Chapter 2
The Renaissance of General Relativity: A New Perspective

Abstract This chapter presents a general historiographical framework for interpreting the renaissance of general relativity as a consequence of the interplay between internal and environmental factors. The internal factors refer to the resilient theoretical framework provided by general relativity to physicists working in diverse and dispersed fields. The external factors relate to the changing working conditions of physicists in the post-World War II period, with the newly created conditions for the mobility of young researchers, for the transfer of knowledge in a growing international community, and for the self-organization of an identifiable community. These external factors created a favorable environment for integrating the dispersed research endeavors under the new heading of "General Relativity and Gravitation" research. This, in turn, provided the conditions for the emergence of a coherent investigation of the theoretical core of general relativity for its own sake and for the creation of a community specifically dedicated to this goal.

Keywords Albert Einstein · Epistemic dispersion · General relativity · Low-water mark of general relativity · Quantization of gravity · Relativistic cosmology · Renaissance of general relativity · Unified field theory · Untapped potential of general relativity

What was the renaissance of general relativity? What were the main features of this phenomenon? What were its main phases? On what empirical foundations can we base our claim that there was a revitalization of the field of general relativity in the post-World War II period? Does the term "renaissance" really capture the many facets of this complex historical process?

These and other related questions are at the center of a lively debate among historians of modern science and physicists. The origin of this debate is to be found in the works of historian of physics Jean Eisenstaedt and physicist Clifford Will who identified two consecutive, and symmetrical, epochs in the history of general relativity. In his influential papers, Eisenstaedt maintained that the initial burst of

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This chapter is based on the historiographical framework developed in Blum et al. (2015).

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excitement about the theory following the acclaimed 1919 announcement that one of its few empirical predictions—gravitational light bending near massive bodies—had been confirmed by authoritative British astronomers was short-lived. According to Eisenstaedt (1986, 1989), as of the mid-1920s, research about the theory of general relativity underwent a thirty-year period of stagnation. This situation, which Eisenstaedt called the “low-water mark” of general relativity, ended around the mid-1950s, when work on the theory began producing novel results at a higher pace and attracting a host of new research scholars.

In his reviews of the experimental tests of Einstein’s theory of gravitation, physicist Clifford Will (1986, 1989) stressed that this activity did not emerge in full force until the late 1950s. In his view, by 1970, general relativity has become “one of the most active and exciting branches of physics” (Will 1989, p. 7)—a process that deserved the splendid title of “renaissance.” It is striking that both these analyses were published in the second half of the 1980s, suggesting that by that time general relativity had attained the status of one of the building blocks of modern physics, together with quantum mechanics and quantum field theory. Practitioners probably felt that what was seen as a solid column in the edifice of physical knowledge in the mid-1980s stood on very shaky ground less than three decades previously. Following these early attempts to frame the post-WWII history of the theory and recent explorations of its early phase, a periodization of the history of general relativity was proposed (Gutfreund and Renn 2017):

1907–1915: The genesis of general relativity: this phase represents Einstein’s search for a relativistic gravitational theory culminating in the final formulation of the equation of general relativity published on 25 November 2015 (Renn 2007).

1915–ca. 1925: Formative period of general relativity: this decade is marked by attempts to test the theory, its extension of application to cosmology, and early lively discussions within the physics and mathematics communities (Gutfreund and Renn 2017).

ca. 1925–ca. 1955: Low-water-mark period.

From ca. 1955: Renaissance of general relativity.

Although the dates are still a matter of debate, most experts usually agree that this view is a respectful representation of the historical trajectory of general relativity. We still need, however, to better identify the transition between the low-water-mark and the renaissance phases and define these two periods together, for neither the term “low-water mark,” nor “renaissance” makes complete sense without a clear definition of the other. For Eisenstaedt, the main features of the low-water-mark phase were the following. Firstly, only a few scientists—mostly mathematicians—worked on the theory during this period. From the early 1920s, physicists lost interest in a theory that, on the one hand, was very complex from the mathematical standpoint and, on the other, had very little, if any, connection with experimental or observational research. It is not particularly surprising that most theorists preferred to focus on quantum mechanics and its plethora of applications to microphysics and solid-state physics. Contrary to general relativity, theoretical problems of quantum mechanics had direct and productive links to experimental activities. Besides the technical difficulties, research into general relativity was unattractive, for the general impression was that working on it would have led only to purely formal improvements or minor corrections to Newtonian physics.

From the conceptual standpoint, this state of affairs created a barrier to gaining a deeper understanding of the physical predictions of the theory. The meaning and physical characteristics of the Schwarzschild solution and the implications of general covariance for the notions of space and time, for instance, remained clouded with confusion up until the renaissance phase. Eisenstaedt maintains that the few who worked on the theory employed what he called the "neo-Newtonian interpretation" of the theory, particularly of the space-time coordinates. This implied that, during this period, scientists found it very difficult to draw a clear demarcation between actual predictions of the theory and artifacts due to the coordinates used, which were often chosen only to simplify calculations for specific problems. Implicitly, Clifford Will agrees with this view by stating that the theory moved away from being perceived as a highly formalistic subject to being considered one of the most exciting branches of physics by the late 1960s.

After the groundbreaking analyses by Eisenstaedt and Will, historians of science and physicists who discussed the post-World War II history of general relativity tended to agree with this general picture: an important shift in the relevance of research in general relativity occurred sometime around 1960 (see, e.g., Thorne 1994; Kragh 1999; Kaiser 2000; Kennefick 2007). These scholars either accept the term "renaissance" or use a similar characterization of the period, such as the "Golden Age" of general relativity (Thorne 1994).

With at least one important exception (Goenner 2017), there is strong agreement among scholars that a process that could be called "renaissance of general relativity" actually occurred after World War II. The same scholars, however, have provided quite different views about what the causes of this phenomenon were, which is related to different definitions of the renaissance, its periodization, and its main features.

2.1 Review of the Historiographical Debate

One explanation that has been proposed by Will and is usually highly respected by working physicists is that the revitalization of the interest in general relativity and its sudden progress was sparked by empirical confirmations and experimental discoveries, particularly in the astrophysical domain. The major events normally credited as having resurrected the field were the discovery of quasars in 1963, of the cosmic microwave background radiation (CMB) in 1965, and of pulsars in 1967. All these discoveries required a theory of gravitation that allowed these empirical phenomena to be analyzed and understood in a coherent theoretical framework. The theory of general relativity provided this framework as the currently accepted theory of gravitation. All the abovementioned discoveries were serendipitous and resulted from the rapid innovation in instrumentation. Therefore, the focus on the experimental impulse of the renaissance of general relativity implies that the

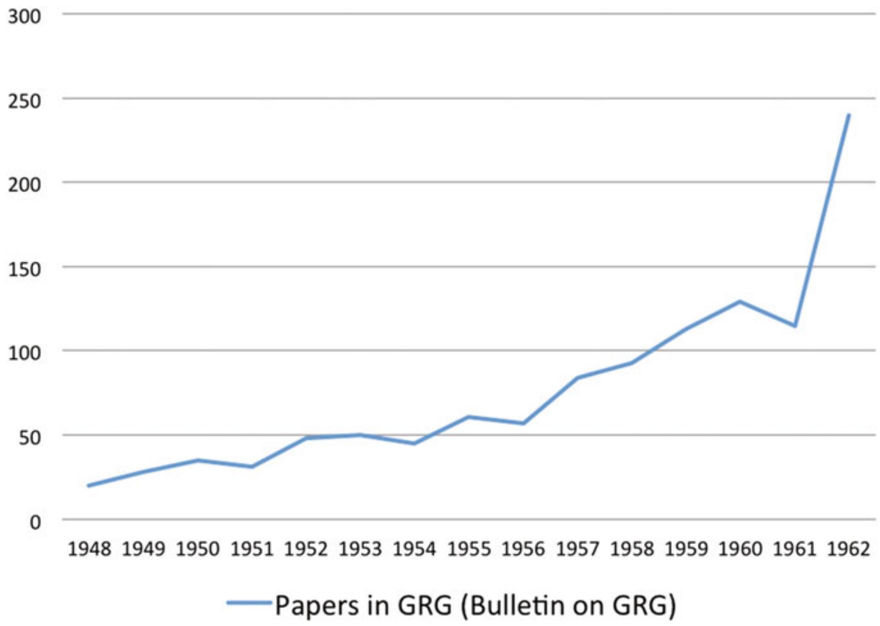

Fig. 2.1 Statistical analysis conducted by the author on the papers in the field of GRG published between 1948 and 1962 as listed in the *Bulletin on GRG*

process was a direct consequence of tremendous technological advances, mostly related to scientific research during World War II and the ensuing Cold War. Only thanks to these new technologies, so the argument goes, could the theory eventually find novel and successful connections with the empirical domain.[1]

Without doubt, these discoveries played a major role in shaping how theoretical gravitation research unfolded. Yet it does not explain other features of the process, such as, for instance, the extraordinary increase in the number of papers addressing topics related to Einstein's theory of gravitation during the 1950s. In Figs. 2.1 and 2.2, different criteria and methodologies have been applied to examine the changes in the number of scientific publications on subjects related to general relativity over the years.[2] Although the two diagrams do not agree on the details, they both strongly support the view that a substantial increment of the scientific production occurred *before* 1962, namely, one year before the discovery of quasars. This increment was therefore completely unrelated to the serendipitous astrophysical and astronomical discoveries cited above.

[1]For a review of these discoveries and their consequences, see Longair (2006). See also Peebles (2017) for a thorough discussion on the evolution of the experimental work in the field of gravitation from the late 1950s to the late 1960s—a period that Peebles calls the "naissance" of experimental gravity physics.

[2]See also the study published in Eisenstaedt (2006. p. 248).

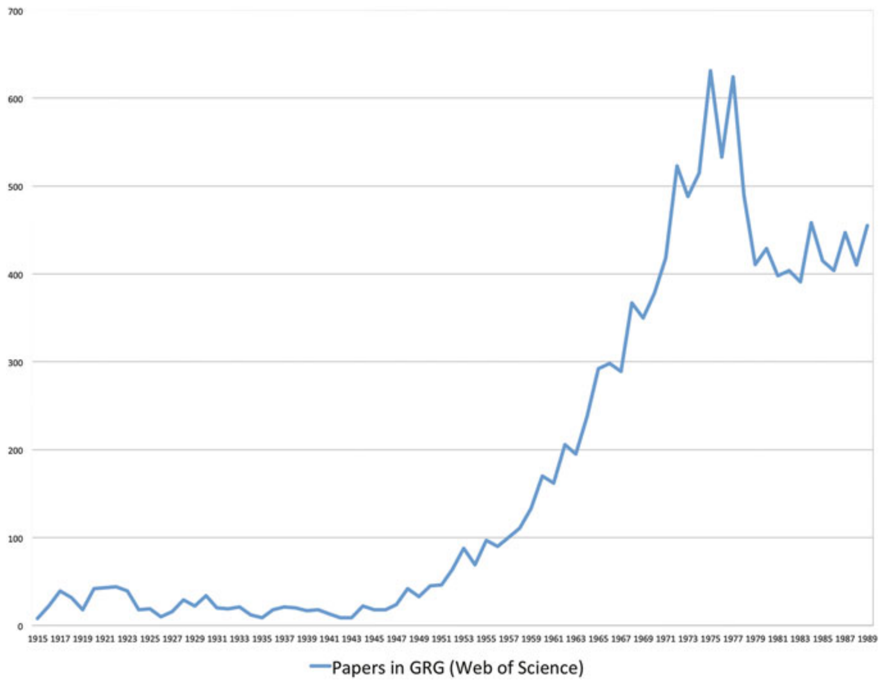

Fig. 2.2 Statistical analysis conducted by the author on papers on topics related to gravitation found in *Web of Science*

One explanation in agreement with the diagrams is that what Will called the "renaissance of general relativity" was a simple consequence of the enormous increase in the physics population after World War II, including of course the growth in the number of theoretical physicists.[3] In other words, this argument states that the proportion of the scientific community working in the field of general relativity did not change significantly after World War II. It was the abrupt change in the total number of active physicists that made a huge difference because this change implied much more far-reaching consequences in a field as small as general relativity was at the time.

An argument strongly related to the previous one is that this research field also benefited from the unprecedented flow of money going into basic science research in the post-World War II period, much of which came from military sources, especially in the United States. Recent studies by Kaiser (2000) and Rickles (2015) have convincingly shown that military funds and private patronage allowed the emergence and flourishing of research centers devoted to general relativity and related fields. The motivation for this generous support was often the hope that theoretical

[3]A very meticulous study of this demographic transformation in the United States was conducted by Kaiser (2012).

and experimental gravitation research could help create anti-gravitational devices in the not-too-distant future.

No doubt, the growth of the physics population and the increase in financial support for basic research in gravitation played a fundamental role in the renaissance process. These elements could be considered to be necessary conditions for the explosion of publications in research topics connected to Einstein's theory of gravitation shown in Figs. 2.1 and 2.2. However, they alone cannot explain the conceptual changes that also occurred in this period. The idea of a direct proportionality between the number of scientists working on a particular problem and conceptual innovations designed to resolve that problem does not always do justice to the dynamics of the evolution of knowledge. Well-known historical cases show that sometimes science works the other way round. In some instances, innovative ideas proposed by individuals often had to overcome the opposition of a majority of authoritative scholars before they could find their way into what was eventually accepted as legitimate knowledge. And when this happened, the process was long, painful, and controversial.[4] Therefore, precisely how social changes were connected to conceptual innovations concerning, for example, the understanding of space-time singularity, the physical interpretation of gravitational waves, the theory of measurement in general relativity, still remains a matter of historical scrutiny.

Some historians of science have argued that conceptual innovations of this type depended on the development and employment of new theoretical tools with a twofold function. First, they made it possible to speed up and simplify the calculations in general relativity, which, everyone agreed, were painstaking.[5] Second, some of these new tools led to improved visualization of the general relativistic space-time, allowing a clearer intuitive, physical interpretation of the theory. Many are the theoretical tools introduced between the mid-1950s and the early 1960s that, according to commentators and practitioners, were crucial to the most important conceptual advances related to the belief in entities such as gravitational waves and black holes. The most quoted are: (a) the Petrov classification (also called the Pirani-Petrov or Penrose-Pirani-Petrov classification) of the Weyl tensor, first published in 1954 (Petrov 2000); (b) the tetrad and spinor formulation developed mainly by the British mathematician Roger Penrose in the early 1960s (Penrose 1960; Newman and Penrose 1962); (c) the Kruskal-Szekeres coordinates elaborated by 1960 (Kruskal 1960; Szekeres 1960); and (d) the Penrose diagrams, which became a diffused tool during the 1960s. The only in-depth historical study on the development and relevance of these theoretical tools to date has been by historian of science Aaron Wright (2014) who argued that the Penrose diagrams did for general

[4]This kind of process might be considered a fundamental part of the concept of scientific revolution as defined in Kuhn (1970).

[5]Even the mathematically minded physicist Pascual Jordan complained about the "mismatch between the simplicity of the physical and epistemological foundations and the annoying complexity of the corresponding thicket of formulae" (Jordan 1955, p. 5, translated in Blum et al. 2017, p. 96).

relativity what the Feynman diagrams did for quantum electrodynamics.[6] More specifically, Wright stresses that the Penrose diagrams made it intuitively possible to grasp the meaning of space-time infinity in the theory of general relativity.

The view that new theoretical tools, particularly those quoted above, played a predominant role in the epistemic shift between the previous neo-Newtonian interpretation of the theory and a fully relativistic understanding of the general relativity theory is certainly consistent. Recollections of the protagonists also stress the relevance of one or more of these tools in allowing a deeper grasp of the extreme physical implication of Einstein's theory.[7] But no study to date has produced a detailed analysis of the conceptual changes in general relativity in terms of these theoretical tools. Moreover, the recourse to theoretical tools to explain the renaissance appears somehow tautological, for it does not explain the phenomenon itself of the emergence and use of these theoretical tools. It does not explain why these tools were all formulated in the period between mid-1950s and early 1960s and why they were soon successfully used by many scientists to produce conceptual advances which might be considered to be of a somewhat revolutionary nature as far as the predictions of actual physical phenomena is concerned.

Historical studies have in fact revealed that precursors of many of these tools were already available in the low-water-mark period. The work of French mathematician Cartan (1922a, b) on the classification of the Weyl spaces that led to the Petrov classification was largely ignored for decades. The work of American cosmologist and mathematical physicist Howard P. Robertson and others on the Schwarzschild singularity could have led to a better understanding of what we now call black holes much earlier than 1960 (Eisenstaedt 1987). The tetrad formalism was actually developed in the context of research in unified field theory in the 1920s (Goenner 2004). None of these precursory advances led to the same definition of problems in physical terms within general relativity proper as occurred between the mid-1950s and the early 1960s. Why this sudden increase in new theoretical tools explicitly created to deal with the problems of the theory of general relativity happened in this specific period remains unexplained.

2.2 Re-assessing the Low-Water-Mark Period

As I have shown in the previous sections, the different views proposed so far by historians of science and physicists leave some major questions unanswered, the main problem being that we still do not have a unified framework to describe the

[6]On the dissemination of the Feynman diagrams and their role in the evolution of theoretical physics, see Kaiser (2005).

[7]Ezra Newman and Roger Penrose, 13 December 2013, interview with Alexander Blum, Jürgen Renn, and Donald Salisbury; and Dieter Brill and Charles Misner, 13 December 2013, interview with Alexander Blum, and Donald Salisbury. I am very grateful to Alexander Blum, Jürgen Renn, and Donald Salisbury for having provided the records of these interviews.

renaissance process. An attempt to frame this unified narrative which takes into account both epistemic and social factors was recently made by Alexander Blum, Jürgen Renn and myself (Blum et al. 2015; see also Blum et al. 2016, 2017). To understand and define the period of the renaissance, the first step was to revise the concept of low-water-mark period. The low-water mark and the renaissance are in fact symmetrical historical categories and it is not possible to understand the renaissance without an in-depth discussion of what happened before.

In our view, one of the most striking features of the low-water-mark period—one that distinguishes it from the renaissance—has not been taken into consideration by previous historical analyses. If we look at the low-water-mark phase without taking the survival of the theory for granted, we see that those who worked on the theory pursued the main goal to modify general relativity and to replace it with a more encompassing one. They mostly aimed at formulating a theory able to describe different physical forces under the same theoretical framework. These manifold attempts were directed in particular toward the search for a unified field theory of the gravitational and electromagnetic phenomena (Goldstein and Ritter 2003; Goenner 2004, 2014). Einstein himself dedicated many years of research to this attempt (van Dongen 2010). Whereas, during the low-water-mark period, there were many approaches to this problem, the most diffused followed the methodology allegedly pursued by Einstein himself in his successful path toward the theory of general relativity. The geometrization of physics was perceived by many as the high road that could have led to a unified theory of gravitation and electromagnetism.

A second, minor, theoretical approach saw the gravitational field only as another field to be quantized following the success of quantum mechanics. These attempts first began in the early 1930s and produced a set of formal steps forward, but without any physical predictions (Blum and Rickles 2017). Both the programs on unified field theory and on the quantization of Einstein's equations made use of some principles of Einstein's gravitational theory as well as his heuristics and methodology. However, this was done with the goal of finding a superior theory, through attempts that were ultimately unsuccessful. The superior goal of going beyond Einstein's theory shaped the way scientists looked at general relativity and at its physical predictions. Those who worked on the above-mentioned research agenda did not consider Einstein's theory fundamental enough to warrant detailed scrutiny of its implications, nor did they think that the theory contained much empirical potential besides what was already known.

The major exception to this attitude was in cosmology. Between 1927 and 1933 there were numerous advances in the field of physical relativistic cosmology, which led to the formulation of the expanding universe. Research in this area was so advanced that in 1933 Howard P. Robertson published a review on relativistic cosmology presenting a basic model of the evolving universe, which is still considered part of the standard present-day Big Bang cosmological model (Ellis 2012, p. 2108). Even in the case of cosmology, however, these developments were received with skepticism by the majority of physicists who questioned whether cosmology was a scientific field at all. It did not help matters that controversies between founders of relativistic cosmology and proponents of alternative theories focused on somewhat philosophical and meta-scientific arguments concerning what was the most suitable method to make progress in a field so far from the observational domain as that of cosmology.[8] Consequently, the extreme physical implications of the theory, such as the primeval atom proposed by Lemaître in 1931, were distrusted by the majority of practitioners (Kragh and Lambert 2007).

During the low-water-mark period, mathematical advances in the area of gravitational theory continued to be pursued both within the program on unified field theory and as an independent research field in mathematics. An important result regarding the physical application of the theory was also obtained by Oppenheimer and his co-authors in their study of the gravitation of a collapsing star in 1939 (Bonolis 2017). All these advances did not become, however, a pool of knowledge shared by practitioners in the field. Most of the results that were considered of value with hindsight were at the time often ignored or distrusted (Ortega-Rodríguez et al. 2017). All these research agendas connected to Einstein's theory of gravitation, in fact, appear as a set of different approaches directed toward quite different goals where the only connection was that knowledge of general relativity and of specific mathematical tools was necessary in order to make progress. These activities were therefore characterized by a strong degree of epistemic dispersion, where scholars did not agree either on the goal or on the methodology. There was no common way to evaluate results, nor was it clear which discipline these results belonged to, whether it was pure mathematics, physics, astronomy, or astrophysics.

This kind of epistemic dispersion was accompanied by a strong social dispersion. Historical studies have revealed that a number of insights were gained in some research branches related to general relativity, particularly in the fields of cosmology and unified field theory (see, e.g., Goenner 2004, 2014; Eisenstaedt 2006), but this progress remained unrecognized in a strongly dispersed network of practitioners that was divided by disciplinary and national boundaries. The means of communication employed by scientists working on problems related to general relativity did not favor a smooth and rapid transmission of knowledge. Papers on these matters could be found in highly diverse publication venues in disciplines such as mathematics, astrophysics, astronomy, and physics. No conference specifically dedicated to exploring all aspects of general relativity, less alone a specific one, was ever organized before 1955.[9] In brief, it was not possible to identify a coherent community of practitioners with shared methods, research questions, and a similar language.[10] The

[8]See George Gale, "Cosmology: Methodological Debates in the 1930s and 1940s," *The Stanford Encyclopedia of Philosophy* (Spring 2014 Edition), ed. Edward N. Zalta, http://plato.stanford.edu/archives/spr2014/entries/cosmology-30s/. Accessed 21 September 2016.

[9]There were a few exceptions, however. Following some developments, the program of unified field theory was revitalized in the period 1929 to 1930 and unified theory also became one of the main topics at the first Soviet All-Union Conference on Theoretical Physics in Kharkov, Ukraine (Goldstein and Ritter 2003). Shortly afterwards, the program seemed be peripheral again (see Vizgin and Gorelik 1987, p. 312).

[10]I am referring in particular to the definition of a scientific field from the perspective of a collaboration network (see, e.g., Bettencourt et al. 2008).

dispersion of the activities in the macro-area broadly connected to general relativity, which, as we have seen, was as much epistemic as social, implies that no scientific field known as general relativity existed at all during the low-water-mark phase. There was no identifiable area of research to which practitioners could refer, or belong, in their pursuit of various research agendas.

2.3 Exploiting the Untapped Potential of General Relativity

These different, dispersed research traditions constituted a potential which was activated during the more favorable societal conditions of the post-WWII period. The abovementioned research activities were the foundations of what is broadly considered to be the successful return of general relativity to the mainstream of physics. The question that then arises is precisely how the existing potential for further developments was activated.

Albeit dispersed, the research traditions previously discussed kept interest in general relativity alive and acted as a conduit for the transmission of Einstein's theory to the next generation through research projects in fact aimed at going beyond Einstein's theory. This process led to a cascade of transformations of general relativity in the 1950s. A few research centers devoted to one or more of the various traditions going beyond general relativity were established around the mid-1950s. By research center, I refer to any kind of institution (universities, private or public research institutes, sections of scientific academies, etc.) where there was at least one principal investigator who had an institutional position stable enough to attract postdocs and/or produce new Ph.D.'s in the field (see Fig. 2.3 and

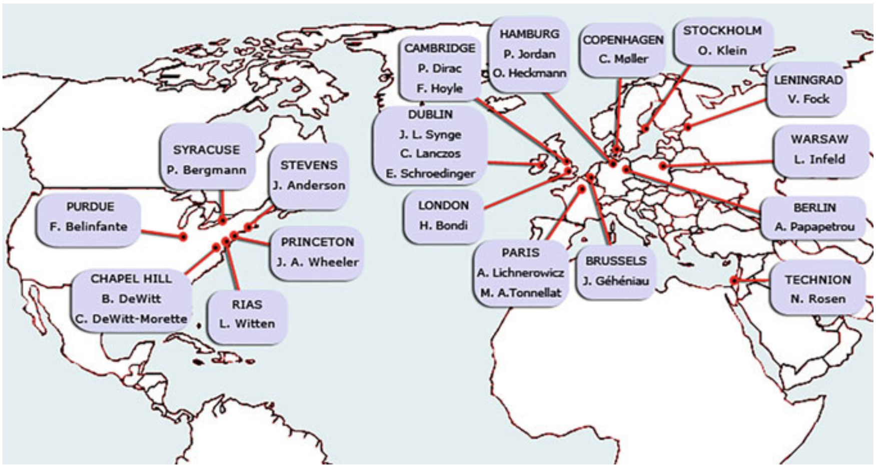

Fig. 2.3 Map of the major research centers working on topics related to general relativity in the United States and Europe in 1955 (see also Appendix A)

Appendix A for a list of the research centers working on research agendas connected to general relativity in 1955.) These research centers benefited enormously from the general transformation in the social dimension of physics that occurred in the post-World War II period, namely, the substantial increase in talent and money flowing into physics in general, and theoretical physics in particular.

Besides this general transformation, one element that seemed to play a specifically important role was the establishment and consolidation of the tradition of postdoctoral education. Given the demographic explosion of physics in the 1950s, many of the new Ph.D.'s did not, and could not, find a stable position in the academe immediately after graduating. They had to spend two or three years, or in some cases even longer, doing postdoctoral research in various research centers in more than one country. In fields related to general relativity, with almost nonexistent connections with industrial and military applications, this phenomenon was even more marked than in other branches of theoretical physics. The long pilgrimage of young researchers made it possible to establish links between the different research centers. The transfer of persons, in turn, facilitated the transmission of theoretical tools, concepts, and research questions between the different research centers and then from one research tradition to another. This process turned the dispersion of the activities into an asset as the developments pursued in different centers soon bore fruit in different contexts.[11] As we see it, this process was a major component in the reconstruction of knowledge giving rise to conceptual transformation in the field of general relativity.

This was not sufficient, however. A relevant role was also played by the explicit attempts to build a community of scientists working on what could be identified as the larger research domain, which included the various research agendas previously described. These attempts began around the mid-1950s and led, through a series of steps summarized in the introduction to this book, to the institutional establishment of General Relativity and Gravitation as a scientific field (see Chap. 1).

The new possibility of social interactions led the leaders of many research centers to identify and formulate common questions, which started to focus more and more on general relativity proper. Initially, this recognition occurred under the assumptions that it was necessary to explore the original theory in detail before furthering the different research programs, which aimed at modifying the theory or going beyond it. This conscious recognition was at the basis of a conceptual reconfiguration—an epistemic shift—where new shared questions concerning, for instance, the theory of observables in general relativity and the properties of gravitational waves became central to the various research agendas (Blum et al. 2017). And because of the social evolution toward a more structured community of scholars, this shift rapidly became a common feature of the newborn community at

[11] Kaiser (2005) studied this process in the context of the diffusion of the Feynman diagrams and called it the "postdoc cascade."

large.[12] This commonly shared change in the focus of research programs toward more conservative goals concerning Einstein's theory of gravitation in its own right was, in our view, the central mechanism of the renaissance of general relativity, which anticipated the new discoveries in astrophysics in the 1960s.

The role of these discoveries was then to bolster a process already well established. It is remarkable, in fact, that only nine months after the first announcement of the discovery of a new astrophysical object, soon to be named quasar, a large and successful conference, the First Texas Symposium on Relativistic Astrophysics, was held where the connections between this discovery and the possible explanation within the context of general relativity were explicitly drawn (Robinson et al. 1965). Even if general relativity was not immediately used to give a realistic physical description of the dynamics involved in the newly discovered astrophysical objects, it was accepted that it would be able to do so in future. In other words, it was acknowledged that the general physical mechanisms Einstein's theory proposed to describe, such as the formation of quasars, were correct, and consensus was rapidly built around such a belief. The speed with which this process occurred would have probably been inconceivable without a community of relativists prepared to absorb this discovery both epistemically and sociologically by organizing a large conference within a few months.

To summarize, in our recent work (Blum et al. 2015, 2016), we claimed that the phenomenon of the renaissance can be seen as a consequence of the interplay of what we categorize as internal and environmental factors. The internal factors refer to the resilient theoretical framework provided by general relativity to physicists working in diverse (and dispersed) fields; the external factors relate to the changing working conditions for physicists in the post-World War II period. Here, we do not only mean the availability of new technologies, the growing number of practitioners, and the exponential increase in funding. We also refer to newly created conditions for the mobility of young researchers (post-doc cascade), for the transfer of knowledge in a growing international community, and for the self-organization of an identifiable community. These external factors created a favorable environment for integrating the dispersed research endeavors under the new heading of GRG research. This, in turn, created the conditions for the emergence of a coherent investigation of the theoretical core of general relativity for its own sake and for the creation of a community specifically dedicated to this goal. This is also the sense in which Blum, Renn and I propose to speak not of the mere renewal of relativity research but of the reinvention of general relativity within the physics discipline, which was thus turned from a theoretical framework into a field of research in its own right.

Within the historical framework outlined above, this book explores a fundamental aspect of the social dimension of this process by focusing on the explicit

[12]This is confirmed by physicists active at the time. Dean Rickles and Donald Salisbury, interview with Louis Witten, 17 March 2011, https://www.aip.org/history-programs/niels-bohr-library/oral-histories/36985. Accessed 12 March 2017.

attempt to build an international community of “relativists” and all the problematic aspects that this community building and institutionalization process entailed in that particular historical period. As briefly mentioned in Chap. 1, I focus mainly on two elements. The first concerns the unsettled epistemic status of the theory at the time. The socio-epistemic dispersion identified in our description of the low-water-mark period was still ongoing in the 1950s and was one of the major obstacles to overcome in the attempts to build a community. The epistemic dispersion characterizing the relationships between the different, loosely connected, research agendas as well as national and disciplinary divides still shaped the work carried out at the research centers. This implied that it was not easy to envisage a common framework from the different research activities and that the attempts to do so had consequences on the research activities themselves. The second element regarded the problem of how to structure a community in the international arena during the Cold War. At the time, community builders could look only to a very few examples of organized international scientific collaboration, and these structures imposed constraints on the ways in which institutional community building was to be pursued. As we shall see, these constraints allowed the actors to initiate the process in the first place but also created a series of problems when politics suddenly entered the equation. In the next chapter, I will discuss the existing structures of international scientific collaboration that served as models for the construction and institutionalization of the GRG community. These were existing institutional bodies that, although created before World War II, were being transformed in the changing political climate of the postwar and Cold War periods.

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