964 until 1968. The most important article published here was Bell's 1964 paper, where he presents his now very famous inequality for the first time. In the Editorial Preface, Philip Warren Anderson and Bernd Theodor Matthias stated:

> … in our opinion physics has reached the point at which there is far more good physics written than any physicist can read, especially if he hopes to cover more than his own special field. On the other hand, it would be too bad if most physicists were to have to give up reading original material in other fields even fairly close to their own, as perforce most of them have long since given up reading articles in the other sciences. Therefore, we believe it is a good idea to institute a selective journal in which the editors try their very

[2] The historical literature taking up scientific journals as their subject is rather scant, and as far as I can tell, this work is the first one to examine the importance of these three journals within the context of the increasing specialization of physics.

> best to present a selection of papers which are worth the attention of all physicists. (Anderson and Matthias, 1964)

So, the editors thought that Bell's paper "was worth the attention of all physicists no matter their area." Ironically, however, and as a clear sign of the lack of popularity of the foundations of quantum mechanics, nobody but Bell himself cited this piece in the three years after its publication (this happened in his 1966 paper, where he discussed the problems with von Neumann's proof against hidden variable theories). In contrast, all of the other papers appearing in the same issue as Bell's were cited at least twice and, in one case, seven times throughout the following three years (to this date, Bell's paper has been cited more than six thousand times).

Then, in 1970, a journal explicitly dedicated to the foundations of physics was created. This was *Foundations of Physics*, created by Henry Margenau and Wolfgang Yourgrau, both very respectable physicists who also actively worked on the philosophy of science and the foundations of quantum mechanics. David Bohm, Louis de Broglie, V.A Fock, Karl Popper, and Eugene Wigner, all well-known physicists (except Popper, who was a philosopher) interested in the foundations of quantum mechanics, were part of the editorial board (Freire 2004, p. 1754). After explaining what they mean by "foundations" and why it is a worthy area of investigation, at the end of the Editorial Preface Marganeu and Yourgrau also make a reference to the fact that speculative ideas are especially encouraged in their journal (this sets a startling contrast to the policy of *Physical Review* mentioned earlier):

> Very few scientific journals today encourage speculation not tied to hard and demonstrable facts. One wonders whether brilliant ideas are not lost by this restrictive attitude.

> *Foundations of Physics* will publish with suitable frequency disciplined speculations suggestive of new basic approaches in physics. (Marganeu and Yourgrau 1970, p. 3)

It is interesting that the editors also viewed this kind of focus on foundations as something that would foster interdisciplinary collaborations between different sciences:

> For the most basic theories provide the approaches to other areas of science. Thus, the fundamental concepts of physics find natural applications in chemistry, astronomy, and, we hopefully observe, biology. One of the fervent desires of the editors is that this journal, committed to this view of foundations, shall be instrumental in sponsoring work that brings large physical principles to bear upon adjacent fields. (Marganeu and Yourgrau 1970, p. 1)

In the same preface, they say that the journal will focus on topics such as the equivalence of matrix mechanics and wave mechanics, the nature of observables, the strange role of variational principles, time and space, axiomatization of statistical mechanics, unified field theory, and others. Notice that foundational issues of quantum mechanics are just a subset of the many areas that the journal aimed to explore.

2. The Association Ferdinand Gonseth

The same year *Foundations of Physics* was created, the well-renowned Swiss philosopher of science and mathematics, Ferdinand Gonseth, turned 80. As I noted earlier, Gonseth (1890-1975) was one of the founders of *Dialectica*. Trained in physics and mathematics at the Swiss Federal Polytechnic (EPF/ETH) in Zurich, he taught mathematics and philosophy of science at the University of Zurich, the University of Bern, and, from 1929 onwards, the EPF/ETH (Fuchs 2007).

He was the author of several important books, including *Les fondements des mathématiques* (Gonseth 1926), *Les mathématiques et la réalité* (Gonseth 1936), *Déterminisme et libre arbitre* (Gonseth 1944), *La géométrie et le problème de l espace* (Gonseth 1945), *Le problème du temps* (Gonseth l964). And in 1944, two years before creating *Dialectica*, he founded, together with Paul Bernays, Karl Dörr, and Karl Popper, the International Society for Logic and Philosophy of Science (Lauener 1977, p. 113). In 1970, he expressed the desire to create a center for methodological studies" in the spirit of his own work (http://afg.logma.ch/mnfst.htm. Accessed August 1, 2020). His wish was quickly satisfied when, in 1971, the Association Ferdinand Gonseth was created at Bienne with the purpose of pursuing and developing Gonseth s oeuvre. Among the different values promoted by the Association, it is noteworthy citing the following one:

> [The Association] promotes openness to the philosophy of science, to an interdisciplinary dialogue with science. Science and philosophy form one body, and all that happens again in science, whether in its methods or in its results, may resound on philosophy even in its most fundamental principles. [http://afg.logma.ch/afg.htm. Accessed August 1, 2020 (my translation)]

Note how one of the core goals of the association was to strengthen the dialogue between philosophy and science, which is of course very reflective of Gonseth's own legacy. The same year of its foundation, the association also created the Institut de la Méthode to serve as a home for activities as varied as the interests of Gonseth himself:

> They range from a reflection on the teaching of mathematics to discussions on relatively technical problems from the philosophy of physics to the promotion of a dialogue between

> science and philosophy [http://afg.logma.ch/afg.htm Accessed August 1, 2020 (my translation)]

In contrast to *Foundations of Physics* and *Physics*—journals that were more interested in addressing the specialization within physics itself— this institute was very explicit in their desire to establish a dialogue between physics and philosophy. Notice also the use of the term "philosophy of physics," which is not found in the preface to the other journals.

The secretary of the Institut was François Bonsack (1926-2006). Born in Bienne in 1926, he took a doctorate in philosophy at Geneva in 1961 with a dissertation on Information, thermodynamique, vie et pensée (Bonsack 1961). A devoted student of the work of Gonseth, Bonsack was also a lecturer in the philosophy of science at the nearby University of Neuchâtel (https://prabook.com/web/francois.bonsack/488192. Accessed August 1, 2020). From 1972 up until 2003, the Institut de la Méthode created several "written symposia" on topics ranging from the pedagogy of math to the philosophy of physics to political philosophy. These so-called "written symposia" were not really journals or newsletters but instead functioned more like today s preprint servers. Of the eleven symposia published by the Institut de la Méthode, the one with the most issues, by far, was on the topic of hidden variables and quantum uncertainty. Its printed titled was *Epistemological Letters*, and it ran from November 1973 until October of 1984, after publishing thirty-six issues. In 1978 and 1979 the Institut also hosted two conferences on the same topic as *Epistemological Letters*, Indéterminisme quantique et variables cachées," among whose participants we include d'Espagnat, Shimony, Vigier, K. Popper, and O. Costa de Beauregard (one finds the announcement of the first conference in the 17th issue of *Epistemological Letters* published in December 1977, and a list of participants in the 18th issue published in June 1978).

Before we focus our attention on *Epistemological Letters*, it is useful to consider the following question: one might ask why such a modest, private foundation such as the Association Ferdinand Gonseth, located in the small city in Northwest Switzerland, successfully created and up-kept a journal dedicated to the foundations of quantum mechanics. Of course, part of the answer is that Gonseth himself was interested in the foundations of quantum mechanics, as was clear from the fact that while acting as the editor of *Dialectica* he organized a whole issue on the concept of complementarity, as I mentioned earlier. But another important part of the answer involves geography. At the time *Epistemological Letters* was established, Josef-Maria Jauch and Constantin Piron were pursuing what would prove to be some of the most important work on the foundations of quantum mechanics and quantum logic while they were at the University of Geneva (see Jauch 1968, 1973, Piron 1976), which was an hour and forty-five minutes southwest of Bienne by either car or train. And Bell himself was then working at CERN in Geneva, where he had been since the mid-1950s. Expanding our view a bit wider, we find a very influential pioneer of quantum foundations, Bernanrd d Espagnat, at the Sorbonne in Paris, where he had worked since 1959, after having been Bell s colleague in the theory group at CERN for a few years in the late 1950s (see d Espagnat 1976, 1983). And, looking eastward, there was the remarkable physical chemist and student of the foundations of quantum mechanics, Hans Primas, at the ETH in Zurich (see Primas 1983). By some measures, in the early 1970s the triangle comprising Paris, Geneva, and Zurich had the world s densest concentration of physicists working on the foundations of physics. Bienne and the Association Ferdinand Gonseth lay at the heart of that region.

But of course geography alone would not explain the success of *Epistemological Letters*. One must also mention Shimony's role in the production of the journal. The "official" editor was

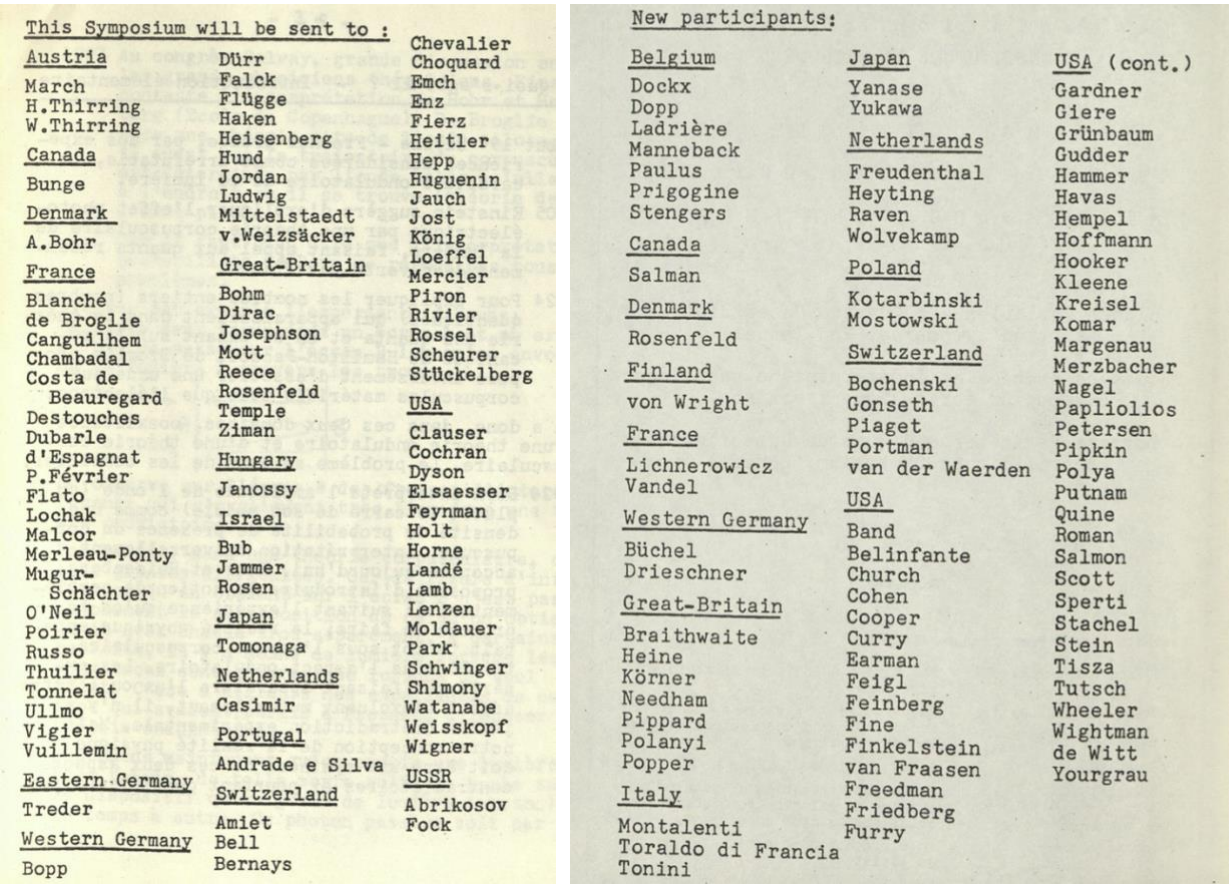
Bonsack, but Shimony was very much involved for the whole eleven years that *Epistemological Letters* ran. In 1970, because of the publication of the CHSH paper, Shimony had been invited by d'Espagnat to the "International School of Physics Enrico Fermi, " where he "began a lasting friendship with Bell and d Espagnat, and became still more involved with issues related both to Bell s inequalities and measurement problem" (Freire 2006, p. 592). So, by the time he began working on *Epistemological Letters* in 1973, Shimony was already a highly regarded figure in the community of quantum foundations in Europe, and this was going to be key in building *Epistemological Letters* into a very successful publication. It is also important to stress that because he had a Ph.D. in philosophy from Yale in 1953 and another one in physics from Princeton in 1963 under the supervision of Wigner, Shimony was a perfect fit for establishing the kind of dialogue between science and philosophy that the Association Ferdinand Gonseth fervently advocated for.

3. Epistemological Letters

From the very start, *Epistemological Letters* emerged as a very unique kind of publication. The first thing readers encounter when opening the first and second issues is a list of the people to whom *Epistemological Letters* was distributed. As the reader can appreciate in Figure 1, nearly all of the key protagonists who helped the foundations of quantum mechanics become a more established discipline during the 70s are listed as recipients. This includes figures who were already well renowned in the discipline, such as Wigner, Bohm, Bell, DeWitt, Shimony, Clauser, D Espagnat, Vigier, de Broglie, Margenau, Yanase, Jauch, and Piron. But of perhaps more importance, it also included scholars in the early stages of their careers, many of whom would become the leading philosophers of physics and science of our time. I am referring, in particular,

to figures such as Howard Stein, Arthur Fine, John Earman, Bas van Fraassen, and Jeff Bub. It seems natural to speculate that the direct contact with the discussions by Bell, d'Espagnat, Shimony, and others that *Epistemological Letters* provided them would shape their own professional paths considerably. For instance, it is interesting that although by 1973 Fine had already published some papers on the foundations of quantum mechanics, including a paper on the interpretations of quantum mechanics (1973), the first time he addressed Bell s 1964 paper was in 1974, precisely one year after *Epistemological Letters* was founded. And for the next ten years, during the time *Epistemological Letters* ran, some of Fine s most important work on the philosophy of physics would be about the Bell inequalities and their philosophical and physical significance. Indeed, in the early 1970s, philosophers working on the foundations of quantum mechanics did not really take Bell s paper to be that significant. For example, in 1974, Patrick Suppes edited a *Synthese* volume completely dedicated to the foundations of quantum mechanics with contributions by philosophers like van Fraassen, Putnam, Cartwright, and Fine. Only three out of seventeen papers in that volume addressed Bell s papers (one paper that did so was Fine (1974)). Actually, van Fraassen's paper, The Einstein-Podolski-Rosen Paradox," did not even discuss

Bell s results, despite the fact that it was about hidden variables. Obviously, in the second half of



This Symposium will be sent to :

Austria
March
H.Thirring
W.Thirring

Canada
Bunge

Denmark
A.Bohr

France
Blanché
de Broglie
Canguilhem
Chambadal
Costa de Beauregard
Destouches
Dubarle
d'Espagnat
P.Février
Flato
Lochak
Malcor
Merleau-Ponty
Mugur-Schächter
O'Neil
Poirier
Russo
Thuilier
Tonnelat
Ullmo
Vigier
Vuillemin

Eastern Germany
Treder

Western Germany
Bopp
Dürr
Falck
Flügge
Haken
Heisenberg
Hund
Jordan
Ludwig
Mittelstaedt
v.Weizsäcker

Great-Britain
Bohm
Dirac
Josephson
Mott
Reece
Rosenfeld
Temple
Ziman

Hungary
Janossy

Israel
Bub
Jammer
Rosen

Japan
Tomonaga

Netherlands
Casimir

Portugal
Andrade e Silva

Switzerland
Amiet
Bell
Bernays
Chevalier
Choquard
Emch
Enz
Fierz
Heitler
Hepp
Huguenin
Jauch
Jost
König
Loeffel
Mercier
Piron
Rivier
Rossel
Scheurer
Stückelberg

USA
Clauser
Cochran
Dyson
Elsaesser
Feynman
Holt
Horne
Landé
Lamb
Lenzen
Moldauer
Park
Schwinger
Shimony
Watanabe
Weisskopf
Wigner

USSR
Abrikosov
Fock

New participants:

Belgium
Dockx
Dopp
Ladrière
Manneback
Paulus
Prigogine
Stengers

Canada
Salman

Denmark
Rosenfeld

Finland
von Wright

France
Lichnerowicz
Vandel

Western Germany
Büchel
Drieschner

Great-Britain
Braithwaite
Heine
Körner
Needham
Pippard
Polanyi
Popper

Italy
Montalenti
Toraldo di Francia
Tonini

Japan
Yanase
Yukawa

Netherlands
Freudenthal
Heyting
Raven
Wolvekamp

Poland
Kotarbinski
Mostowski

Switzerland
Bochenski
Gonseth
Piaget
Portman
van der Waerden

USA
Band
Belinfante
Church
Cohen
Cooper
Curry
Earman
Feigl
Feinberg
Fine
Finkelstein
van Fraasen
Freedman
Friedberg
Furry

USA (cont.)
Gardner
Giere
Grünbaum
Gudder
Hammer
Havas
Hempel
Hoffmann
Hooker
Kleene
Kreisel
Komar
Margenau
Merzbacher
Nagel
Papliolios
Petersen
Pipkin
Polya
Putnam
Quine
Roman
Salmon
Scott
Sperti
Stachel
Stein
Tisza
Tutsch
Wheeler
Wightman
de Witt
Yourgrau

Figure 1: On the left, we see the list of participants as found on the first issue of *Epistemological Letters*. For the second issue, new members are added, as seen in the list on the right (this is not the last time new members were announced; in the third issue a couple of new names are added as well). Notice, in the second issue, the addition of philosophers of science and physicists like van Fraassen, Fine, Earman, and Freedman, all of whom would become prominent figures in the years to come.

the 1970s it would have been virtually impossible to find a philosophy volume on the foundations of quantum mechanics where most of the contributions ignored Bell's results (how much this changed due to *Epistemological Letters* is hard to quantify, but the fact that scholars such as Fine and van Fraassen were getting direct access to this publication probably played a significant role in this shift).

Following the list of recipients, the first issue includes a quick introduction to the symposium, which is written in French. The introduction gives a very rough overview of the most important events regarding the foundations of quantum mechanics. It mentions the double-slit experiment, Born's probability rule, Einstein's view on the incompleteness of quantum mechanics, the Bell inequalities, the CHSH paper, and the experiment by Freedman and Clauser (Freedman and Clauser 1972) that shows the violations of the inequalities. The last line reads, "The discussion is open for evaluating the exact importance of these results and the consequences that one ought to make." The issue then ends with an entry by Shimony and Horne where the authors go into the details behind Einstein's incompleteness argument, the Bell inequalities, and the CHSH experiment (1973). In summary, the very first issue, though relatively short, sets clear expectations about what to expect of *Epistemological Letters*: open discussions about the Bell inequalities and recent experimental results favoring standard quantum mechanics. This is very important because *Epistemological Letters* was the only academic publication at the moment (and since then) *completely* dedicated to the foundations of quantum mechanics. The closest "competitor" was the *Foundations of Physics*, but the latter would publish on many other foundational areas, including the foundations of thermodynamics, quantum field theory, and special and general relativity. Actually, it is surprising that between its creation in 1970 and 1973, after more than 50 papers had been published already in *Foundations of Physics*, an article addressing Bell's inequalities appeared for the first time (by Jeff Bub, who was included in the list of people who received copies of *Epistemological Letters*). Furthermore, between 1970 and 1976, less than a third of the papers in *Foundations of Physics* focused on the foundations of (non-relativistic) quantum mechanics, and of these, only 9 papers (less than 4% of all the papers published in the journal until that point) cited Bell's 1964 work! My purpose is not to undermine the role that *Foundations of Physics*

played in helping the foundations of quantum mechanics become a more established discipline, but rather to note that even for this journal, questions on the physical and philosophical implications of Bell's theorem were marginalized during the first half of the 1970s. In contrast, *Epistemological Letters* was explicitly conceived as a publication dedicated to this topic, and the majority of its more than 170 entries explicitly took up this mission.

Epistemological Letters was also different from standard academic journals because of its informality, and that informality actually turned out to be one of the reasons this publication so effectively energized the foundations of quantum mechanics at the time. This feature of the publication was intimately tied to its overall goals, as the declaration printed on the back cover of every one of its issues attests: Epistemological Letters are not a scientific journal in the ordinary sense. They want to create a basis for an open and informal discussion allowing confrontation and ripening of ideas before publishing in some adequate journal." This invitation for "open and informal discussions" was taken very seriously by both the editors and the participants. Throughout its 36 issues, one finds more than 70 "original" contributions and more than one hundred and twenty "response" articles. When the creators of *Epistemological Letters* said that they encouraged debates and confrontations of ideas, they really did mean it! Needless to say, by encouraging and facilitating an environment for these kinds of informal discussions, the journal truly enriched debates surrounding the foundations of quantum mechanics.[3]

[3] Of course, there was a more trivial sense in which the journal was informal. For one, it was printed and assembled in a rudimentary way (as can be seen from the often uneven margins). Also, at some points the equations would be typed, but at other points they would be handwritten (sometimes a single paper combined both styles). And with the goal of optimizing space, new entries could start immediately below the last entry, even if it meant starting a new article in the lower fourth of a page.

For example, in the 7th issue of *Epistemological Letters*, published in November 1975, th`e editor invited Bell to submit a response to different objections to the derivation of his inequalities, objections that had all been published in previous issues of *Epistemological Letters*. Bell's response, titled "Locality in Quantum Mechanics: Reply to critics," was an important piece in its own right because in it, Bell is clearer than he was in his 1964 paper about how we should think of locality and of the hidden variables used in his theorem. Actually, one easily recognizes that this response is somewhat of a close cousin to his well-known "Theory of local beables" paper, which would appear one year later in *Epistemological Letters* (1976). It thus seems that Bell was likely led to his theory of local beables, by a good extent, as a result of the "confrontation and ripening of ideas" that *Epistemological Letters* so strongly promoted. Interestingly, the "Theory of local beables" itself led to other rich debates and to the creation of very important papers that appeared first in *Epistemological Letters*. For instance, that paper led to a debate around the so-called "free will assumption" — the assumption that the hidden variables for the particles are statistically independent from the experimenter's decision to measure one property or the other. The main participants in this conversation as it played out in *Epistemological Letters* were Shimony, Horn, and Clauser (1976), Bell (1977), and Shimony (1978). These papers have now became classics in this particular debate. In total, one finds sixteen responses to the "Theory of local beables" scattered over five years' worth of issues. As this discussion illustrates, *Epistemological Letters* did in fact facilitate an environment that promoted open and rigorous debate amongst scholars.

As a side note, one might wonder how exactly the journal managed to keep track of all this back and forth conversation, which often involved the participation of several authors throughout different issues. By the time the third issue was published, the editors had come up with a simple

but clever system to address this challenge. In the table of contents, to the left of each author's name, readers will find a number. If that number is an integer, say 4.0, then one knows that this entry is the fourth original contribution (that is, not a *response*) in *Epistemological Letters* since the very first issue. But if the number to the left of the author's name has some decimal digits, say 5.3, then one knows that this is the third response to the fifth original contribution. So by just looking at the table of contents of each issue and the numbers printed on the left, one could quickly figure out if an entry is a response to an on-going debate or an entirely new idea. Now, this system was far from perfect, as there were instances of repeated numbers for different entries. And the system was confusing at times, since in some cases the response pieces were no longer about the "original" entry but about another response. Hence, 5.3 could indicate that this piece was a response to 5.2, as opposed to indicating that the piece is a response to 5.3. Fortunately, most of the time, the authors would specify who exactly they were responding to in the title of the paper.

Let me now focus on another aspect related to the informality of the journal, which has to do with the following passage printed on the back of each issue: "allowing confrontation and ripening of ideas *before publishing in some adequate journal* [my emphasis]." This is interesting because it was a way of signaling to authors that they could find here a space where speculation and half-baked ideas about quantum mechanics were well received, in startling contrast with the policies or standards of other physics journals of the time (such as *Physical Review*) were speculative papers would not be well-received, or even in contrast with any other academic journal were only very polished pieces are considered for publication (as far as I can tell, *Epistemological Letters* was only peer reviewed—if ever—by the editors). Because of this, the purpose of publishing in *Epistemological Letters* (at least according to the editors) was primarily that of

getting feedback from other contributors "before publishing in some adequate journal," functioning similarly to preprint servers today such as Arxiv, Phil Science Archives, or Academia.

Having said this, as a sign of the importance that this publication had in the foundations of quantum mechanics community, one does not really find cases of an author first publishing here and then moving on to a "formal" journal but of the opposite phenomenon: authors would send papers to *Epistemological Letters* even if they had already published it or at least submitted the paper to other journals.[4] Let me give three examples. By the time he already knew one of his papers (1974) was accepted into *Foundations of Physics*, P.A. Moldauer sends a short version of that paper to the second issue of *Epistemological Letters* (he points out there that a more complete discussion is given in the *Foundations of Physics* version (1974, p. 24)). Second, in the 6th issue of *Epistemological Letters* (which was published in September 1975), George Lochack published a piece in French criticizing Bell's derivation of his inequalities (this is one of the papers Bell responds to in the November 1975 issue I mentioned earlier). However, by October 1974 an English version of this paper had already been received by *Foundations of Physics* (as indicated in the first page of the publication in 1976). Third, Popper, Garuccio, and Vigier published a paper in *Epistemological Letters* in July 1981 where they outlined a new experiment designed to detect de Broglies waves (1981). Although the same paper was published later in December of the same year in *Physics Letters A*, the paper was received in April 18th 1981, from which we can infer that the authors were not sending the paper to *Epistemological Letters* with the goal of getting feedback before sending it to *Physics Letters A.* At the very least, cases like this indicate that authors

[4] There are several cases of papers by Bell found in *Epistemological Letters* that were reprinted later in other places (more on this below), but this was not a case of an author using *Epistemological Letters* to polish a paper before sending the paper somewhere else. Rather, this happened only after several years had passed between the publication in *Epistemological Letters* and the reprinted version.

recognized the value in publishing in *Epistemological Letters* for its own sake (and not just for getting some preliminary feedback), even if they had already published in (or submitted to) a "more adequate journal."

I want to mention one more, perhaps subtler, reason that the informal style of *Epistemological Letters* benefited the foundations of quantum mechanics. Scattered at random places, one can find short notes calling the attention of readers to new conferences, books, papers published elsewhere on the foundations of quantum mechanics and even correspondence sent to them by other scholars. For instance, in the fourth issue published in December 1974, a very short note by C.A. Hooker is printed announcing the publication of two books, *Physics and Metaphysics: A Prolegomena for the Riddles of Quantum Theory* (1973) and *The Nature of Quantum Mechanical Reality: Einstein versus Bohr, Paradox & Paradigm* (1972). In the 6th issue published in September 1975, the editors decided to print two contributions based on presentations from the conference "Un demi-siècle de mécanique quantique" organized in Strasbourg in May 1974 (papers from this conference were later published as Lopes and Paty (1977))[5]. In the 7th issue, from November 1975, the editors inform others about a new paper appearing in *Helvetica Physica Acta* criticizing the derivations of the Bell inequalities. In the 17th issue published in December 1977, the editors note that they plan to organize a small conference to take place in March 1978, at Geneva, to take advantage of the fact that Shimony would be visiting them. But perhaps the best example of all is provided in issue 19, were the authors made a conscious effort to report the main exchanges, in form of short fragments, between the participants of a small colloquium that included authors like Costa de Beauregard, d'Espagnat, and Shimony. Clearly, these informal

[5] Thanks to Olival Freire for this reference.

announcements about other publications and about what had been discussed at conferences on the subject kept the community very alive during these crucial years.

I hoped it is clear, then, that a great part of *Epistemological Letters'* success originated in its informal style; however, let me close this section by pointing out that this feature of the journal did hurt it in some ways. Since it was self-labeled as an informal journal, many scholars publishing in more standard venues do not cite papers that appeared in *Epistemological Letters*, perhaps because they thought it was risky for their own careers or simply because they did not think it was necessary to do so. This meant that the impact of the journal is not adequately reflected on the number of citations received, despite the fact that many of the most significant papers on the subject were first published here. This, together with the fact that many of these important contributions were reprinted in other journals (such as in a *Dialectica* issue from 1985) or in books (such as Bell's "Speakable and Unspeakable in Quantum Mechanics"), means that scholars today have a hard time measuring the actual influence of *Epistemological Letters* by looking at citations or by using tools such as Web of Science or Google Scholar.[6] From the perspective of actual citations, *Epistemological Letters* seems like it was a marginal player in the foundations of quantum mechanics, and it does not help that up until last year, there was no library in the US where one could find the entire collection (when Clauser said that it "probably cannot be found in most physics libraries" he was understating it!). This prompted me to digitize the collection together with Don Howard, and we are very happy to say that as of January of 2020, all the issues are openly available through www.curate.nd.edu. The fact that Howard had the entire collection, except for the first issue (which Howard Stein kindly gifted to us), sitting in his basement was both

[6] However, if one uses Web of Science to analyze the citation of Bell's 1964 paper from 1973 up until the end of *Epistemological Letters*, one sees a clear upward trend, which can be a sign that *Epistemological Letters* was considerably increasing awareness of Bell's paper in the broader academic community.

amusing and unsurprising since he was a student of Shimony during the years that *Epistemological Letters* was published. For an informal story of the digitization process, see https://www.nd.edu/stories/quantum-interest/.

4. Concluding Remarks

Overall, *Epistemological Letter*'s strong dedication to creating a platform conducive to open debates between the most prominent scholars of the field, its evident effort to reach as many participants interested in the philosophy of quantum mechanics as possible including some raising philosophers of physics who would soon lead the discipline in the years to come, its clearly delineated subject matter, its constant effort to remind participants of conferences, books, and papers on its topic of focus, and the fact that a figure like Shimony closely worked on its production are all important features that explain why the journal had a significant impact on establishing the foundations of quantum mechanics as a respectable discipline. Who better to summarize the impact of *Epistemological Letters* than the editors themselves. In the preface of an special issue of *Dialectica* (1985) dedicated precisely to highlighting some of the most important papers that had appeared in *Epistemological Letters* (including the exchange on "The Theory of Local Beables" between Bell, Clauser, Horne, and Shimony mentioned before), Shimony says:

> The variety of the contributions and the vigor of the debates showed that the purpose was very well accomplished. Because of the brief time interval between issues and the absence of customary refereeing procedures, it was possible to carry on a debate more rapidly than in standard journals, and speculative ideas could be more easily made public. It is remarkable that in spite of the informality of *Epistemological Letters*, the

> typing of the articles, including mathematical formulae, was very accurate. The reputation of the written symposium spread rapidly, and many people throughout the world wrote to be added to the list of recipients. (Shimony 1985, p. 83)

Just as *Dialectica* did one year after it first emerged in 1947, *Epistemological Letters* stepped forward as the vehicle facilitating precisely the sort of dialogue between physics and philosophy that has rested at the heart of the foundations of quantum mechanics since its origins.

But let me end this piece by presenting something Bonsack himself said in a pamphlet found in the penultimate issue, announcing, in both French and English, the end of the symposium:

> The editors can consider, without immodesty, this written symposium as a success: 36 issues spread over more than ten years (to which two meetings in Geneva, 1978 and 1979 must be added), the contribution (with original papers) of the most distinguished students of this field, … , the numerous references in physical literature, all that have proved enough its utility and its contribution to the ripening of the debate.
>
> For my part — and I hope I am not the only one — I have learned very much: the ideas I first had have evolved, others became clear, especially Bell's Theorem, the conclusively of which I questioned at the start and that finally appeared to be out of any doubt capable if calling into questions some fundamental features of our world view, particularly the non-separability between subsystems, about which we meant we could admit that they evolve independently, since they were locally disconnected and didn't show any known physical interaction.

> But the best things have an end. Everything — or almost everything — has been said … It seemed thus to the Institute for Methodology that time has come to stop (Bonsack 1984).

Bonsack was of course right that *Epistemological Letters* had been a success, but how wrong he was about the fact that "almost everything" had been said! On the contrary, the early 1980s were just the beginning of a rich literature on the subject, both in physics and in philosophy. In the early 1980s, a new generation of experiments by Aspect and collaborators (1982a, 1982b) were performed, further confirming the violation of the Bell inequalities. Importantly, these new experiments (which introduced things like rapidly changing polarizers) further legitimized the foundations of quantum mechanics as a serious field of research within the physics community (see Freire (2006, p. 608-10)). And very soon after *Epistemological Letters* stopped, philosophers like Jon Jarret (1984), Don Howard (1985) or Fine (1986) were making long-lasting contributions regarding the logical and conceptual implications of the violation of the Bell inequalities. Thus, the end of *Epistemological Letters* was only the beginning of an even more active era on the subject.

Acknowledgments

I want to thank Chris Hamlin and Don Howard for encouraging me to pursue this topic. I learned a lot about the journal itself and the broader historical context from personal conversations with Don, who I also worked with during the digitization process. I also want to thank Olival Freire for his very helpful comments on this piece. I also appreciate the assistance of my partner, Stacy

Sivinski, who helped me edit the piece. Finally, I want to thank Natalie Meyers, from the Navari Family Center for Digital Scholarship of the University of Notre Dame, who guided me through the multiple stages involved in the digitization of the files.

References

Anderson, P. W. and Matthias, B. T. (1964). Editorial foreword. *Physics Physique Fizika*, 1:i–i.

Aspect, A., Dalibard, J., and Roger, G. (1982a). Experimental test of Bell's inequalities using time-varying analyzers. *Physical review letters*, 49(25), 1804.

Aspect, A., Grangier, P., and Roger, G. (1982b). Experimental realization of Einstein-Podolsky-Rosen-Bohm Gedankenexperiment: a new violation of Bell's inequalities. *Physical review letters*, 49(2), 91.

Association Ferdinand Gonseth (1971 (accessed Ausgust 1, 2020)). *L Association Ferdinand Gonseth en quelques mots*. `http://afg.logma.ch/ afg.htm`.

Bell, J. (1964). On the Einstein Podolsky Rosen paradox. *Physics Physique Fizika*, 1:195–200.

Bell, J. (1966a). On the problem of hidden variables in quantum mechanics. *Reviews of Modern Physics*, 38(3):447.

Bell, J. (1966b). On the problem of hidden variables in quantum mechanics. *Rev. Mod. Phys.*, 38:447–452.

Bell, J. (1975). Locality in Quantum Mechanics: Reply to critics. *Epistemolog- ical Letters*, (7).

Bell, J. (1976). The Theory of Local Beables. *Epistemological Letters*, (9). Bell, J. (1977).

Free variables and local causality. *Epistemological Letters*, (15).

Bell, J. and Aspect, A. (2004). *Speakable and Unspeakable in Quantum Mechanics: Collected Papers on Quantum Philosophy*. Cambridge University Press.

Bertholet, E. (1971 (accessed Ausgust 1, 2020)). *Manifeste de l Association Ferdinand Gonseth pour la création d un institut de la méthode à Bienne*. `http://afg.logma.ch/mnfst.htm`.

Bohm, D. (1952). A suggested interpretation of the quantum theory in terms of hidden" variables. i. *Physical Review*, 85(2):166–179.

Bohr, N. (1948). On the notions of causality and complementarity 1. *Dialectica*, 2(3-4):312–319.

Bonsack, F. (1961). *Information, thermodynamique, vie et pensée*, volume 2. Gauthier-Villars.

Bonsack, F. (1984). End of the written symposium hidden variables and quantum uncertainty. Brochure.

Bub, J. (1973). On the possibility of a phase-space reconstruction of quantum statistics: A refutation of the bell-wigner locality argument. *Foundations of Physics*, 3(1):29–44.

Clauser, J. (2002). Notes on Early History of Bell s Theorem. In Bell, J., Bertlmann, R., and Zeilinger, A., editors, *Quantum (Un)speakables: From Bell to Quantum Information*. Springer.

Clauser, J. F., Horne, M. A., Shimony, A., and Holt, R. A. (1969). Proposed experiment to test local hidden-variable theories. *Physical review letters*, 23(15):880.

de Broglie, L. (1948). Sur la complÉmentaritÉsystÈme. *Dialectica*, 2(3/4):325–330.

d Espagnat, B. (1976). *Conceptual foundations of quantum mechanics. Second edition*. W. A. Benjamin, Inc.,Reading, MA, United States.

d Espagnat, B. (1983). Veiled reality. In *In Search of Reality*, pages 82–104. Springer.

Einstein, A. (1948). Quanten-Mechanik und Wirklichkeit. *Dialectica*, 2(3/4):320–324.

Einstein, A., Born, M., and Born, H. (1969). Briefwechsel 1916-1955 [zwischen] Albert Einstein, Hedwig Born und Max Born.

Einstein, A., Podolsky, B., and Rosen, N. (1935). Can quantum-mechanical description of physical reality be considered complete? *Physical Review*, 47(10):777–780.

Fine, A. (1973). Probability and the intepretation of quantum mechanics. *The British Journal for the Philosophy of Science*, 24:1.

Fine, A. (1974). On the completeness of quantum theory. *Synthese*, 29(1):257– 289.

Fine, A. (1986). *The shaky game: Einstein, realism, and the quantum theory*. Science and its conceptual foundations. University of Chicago Press, Chicago.

Fraassen, B. C. V. (1974). The Einstein-Podolsky-Rosen Paradox. *Synthese*, 29(1):291.

Freedman, S. and Clauser, J. (1972). Experimental test of local hidden-variable theories. *Phys. Rev. Lett. 28: No. 14, 938-41(3 Apr 1972)*, 28(14).

Freire, O. (2004). The Historical Roots of the Foundations of Quantum Physics" as a Field of Research (1950-1970). *Foundations of Physics*, 34(11):1741–1760.

Freire, O. (2006). Philosophy enters the optics laboratory: Bell s theorem and its first experimental tests (1965-1982). *Studies in History and Philosophy of Modern Physics*, 37(4):577–616.

Fuchs, T. (2007 (accessed Ausgust 1, 2020)). *Ferdinand Gonseth*. https:// hls-dhs-dss.ch/fr/articles/031363/2007-01-04/.

Garuccio, A., Popper, K., Vigier, J.P. (1981). Possible direct physical detection of de Broglie waves. *Physics Letters A*, 86 (8): 397-400

Gonseth, F. (1926). *Les fondements des mathématiques*. A. Blanchard, Paris.

Gonseth, F. (1936). *Les mathématiques et la réalité*. F. Alcan, Paris.

Gonseth, F. (1945). *La géométrie et le problème de l espace.* Editions du Griffon, Neuchâtel.

Gonseth, F. (1964). *Le problème du temps. Essai sur la méthodologie de la recherche.* Bibliotheque scientifique. Editions du Griffon, Neuchâtel.

Hooker, C. (1973). Physics and metaphysics: A prolegomena for the riddles of quantum theory . *Contemporary Research in the Foundations and Philosophy of Quantum Theory, Dordrecht, Reidel*.

Howard, D. (1985). Einstein on locality and separability. *Studies in History and Philosophy of Science Part A*, 16(3):171–201.

Jarrett, J. P. (1984). On the physical significance of the locality conditions in the bell arguments. *Noûs*, pages 569–589.

Jauch, J. M. (1973). Are quanta real?: a Galilean dialogue.

Jauch, J. M. and Morrow, R. A. (1968). Foundations of quantum mechanics. *AmJPh*, 36(8):771–771.

Kaiser, D. (2007). Turning physicists into quantum mechanics. *Physics World*, 20(5):28.

Kaiser, D. (2011). *How the Hippies Saved Physics: Science, Counterculture, and the Quantum Revival*. W. W. Norton.

Kevles, D. (1995). *The Physicists: The History of a Scientific Community in Modern America*. Harvard University Press.

Lauener, H. (1977). Ferdinand Gonseth 1890-1975. *Dialectica*, 31(1-2):113–118.

Lochak, G. (1975). Paramètres cachés et probabilités cachées. *Epistemological Letters*, (6).

Lochak, G. (1976). Has Bell s inequality a general meaning for hidden-variable theories? *Foundations of Physics*, 6(2):173–184.

Lopes, J.L., Paty, M.: *Quantum Mechanics: A Half Century Later*. Holland/D. Reidel, Dordrecht/Boston, MA (1977)

Margenau, H. and Yourgrau, W. (1970). Editorial preface. *Foundations of Physics*, 1(1):1–3.

Moldauer, P. (1974a). A new critique of EPR. *Epistemological Letters*, (2).

Moldauer, P. (1974b). Reexamination of the arguments of Einstein, Podolsky, and Rosen. *Foundations of Physics*, 4(2):195–205.

Myrvold, W., Genovese, M., and Shimony, A. (2019). Bell s Theorem. In Zalta, E. N., editor, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, spring 2019 edition.

Pauli, W. (1948). Editorial. *Dialectica*, 2(3/4):307–311.

Piron, C. (1976). *Foundations of quantum physics*. W. A. Benjamin, Inc.,Reading, MA, United States.

Prabook (2020 (accessed Ausgust 1, 2020)). *François Bonsack*. `https://prabook.com/web/francois.bonsack/488192`.

Primas, H. (1983). *Chemistry, quantum mechanics and reductionism : perspectives in theoretical chemistry*. Lecture notes in chemistry ; 24. Springer-Verlag, Berlin ; New York, 2nd corr. ed.. edition.

Shimony, A. (1978). Reply to Bell 17.3. *Epistemological Letters*, (18).

Shimony, A. (1985). Introduction. *Dialectica*, 39(2):83–84.

Shimony, A. and Horne, M. (1973). Local Hidden-variable Theories. *Epistemo- logical Letters*, (1).

Shimony, A., Horne, M., and Clauser, J. (1976). Comment on The Theory of Local Beables". *Epistemological Letters*, (18).

Suppes, P. (1974). Introduction. *Synthese*, 29(1):3.