

Appendix A

Research Centers on Fields Related to General Relativity Around the Mid-1950s

In this Appendix, I will give short descriptions of the various research centers active in the mid-1950s that were working on topics soon to be included in the larger GRG domain. As discussed in Chap. 2, I use a broad definition of research centers. These are institutions (such as universities, research institutes, sections of national academies of science, etc.) in which 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. In the presentation that follows, research centers are organized according to their national contexts. This is intended to convey the status of the relevant research activities in the various countries at the outset of the renaissance process, which coincided with the community-building activities in the international arena discussed in this book. The list presented is broad, but it does not claim to be exhaustive. It should not be considered to be a complete representation of what was happening in the different countries. Research activities that did not have a relevant part in the formation of the community might have escaped the author's attention and research centers that were established after 1956 have been excluded. Priority has, in fact, been given to research activities that were represented in the ICGRG when it was first established in 1959. It is assumed that these research centers were considered by the emerging community to be the most active or relevant for topics related to general relativity in the late 1950s.

It was not easy to choose the order of presentation of research centers. The argument of this work and considerations about the different relevance of the centers would have suggested beginning with the status of these centers in the United States and the Soviet Union. However, the following system has been used to make it easier to search within the document: countries are presented in alphabetical order, while research centers within each country are roughly in chronological order based on the date they were established. The scientists' dates of birth and death have only been included for scientists who were in charge of these research centers in the mid-1950s.

A.1 Belgium

Free University of Brussels

Within a tradition firmly linked to the French school in differential geometry, at the time of the Bern conference, two Belgian scientists were working on mathematical aspects of the theory of general relativity at the Free University of Brussels: mathematician Robert Debever (1915–1998) and mathematical physicist Jules Géhéniau (1909–1991). Around the mid-1950s, Debever and Géhéniau initiated a fruitful collaboration on a research agenda concerning the invariants of the Riemann tensor. Notwithstanding these favorable preconditions, the center in Brussels did not develop further in the period between the mid-1950s and the mid-1960s. It was essentially limited to the work of Debever and Géhéniau, who were also both pursuing active research in other topics not directly related to GRG. During this decade, the only Ph.D. student working in this field was Michel Cahen. He earned his Ph.D. in 1960 with a dissertation on the unified theory of gravitational and electromagnetic fields related to the equations of Rainich and Wheeler. The capacity to attract postdocs from abroad was also limited, perhaps also as a consequence of the refusal by the U.S. Air Force to financially and logistically support this center for political reasons (Goldberg 1992).¹ However, the center organized one of the first smaller European international meetings in the late 1950s, which was attended by researchers of the younger generation.² Neither Debever nor Géhéniau became a member of the ICGRG.

A.2 Denmark

Institute for Theoretical Physics, Copenhagen University

Authoritative theoretical physicist Christian Møller (1904–1980) was a central figure in the development of theoretical physics in Denmark and played a leading role in the Danish involvement in establishing CERN in the mid-1950s (Blum and Hartz 2017). At the same time, Møller was one of the few theoretical physicists of

¹The reason was that Géhéniau was identified with the Belgian Communist party. Joshua Goldberg, e-mail to the author, 3 March 2016; and Goldberg, Joshua, 21 March 2011, interview with Donald Salisbury and Dean Rickles. <https://www.aip.org/history-programs/niels-bohr-library/oral-histories/34461>. Accessed 5 March 2016.

²Goldberg, Joshua, 21 March 2011, interview with Donald Salisbury and Dean Rickles. <https://www.aip.org/history-programs/niels-bohr-library/oral-histories/34461>. Accessed 5 March 2016.

the older generation who was actively engaged in research on gravitation theory in the 1950s. In 1952, he had published a textbook on general relativity, which at the time of the Bern conference was considered to be one of the most up to date (Møller 1952).³ As a research center, the Institute for Theoretical Physics was characterized by its role as a meeting point for scholars coming from abroad for both short and long periods, rather than by training new Ph.D. students in the field. Thus, it assumed a particular relevant role in improving links between the various groups working on different topics related to GRG. Among the researchers who spent a period at the Institute for Theoretical Physics in the period 1955–1965 are Stanley Deser, Bryce S. DeWitt, Leopold E. Halpern, Bernard Juvet, Oskar Klein, Arthur B. Komar, Bertel Laurent, Charles W. Misner, Erwin Schrödinger, and Frank R. Tangherlini.

One important event taking place in this institutional setting was the month-long meeting dedicated to the quantization of the gravitational field, which was held in July 1957, only a few months after the Chapel Hill conference (Blum and Hartz 2017, DeWitt 2017). In 1957, Møller also became the Director of the newly established Nordic Institute for Theoretical Physics (NORDITA) and, one year later, Léon Rosenfeld was also invited to join the institute. The Copenhagen research environment had a strong representation within the ICGRG from the outset: both Møller and Rosenfeld were among the founding members of the ICGRG in 1959.

A.3 Federal Republic of Germany (West Germany)⁴

A.3.1 Hamburg University and Hamburg Observatory

In the mid-1950s, Pascual Jordan (1902–1980) was without doubt the most authoritative scientist working on research connected to general relativity in West Germany. A former active member of the Nazi party, he was not able to obtain a guest professorship at the University of Hamburg until 1947 after the denazification process ended and thanks to the personal recommendation of Wolfgang Pauli (Beyler 1996; Hoffmann and Walker 2007). At this university, he worked in fields related to general relativity with a focus on two areas: Dirac's large numbers hypothesis and the formulation of a scalar-tensor theory of gravitation (Goenner 2012). Jordan's alternative gravitation and cosmological theories had a certain

³Wheeler, for instance, refers in his notebooks to Møller's book as the major source of reference in his attempt to learn the theory. *Relativity Notebook 1*, JWP, Box 39 (quoted in Blum 2016).

⁴For a detailed description of the development of the field of GRG in Germany, see Goenner (2016).

impact on other researchers in West Germany outside his group. After he became a full professor in Hamburg, he was able to start building a stronger research group with his students and later with postdocs and more senior researchers coming from abroad. By 1965, those who had obtained a Ph.D. under Jordan's supervision included some of most influential German experts of general relativity over the following decades: Engelbert Schucking (Ph.D. in 1956), Jürgen Ehlers (Ph.D. in 1958), Wolfgang Kundt (Ph.D. in 1958), and Manfred Truemper (Ph.D. in 1962). Jordan collaborated very closely with all his students and the focus of the group rapidly shifted toward topics more directly associated with general relativity proper. The work Jordan did with Kundt and Ehlers on the exact solutions of Einstein's field equation, for instance, had a particularly strong impact on the renaissance of general relativity. Among those coming from abroad who spent a period of research in Hamburg in the same timeframe, the following are worth mentioning: Peter Bergmann, Dieter Brill, Joshua Goldberg, Wolfgang Rindler, Ivor Robinson, and Rainer Sachs. This center was one of the few non-American centers to be financially supported by the U.S. Air Force program in gravitation.

Closely associated to Jordan's emerging group in Hamburg, the Director of the Hamburg Observatory, Otto Heckmann (1901–1983), was also working on research questions related to general relativity, particularly in the field of cosmology. Heckmann and Jordan actively collaborated and shared co-workers. Schucking, in particular, even before earning his Ph.D. with Jordan, became Heckmann's assistant and remained his closest collaborator up until 1959 when he moved to the United States. Ehlers, too, cooperated closely with Heckmann after having earned his Ph. D. Given the strong links between these two groups, we could consider the Hamburg environment to be a large research center with two leading figures, with Jordan's group certainly the largest. Heckmann, however, also had at least one Ph. D. student in the field: the Hungarian Istvan Ozsvath (Ph.D. in 1960).

A.3.2 Institute for Theoretical Physics, Freiburg University

In Freiburg, a much smaller group was being established around the figure of Helmut Hönl (1903–1981), an eminent theoretical physicist who had contributed in particular to the development of quantum mechanics. He first became interested in the theory of general relativity in the late 1930s, but by the time of the Bern conference he had only published a few papers on the subject in collaboration with August W. Maue. The group started to grow as of the second half of the 1950s, when Hönl supervised a few Ph.D. students on topics within the field of GRG, including Charlotte Soergel-Fabricsius (Ph.D. in 1960), Heinz Dehnen (Ph.D. in 1961), and Hubert Goenner (Ph.D. in 1966). In the early 1960s, Konrad Westpfahl, another senior member of the institute, began collaborating on this research.

A.4 France

Collège de France and Institut Henri Poincaré, Centre National de la Recherche Scientifique (CNRS), Paris

In the mid-1950s, two research centers had been already established in Paris. These two groups were based at the two different universities (the Collège de France and the Sorbonne), but they also both had an institutional link to the CNRS. Mathematician Andre Lichnerowicz (1915–1988) had been working on the Cauchy problem in general relativity since his doctoral studies under Georges Darmais in the late 1930s, where he made considerable progress on the initial value problem in general relativity following lines of research initially pursued by Élie Cartan and Darmais himself (Lichnerowicz 1992; Stachel 1992; Choquet-Bruhat 2014). From 1949 to 1952, he was Professor of Mathematical Methods at the University of Paris and, in 1952, he obtained a chair at the Collège de France, where he introduced a course on general relativity. From 1949, he trained many students working on different aspects of the theory of general relativity, such as mathematical problems of Einstein’s theory, alternative theories of gravitation and the unified theory of gravitation and electromagnetism. By 1965, Lichnerowicz had been the supervisor of an impressive number of dissertations on these topics, including those of Yves Thiry in 1950, Yvonne Bruhat in 1951,⁵ Pham Mau Quan in 1954, Josette Charles in 1956, Françoise Maurer in 1957, Françoise Hennequin in 1958, Pierre V. Grosjean in 1958, Louis Bel in 1960, Cahen (as co-supervisor together with Debever) in 1960 (see Appendix A.1), Albert Crumeyrolle in 1961, Robert Vallee in 1961, Marcel Lenoir in 1962, and Jean Vaillant in 1964 (Goenner 2014).

The second group active in Paris was led by French theoretical physicist Marie-Antoinette Tonnelat (1912–1980). Tonnelat had earned a doctorate under the supervision of Nobel laureate Louis de Broglie in 1939 with a dissertation on the theory of photons in a Riemannian space. After having worked in the group directed by de Broglie, she was able to start her own group in 1945, when she became Director of Research at the CNRS in Paris. While she had already initiated her program on unified field theory, in establishing the research topic of her group, she was probably influenced by the approach followed by Erwin Schrödinger toward a pure-affine theory, with which she became acquainted when spending a year at DIAS (see Appendix A.7). Like Lichnerowicz, Tonnelat also had a good track record of dissertation supervision within the field of GRG. By 1965, the following

⁵Yvonne Bruhat was known by the surname Fourès-Bruhat while she was married to mathematician Leonce Fourès but later changed her surname to Choquet-Bruhat after her second marriage (to mathematician Gustave Choquet in 1961).

had all earned Ph.D.'s under her guidance or with her support: Jacques Levy in 1957, Pam Tan Hoang in 1957, S. Kichenassamy in 1958, Jean Hely in 1959, Marcel Bray in 1960, Liane Bouche in 1961, Nguyen Phong-Chau in 1963, Philippe Droz-Vincent in 1963, Aline Surin in 1963, Sylvie Lederer in 1964. Under Tonnelat's influence and in collaboration with her, Stamatia Mavrides and Judith Winogradzki also worked on the program of unified field theory in the late 1950s (Goenner 2014).

From the perspective of community building, these two groups played a major role in training a new generation of experts, particularly of French nationality, and in sparking research on similar topics in other European countries, such as Italy (see Appendix A.9). However, it appears that they did not act as strong centers for international postdoctoral studies. In addition, the interconnections between the two groups were quite weak. Collaboration seems to have been mainly of a formal and organizational nature, rather than based on joint research projects. The major collaborative venture was organizing the Royaumont conference, which played a key role in the establishment of the ICGRG and in strengthening contacts between Eastern and Western scholars (see Sects. 4.2 and 4.4). Like Copenhagen, Paris was also strongly represented within the ICGRG. Both Lichnerowicz and Tonnelat became members of the ICGRG when it was established during the Royaumont conference and both assumed the role of co-President for the subsequent three years.

A.5 German Democratic Republic (East Germany)

Institute for Pure Mathematics, German Academy of Sciences at Berlin

In East Germany, there was one major active group working on general relativity and related topics in the mid-1950s. This group was formed around the figure of the Greek theoretical physicist Achilles Papapetrou (1907–1997) at the Institute for Pure Mathematics of the German Academy of Science at Berlin (DAWB). Papapetrou had been working on a variety of topics related to general relativity since the late 1930s. Known for his left-wing attitudes, he had to leave Greece at the dawn of the Greek civil war. He first went to Dublin, where he worked with Schrödinger between 1946 and 1948, on the unified field theory program he pursued at the Dublin Institute for Advanced Studies (DIAS) (Goenner 2014). He later spent almost four years with Rosenfeld at the University of Manchester (see Appendix A.13.4) where he conducted research notably on the equations of motion in general relativity. In 1952, Papapetrou went to East Germany where he established a research group on general relativity at the DAWB (Hoffmann 2017). The main rationale for establishing this group was that it was intended to be linked

directly to the solar eclipse expeditions planned by the German Academy of Sciences under the direction of Erwin Finlay-Freundlich, an early associate of Albert Einstein's and observer at the astrophysical observatory in Potsdam (the Einstein Tower) from its establishment in 1920 up until 1933, when he was removed from office after the implementation of the anti-Semitic Civil Service Law by the Nazi regime (Hentschel 1997). In addition, it was hoped that Papapetrou would re-establish the Berlin research tradition in general relativity, which had been interrupted during the Nazi regime. In the period when Papapetrou worked in Berlin, from 1952 to 1961, he trained at least two Ph.D. students on topics in the field of GRG: Hans-Jürgen Treder (Ph.D. in 1956) and Georg Dautcourt (Ph.D. in 1962). When Papapetrou left the GDR in 1961 to take up the position of Director of Research at the CNRS in Paris, he was replaced at the DAWB by his former student, Treder. In the future, Treder would have a strong influence in shaping and strengthening the field in the GDR also because of his leading role in science administration, which was not only rooted in his scientific competence, but was also backed by the political authorities. None of the scientists working in the GDR became members of the ICGRG when it was established. The first scientist to become a member of the ICGRG was Treder in 1969 (see Sect. 5.1).

A.6 India

Despite the absence of Indian scientists within the membership of the ICGRG up until 1969, India hosted a fairly considerable number of research activities in the mid-1590s, at least by standards at the time. For a variety of reasons that I will not address here, these activities were pursued in isolation from the increasing network of scientists who were establishing a community in North America and Europe (Lalli and Wintergrün 2016). The most relevant exponent in this tradition was mathematical physicist Vishnu Vasudev Narlikar (1908–1991). After having completed his studies at Cambridge University, he became Professor of Mathematics at **Banaras Hindu University** in Varanasi in 1932 and pioneered research on general relativity in India on subjects such as exact solutions of general relativity, unified field theory of electromagnetism and gravitation, equations of motion in general relativity, and invariants of Riemannian metrics. One of his Ph.D. students was Prahalad Chunnilal Vaidya (Ph.D. in 1947), who by the mid-1950s had already established a second flourishing research center on GRG at **Gujarat University**. Narlikar trained, and collaborated with, many younger Indian researchers and had a long-term influence on them. Probably inspired by his research, his son, Jayant Vishnu Narlikar would become an important astrophysicist and cosmologist. Vaidya would be the first Indian scientist to join the ICGRG, which he did in 1969, when the Committee on Gravitation was established in India (see Sect. 5.1).

A.7 Ireland

Dublin Institute for Advanced Studies (DIAS)

By the mid-1950s, DIAS was certainly one of the largest and most authoritative research centers in fields related to general relativity and gravitation in Europe. Three senior scientists were pursuing different kinds of studies in this area. The most influential in community building and in establishing international collaboration was perhaps the Irish mathematician John L. Synge. Synge had been working on general relativity throughout his entire career since the early 1920s. During the low-water-mark period, he established himself as one of the greatest authorities on the mathematical problems of general relativity. After almost twenty years at the University of Toronto, Synge agreed to come back to Ireland as Senior Professor at DIAS. There, he dedicated himself almost completely to research in relativity theories, producing two important books, one on the special theory of relativity (Synge 1956) and the other on the general theory (Synge 1960) and collaborating with a number of younger researchers, including Anadijiban Das, Petros Serghiou Florides, Lochlainn O’Raifeartaigh, and Felix Pirani. He also supervised the dissertation of Werner Israel (in 1960) who would later contribute significantly to the theory of black holes.

The other two scientists who were active at DIAS at the time were Nobel laureate Erwin Schrödinger (1887–1961) who had been pursuing a research program on the unified field theory of gravitation and electromagnetism since the early 1940s, and the Hungarian mathematical physicist Cornelius Lanczos (1893–1974), who was one of the greatest authorities on general relativity during the low-water-mark phase. Before he returned to Vienna in 1956, Schrödinger had the opportunity to work with many colleagues at DIAS, including Bertotti, Papapetrou, and Tonnelat, who would all play a significant role in the renaissance process and in the activities related to establishing the international community. It seems that Lanczos did not play as great a role in establishing collaboration with younger researchers active in the renaissance process. Of the three, Synge was the scientific figure who exerted a long-term influence on the research activities in the field both at the local and international level. This was institutionally recognized during the foundation of the ICGRG when Synge was invited to become a member.

A.8 Israel

Israel Institute of Technology—Technion, Haifa

The American-Israeli theoretical physicist Nathan Rosen (1909–1995) had worked as Albert Einstein’s assistant at the Institute for Advanced Studies (IAS) in Princeton between 1934 and 1936. With Einstein, Rosen produced a number of achievements, including the elaboration of the Einstein-Rosen space-time bridge

published in 1935, the formulation of the EPR paradox (the Einstein-Podolsky-Rosen criticism of quantum mechanics) in the same year, and the paper on gravitational radiation published in a modified version by Einstein alone after the end of Rosen's stay at IAS (Kennefick 2007). After working for two years at the University of Kiev in the Soviet Union, Rosen returned to the United States, but eventually he moved to Israel in 1953 to take up a professorship at the Technion in Haifa. Besides playing an important role in the growth of the institute by serving in many administrative positions, Rosen established a small research center on the theory of gravitation there. Unlike many other centers, at that time, Rosen's center was pursuing research in general relativity proper, focusing in particular on gravitational waves and the equations of motion. At Technion, between 1953 and 1965, Rosen trained a new generation of Israeli scholars pursuing research in the field of GRG, including Asher Peres (Ph.D. in 1960), Gidon Erez (Ph.D. in 1960), and Moshe Carmeli (Ph.D. in 1964). Moreover, he had a considerable influence on the British mathematical physicist Ivor Robinson. The center would grow further after 1959 when American theoretical physicist and general relativity expert Gerald E. Tauber joined the Technion. Rosen was certainly considered one of the greatest authorities in general relativity in the 1950s and became a member of the ICGRG when it was founded.

A.9 Italy

Notwithstanding the very strong mathematical tradition in the field of tensor calculus and differential geometry that had a profound impact on the origin and development of general relativity, by the mid-1950s, research on general relativity in Italy was at a standstill. This form of research had been almost completely disrupted by political events during the low-water-mark period, first with the fascist academic reforms in the early 1930s and, most dramatically, by the Racial Laws heralded in 1938. The Italian mathematical community suffered from an intensified political influence of the fascist regime on academic and scientific life. One of the most active mathematicians in the field during the 1930s was still Tullio Levi-Civita, whose work had a tremendous impact on the genesis of general relativity along with that of his teacher Gregorio Ricci-Curbastro. In 1938, the Racial Laws abruptly ended his career and his chances of pursuing active research. The impact of this political disruption of scientific activity, which also led to the exile of Enrico Fermi, unanimously considered the father of theoretical physics in Italy, and other physicists was still evident in the mid-1950s (see, e.g., Goodstein 1982; Nastasi and Tazzioli 2005; Bergia 2005).

In the fields connected to general relativity, the only institutional entity that might be considered as a research center active in that period was the group under the leadership of Bruno Finzi (1899–1974) at the **Polytechnic Institute of Milan**.

Finzi was a Jewish mathematician and engineer who had been strongly influenced by the work of Levi-Civita. Since the late 1940s, he had been working in areas related to general relativity in collaboration with other scholars, both senior and younger ones, including Emilio Clauser, Paolo Udeschini and, in particular, Maria Pastori. While the group was quite sizeable, this research center remained isolated all through the renaissance, possibly also because they continued to publish in Italian and were not involved in community-building activities (Goenner 2014).

Another group that was established in Rome as late as 1957 had a much greater relevance for building the larger international institutional framework. Mathematician Carlo Cattaneo (1911–1979)—a former student of Levi-Civita’s—had been working on classical mechanics and fluid mechanics before he turned his interest toward mathematical methods in the theory of general relativity in 1957, when international community-building activities were already under way. After he became a professor at the **University of Rome** in 1957, he was able to establish a group on general relativity that was instrumental in the growth of interest in the theory of general relativity in Italy. This happened in 1960, when a research group called “Einstein’s theory of gravitation” was established within the Italian National Research Council, which, besides Cattaneo, included Silvano Bonazzola, Mario Castagnino, and Giorgio Ferrarese. In the 1960s, along with the astrophysics group established by Livio Gratton at the Laboratorio Gas Ionizzati in 1960, Cattaneo and his research group contributed to initiating research on relativistic astrophysics in Italy. One of the first results of this was the work of Franco Pacini together with Bonazzola, which would have a strong impact on the study of neutron stars. Cattaneo’s decision to pursue research in general relativity was motivated by his close intellectual and personal relationship with Lichnerowicz. This connection probably also facilitated Cattaneo’s rapid entry into the international community. Cattaneo, indeed, immediately became a member of the ICGRG when it was first established (see Bonolis et al. 2017).

A.10 Poland

Institute of Theoretical Physics, Warsaw University

Like Rosen, Polish Jewish theoretical physicist Leopold Infeld had also acquired a reputation as a former collaborator of Albert Einstein in the 1930s. Infeld had replaced Rosen as Einstein’s assistant at IAS in 1936 and remained in this position until 1939. In this period, Infeld’s biggest achievement was probably formulating, together with Einstein and Banesh Hoffmann, the Einstein-Infeld-Hoffmann equations of motion in general relativity in 1938, which is considered one of the greatest advances in general relativity during the low-water-mark phase (Einstein et al. 1938).

After his period of cooperation with Einstein and thanks to the support of the authoritative American mathematical physicist Howard P. Robertson, Infeld obtained a professorship at the University of Toronto in 1940, where Synge was a professor (Lalli 2016). After World War II, the decline in political relations between the United States and the Soviet Union with the formation of two geopolitical blocs had a dramatic impact on Infeld's career. Although it was not as strong as the Red Scare in the United States, Canada also experienced growing hysteria against the danger posed by spies and leftists present in the country. Because of his political leaning toward peaceful cooperation and demilitarization as well as his nationality, rumors spread that Infeld was serving as a Soviet spy by passing nuclear secrets to Eastern Bloc countries. Demoralized by this unfair campaign against him and following his desire to work on rebuilding Polish science after the damage during World War II, Infeld decided to leave Canada and moved permanently to Poland in 1950. He soon became a member of the Polish Academy of Sciences, which had just been established, as well as Head of the Institute of Theoretical Physics at the University of Warsaw. From 1950 up until his death in 1968, Infeld made major contributions to the growth of Polish physics and, in return, he enjoyed enormous freedom to pursue and promote his own research interests. Under his direction, the Warsaw center then grew into one of the most prominent in the world and, around the mid-1950s, was certainly the strongest center in countries under Soviet influence.

Infeld began long-term collaboration with theoretical physicist Jerzy Plebanski and trained a number of Ph.D. students, including Andrzej Trautman (Ph.D. in 1959), Stanislaw Bazanski (Ph.D. in 1959), Roza Michalska (Ph.D. in 1966). One of Infeld's explicit goals was to increase the international prestige of the Polish Academy of Sciences and, more specifically, of his center. For this reason, he pushed his students and colleagues to publish in the scientific journal of the Academy and, at the same time, established a policy of openness by inviting international guests to pursue research in Warsaw.⁶ By 1965, the University of Warsaw had hosted a considerable number of emerging experts in the field of GRG, including Pirani, Robinson, and John Stachel. It was the first and, up until the 1960s, only research center in the Eastern Bloc to become part of the increasing network of centers for postdoctoral pilgrimage, which was one of the biggest differences of the renaissance process compared to the previous period. Together with his students and collaborators, Infeld also organized the first international conference on GRG held in the Eastern Bloc: the 1962 GR3 conference in Warsaw and Jablonna (see Sect. 4.4). At the time of the Bern conference, Infeld was certainly considered one of the greatest experts in the physical aspects of the theory of general relativity and was among the founding members of the ICGRG in 1959. At that time, he was the only non-Soviet representative of Eastern Bloc countries.

⁶Andrzej Trautman, interview with Donald Salisbury, 27 June 2016, to appear in *EPJH*. I am grateful to Salisbury for making the content of this interview available.

A.11 Sweden

Stockholm University

Since his 1926 ground-breaking contribution to the five-dimensional unified theory of gravitation and electromagnetism first formulated by Theodor Kaluza, Oskar Klein (1894–1977) had become one of the most prominent Swedish mathematical physicists. After more than a decade abroad, Klein accepted a chair at Stockholm University in 1930. While contributing significantly to various theoretical developments in quantum mechanics and nuclear physics, his interest in approaches linking quantum physics and general relativity continued to be significant. As far as original research is concerned, he was not very active in the field of GRG in the mid-1950s, and the research center was rather small. Between the mid-1950s and the 1960s, only one Ph.D. student completed a dissertation in GRG: Bertel Laurent in 1959. The center also only attracted a few scholars from abroad; notably, Ivor Robinson and Leopold Halpern. Nonetheless, at the outset of the renaissance process, Klein was perceived as one of the major authorities and the Stockholm center was considered to be one of very few at the time, particularly for research into quantization of gravitation. Stockholm was in fact quoted by DeWitt in his list of the eight centers working on the theory of gravitation at the end of 1955 (DeWitt 1957). Klein was one of the founding members of the ICGRG.

A.12 Switzerland

University of Bern

Given the relevant role Switzerland would play in bringing about international collaboration in the emerging field of GRG and in establishing and developing the ICGRG, one might perhaps expect to find a quite active group based at the University of Bern. Yet this was not the case. As discussed at length earlier, André Mercier was mostly interested in the philosophical implications of the theory of general relativity, and was not pursuing any research agenda in this field in the mid-1950s, and neither was Pauli (see Sect. 4.1). A clear indication of this lack of activity is that no presentations by Swiss scholars were given at the Bern conference in 1955. It should be added, however, that once the ICGRG was established, Mercier's international connections and his role in the ICGRG helped him strengthen the research activities in theoretical physics, and particularly in the field of GRG, in Switzerland, especially in Bern. In any case, the University of Bern should not be seen as a research center in this early phase of the renaissance. Mercier was the main driving force in the organization of the Bern conference in 1955, a founding member of the ICGRG and its Secretary from when it was established until after the ISGRG was created to replace the ICGRG.

A.13 United Kingdom

A.13.1 *Cambridge University*

At Cambridge University, research activities connected to general relativity began back in the late 1940s. In 1948, the astronomers Fred Hoyle and Thomas Gold, and the mathematician Hermann Bondi, all with teaching positions at Cambridge, formulated the Steady State theory of cosmology, a theory of the universe that would compete with the expanding universe model up until the late 1960s (Kragh 1996). Several students were attracted by these new developments concerning the links between the theory of gravitation and cosmology on which Bondi, Gold, and Hoyle were working. In the same period, the famous Nobel laureate, theoretical physicist Paul A. M. Dirac began developing the Hamiltonian formalism, which was considered by others to be an important step in the path toward the quantization of Einstein's equation. In the late 1930s, Dirac had also proposed an intriguing idea concerning relations between the age of the universe and the gravitational constant and the mass of the universe, respectively. While broadly discredited, the large numbers hypothesis, as Dirac's bold cosmological idea was called, was still generating a certain amount of interest. While Dirac would not personally start working on topics related to general relativity until the late 1950s, he was well disposed about these kinds of topics. Dirac's support and the fascinating personalities of the younger Bondi, Gold and Hoyle created an intellectual climate that attracted students to reflect on topics related to gravitation and cosmology.

Despite the large number of people interested in GRG, it is not possible to say that at Cambridge in the mid-1950s there was a center working on specific research agendas connected to general relativity, as was the case in the United States and other countries. The abovementioned scientists were working on a variety of different topics. Only Dirac and Bondi proposed at least one dissertation project each connected to general relativity. Dirac's Ph.D. student was Dennis Sciama (Ph.D. in 1953), while Pirani was working with Bondi on a second Ph.D. (earned in 1956), both concerning Mach's principle. The intellectual climate, however, led a few students to enter the field during the 1950s, notably, Roger Penrose (Ph.D. in 1957) inspired by Sciama, and Roy Kerr (Ph.D. in 1959). After Sciama became a professor at Cambridge in 1961, the tradition of research was stabilized through the creation of a well-recognized, important research center explicitly devoted to general relativity and cosmology, which would train a new generation of relativists, including George Ellis (in 1964) Stephen Hawking (in 1966), and Brandon Carter (in 1967). Dirac was among the founding members of the ICGRG when it was established.

A.13.2 King's College London

In 1954, Hermann Bondi was offered a professorship in applied mathematics at King's College London. Only then did Bondi set up the first research group working with a clear focus on gravitational theory, together with his Ph.D. student Pirani and British mathematician Clive Kilmister, who was already working on the mathematical aspects of physical theories. The group was called King's Gravitational Theory Group. After the Bern conference, Bondi's major research focus became gravitational radiation theory, which he pursued with a number of students and postdocs, making King's College one of the most relevant research centers in the world for this type of research. Between the mid-1950s and the mid-1960s, several young scientists pursued research on this topic at King's College, often in close cooperation with Bondi and his group, including Leslie Marder, Trautman, Rainer Sachs, Goldberg, Penrose, Ted Newman, Wolfgang Rindler, Alfred Metzner, Sciama, George Szekeres, Robinson, and Chris Collinson. The group also began organizing frequent, successful meetings and workshops dedicated to the theory of general relativity, attended by all the community of scientists working in the field in London. Bondi was one of the founding members of the ICGRG after he proposed the idea of establishing the committee.

A.13.3 Other Colleges at the University of London

In other colleges of the University of London, various scientists were pursuing more isolated activities in the field of cosmology and general relativity in the mid-1950s. The most relevant was probably the **Imperial College**, where Gerald J. Whitrow had been a lecturer in applied mathematics since 1945. He was pursuing research in relativity and cosmology and trained Ph.D. students such as Charles Rayner (Ph.D. in 1954) and Rindler (Ph.D. in 1956). By the mid-1960s, the Imperial College had also hosted a number of visiting specialists for shorter periods, including Hans Buchdahl, Peter Higgs, Geoffrey Stephenson, and Trautman.

At the **Royal Holloway College**, the authoritative astronomer and cosmologist William H. McCrea was continuing to pursue his research on cosmological problems and trained Ph.D. students in the field, including Jack Hogarth (Ph.D. in 1953), William Davidson (Ph.D. in 1959), and Petros Florides (Ph.D. in 1960). In terms of size and amount of activity, these other groups did not have the same strength or the same impact as the King's College research group. This was also reflected in the composition of the ICGRG. Bondi was one of the founding members in 1959 and Kilmister was the third British expert to become member when the ICGRG was enlarged in 1965. However, the parallel work of different groups in London meant more opportunities for interaction, which bore fruit when the King's College group started organizing larger activities around a common area of interest.

A.13.4 Other British research centers

There were other places in the United Kingdom where work in the field was pursued in the mid-1950s. It is worth mentioning in particular **Manchester University**, where authoritative physicist Léon Rosenfeld was a professor from 1947 to 1958 and the **University of Leeds**, home institution of the British mathematician Harold S. Ruse, who had been interested in the mathematical developments of general relativity since the early 1930s. None of these other groups had the same stability as research centers in the field of GRG as Cambridge and King's College had between the 1950s and the early 1960s. However, in the early 1950s, the University of Manchester was perceived as one of the active research centers conducting research on quantization of the gravitational field and the equation of motion in general relativity. Rosenfeld had been a precursor of this research area with the first paper in the field in 1930 (Blum and Rickles 2017, Rosenfeld 2017, Salisbury and Sundermeyer 2017). In the early 1950s, his involvement with these types of question seemed to be weak, but, between the late 1940s and the mid-1950s, he supported the work in this area of the young Indian-born theoretical physicist Suraj N. Gupta and that of his former Ph.D. student Ernesto Corinaldesi in addition to research on the equation of motion in general relativity conducted by the Greek theoretical physicist Achilles Papapetrou (Blum and Hartz 2017). For these reasons and for his expertise in the quantization problems, Rosenfeld was seen as a natural candidate to join ICGRG when it was established, even though he was not particularly active at the time. In any case, Rosenfeld was already a member of NORDITA in Copenhagen when the ICGRG was established.

A.14 United States

A.14.1 Syracuse University

Peter Bergmann (1915–2002) was a close collaborator of Albert Einstein's from his arrival in the United States as a German Jewish refugee in 1936 up until 1941. In 1947, he was appointed Assistant Professor of Physics at the University of Syracuse and soon inaugurated one of the first physics research centers specifically dedicated to the theory of gravitation in the world. The main research program of the Syracuse center was directed toward the unification of general relativity with quantum mechanics (Salisbury 2012). The approach developed by Bergmann in collaboration with his students and co-workers was the non-perturbative canonical quantization of Einstein's equation. From the late 1940s to the early 1960s, Bergmann was the supervisor of many Ph.D.'s on subjects connected to general relativity and gravitation, including those of Henry Zatkis in 1950, Ralph Schiller in 1952, Robert Penfield in 1952, James L. (Jim) Anderson in 1952, Joshua Goldberg in 1952, Ezra

Ted Newman in 1956, Allen Janis in 1957, Irwin Goldberg in 1957, Rainer Sachs in 1958, and John Boardman in 1962. Many of them continued to be active in the field of general relativity and gravitation. Collaboration between these younger scientists and Bergmann often continued after graduation, and some of them managed to create new research groups.

From the second half of the 1950s, Syracuse rapidly grew as one of the biggest centers in GRG, thanks to new appointments and by attracting a number of visitors as postdocs or visiting scholars who stayed at the university for short or long periods. Those who worked at Syracuse on subjects linked to GRG in the 1950s and the early 1960s include Arthur Komar from 1957 to 1965, Roy P. Kerr from 1959 to 1960, Wolfgang Kundt in 1959, Ivor Robinson from 1960 to 1962, Roger Penrose from 1960 to 1961, Engelbert Schucking in 1961, Andrzej Trautman in 1959 to 1960 and again in 1961, Jürgen Ehlers from 1962 to 1964.⁷ Richard Arnowitt also stayed at Syracuse University as an assistant professor and later associate professor from 1956 to 1959, when he began working with Stanley Deser and Charles Misner on the Hamiltonian formulation of general relativity, which would become known as the ADM formalism. This brief summary shows that Syracuse was one of the major centers in the renaissance process, and not only for the work done by its founder, Peter Bergmann, and his group, but also because it served as a node in the growing network of scientists working on various topics within the field of GRG. Bergmann was among the founding members of the ICGRG when it was established in 1959.

A.14.2 Princeton University

During the renaissance process, Princeton University was comparable with Syracuse in terms of importance as a research center on the relativistic theory of gravitation. The starting point for establishing this research center was the decision by the authoritative nuclear physicist John A. Wheeler (1911–2008) to begin teaching, and at the same time learning about general relativity in 1952. Wheeler initiated this program immediately after his strong involvement in national defense research and in the development of the hydrogen bomb ended with the preparation of the first test of the thermonuclear device Ivy Mike. The group forming around Wheeler at Princeton became one of the most active groups in the field from the mid-1950s onward (Wheeler and Ford 1998). Initially, his major area of research was directed at developing a theoretical model able to describe the behavior of particles in term of fields, through the concept of gravitational electromagnetic entities, called geons (Blum 2016). Among those who obtained a Ph.D. under

⁷For more detailed information about this research center, see Goldberg (2005) and Newman (2005).

Wheeler's supervision between the mid-1950s and the mid-1960s, and played a role in the development of the field, are Komar in 1956, Misner in 1957, Dieter Brill in 1957, John R. Klauder in 1959, Fred K. Manasse in 1961, Richard W. Lindquist in 1962, and Kip S. Thorne in 1965. Moreover, Joseph Weber spent one academic year working in close collaboration with Wheeler in 1956–1957.

Princeton University appeared not to play such a strong role as Syracuse as a center for postdoctoral education in theoretical issues related to general relativity. However, there were important developments related to in-house research on general relativity pursued by other scientists in close collaboration with the Wheeler group. Among those who worked in the field at Princeton were Martin Kruskal up until 1959, Penrose in 1959–1960, Hendrik van Dam in 1962–1963, besides, of course, Wheeler's long-term collaborators Misner, who stayed in Princeton until 1963, and Thorne who left Princeton in 1966. Together, Misner, Thorne, and Wheeler wrote one of the most famous textbooks in general relativity, published in 1973 with the title *Gravitation* (Misner et al. 1973, Kaiser 2012).

Wheeler's activity also had a strong impact in terms of promoting the field of general relativity in the larger physics community in the United States as is clear from the number of letters of recommendation for other scholars belonging to the emerging GRG community which can be found in Wheeler's archival collections.⁸

Wheeler was the first scientist to establish a research center in general relativity at Princeton University, but his group did not remain the only one at the time of the renaissance. When Wheeler was strengthening his group, Robert H. Dicke (1916–1997) began establishing one of the first research groups devoted to the empirical study of gravity physics as of 1956 with the plan to repeat the Eötvös experiment made possible by the considerable technological advances in recent years. Dicke's activity was instrumental in establishing and shaping the field of “experimental gravity physics” between the late 1950s and the late 1960s. Among his Ph.D.'s in topics related to GRG between the late 1950s and the early 1960s were Carl Brans in 1961, James Peebles in 1961, and Carrol Alley, William Hoffmann, Kenneth Turner, and James Brault, all in 1962 (Peebles 2017). The work with Carl Brans proposing an alternative, scalar-tensor theory of gravitation called Brans-Dicke theory would have a particularly strong impact on the community as it provided further motivation to design and perform tests on gravitational theories.⁹ While Wheeler's role in the community-building activity was already recognized in the 1950s, as he became one of the founding member of the ICGRG, Dicke's role remained more marginal and he did not become a member of the ICGRG, which indicates that theoretical work was considered to be more important in the establishment of the community in its earlier stages.

⁸See, for example, Wheeler to Aage Bohr, 24 April 1956, JWP, Box 15; Wheeler to Shearin, 29 November 1962, JWP, Box 7; and Wheeler to the European Office of Aerospace Research, 5 February 1962, JWP, Box 18.

⁹On the history of this and similar theories, see Goenner (2012).

A.14.3 Stevens Institute of Technology, Hoboken

James L. (Jim) Anderson, one of the earlier Ph.D. students of Bergmann's, was appointed an assistant professor at the Stevens Institute of Technology in 1952. He soon established a research agenda on general relativity and gravitation theory, which gained momentum when Ralph Schiller joined the institution in 1954. It was a smaller research center compared to the major ones of Syracuse and Princeton. Nonetheless, this small institution played a major role in building the community and in redefining the research programs on GRG in the United States with the organization of the "Stevens Relativity Meetings" from 1958 onward. These were meetings held once a month at the Stevens Institute in which the most pressing problems in the emerging field of GRG were addressed by the attendees. According to some of the protagonists interviewed, these events were of enormous importance in the socio-epistemic process of the renaissance as they were conducive to the discussions between the growing number of scholars working on the East coast of the United States (as mentioned above, Syracuse, Princeton and the Stevens Institute, plus the RIAS, the IOFP, and the University of Maryland).¹⁰ In addition to the organization of the Stevens Relativity Meetings, this research center also produced at least one Ph.D. in the field in the period between the mid-1950s and the mid-1960s (John Stachel in 1962 under Anderson's supervision) and was for a long time the home institution of David Finkelstein (from 1953 to 1960).

A.14.4 Purdue University, Lafayette

Because of its early appearance in the American pre-renaissance period, this center should be mentioned, although it was essentially limited to the activities of Dutch physicist Frederik J. Belinfante (1913–1991). From 1952, Belinfante began pursuing a research agenda aimed at the quantization of the Einstein equations of gravitation. As emphasized by historians of science Alexander Blum and Thiago Hartz, Belinfante pursued different approaches, including the canonical quantization of Einstein's theory, the quantization of the linearized theory, and the quantization of the interaction between the gravitational field and other fields (Blum and Hartz 2017). Notwithstanding its early appearance, this center remained quite isolated, both geographically and intellectually, and did not become a central institutional player in the GRG community. It was only joined, for three years, by

¹⁰Dean 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. See also Dean Rickles and Donald Salisbury, oral interview with Jim Anderson, 19 March 2011; and Dean Rickles and Donald Salisbury, oral interview with Dieter Brill and Charles Misner, 16 March 2011. I am very grateful to Dean Rickles and Don Salisbury for giving me access to the recorded interviews.

Gupta from 1953 to 1956. One indication of this isolation is that Belinfante did not become a member of the ICGRG when it was established.

A.14.5 Institute of Field Physics (IOFP), University of North Carolina at Chapel Hill

The Institute of Field Physics, established in 1955 under the joint directorship of Bryce DeWitt (1923–2004) and his wife Cécile DeWitt-Morette (1922–2017), was the first university research institute specifically dedicated to the field of gravitation theory in the United States. The venture was financially supported by a wealthy industrialist, Agnew Bahnson, who was intrigued by gravitational physics and fascinated by the possible outcomes of research in gravitational theory for the development of anti-gravitational devices. The major research agenda of the IOFP was in the area of covariant quantization schemes of Einstein’s equation—an approach Bryce DeWitt had been developing since his Ph.D. thesis under Julian Schwinger’s supervision at Harvard in 1950 (DeWitt-Morette and Rickles 2011). The GR1 conference “On the Role of Gravitation in Physics” held in January 1957 was organized as the inaugural event for launching this new institute (see Sect. 4.2). The event was of major importance for the development of the field in the United States and beyond as well as for the formation of the community.

In the early period, DeWitt had only one graduate student working in the field of GRG, Robert W. Brehme (from 1956 to 1959). Like Syracuse, the IOFP was very successful in attracting young postdocs and research associates from different countries and providing a favorable environment for this type of research. In the period between the mid-1950s and the mid-1960s, the IOFP hosted, among others, Bertel E. Laurent in 1957–1958, Felix Pirani in 1958–1959, Robinson in 1959–1960, Leopold E. Halpern in 1960–1961, Frank R. Tangherlini in 1960–1961, Ryoyu Utiyama in 1960–1961, Frigyes Károlyházy in 1963–1965, Giorgio Papini in 1964–1966, and Peter Higgs in 1964–1966. The Dutch theoretical physicist Hendrik Van Dam, who came to the IOFP as a research associate in 1960, later obtained a permanent position at the University of North Carolina.

Although younger than Bergmann and Wheeler, in the late 1950s, Bryce DeWitt had already established himself as a central player within the community of GRG experts, particularly in view of the success of the Chapel Hill conference. DeWitt was the third American founding member of the ICGRG in addition to Bergmann and Wheeler.

A.14.6 Research Institute for Advanced Studies (RIAS), Baltimore

In 1955, the aircraft and aerospace manufacturing firm Glenn L. Martin Company established a research institute to support fundamental research with the explicit

aim of developing anti-gravitational devices. Given the general ambitious goal of the venture, it was natural to make general relativity the principal field of study of the new research center. Head of the group was Louis Witten (b. 1921) who, as he stated in his recollections, did not have any real background in gravitational theory when he accepted the position.¹¹ Once established, however, the RIAS became an attractive center for postdocs. Among the international researchers visiting the RIAS in the period between the mid-1950s and the mid-1960s were Dennis W. Sciama in 1958 and Pirani in 1958–1959. The area of research pursued at this center was less clear-cut than that pursued at other American centers at the time. Witten, in particular, was free to explore alternative methodologies, such as the spinor approach to general relativity, thus becoming a precursor of one of the most successful theoretical achievements of the period, soon to be developed by Penrose. A major achievement was the publication of the edited volume *Gravitation* in 1962 (Witten 1962), whose fresh look at a variety of topics helped redefine the field of general relativity and gravitation as a physics discipline (see Sect. 5.2).

A.14.7 Aeronautical Research Laboratory, Wright-Patterson Laboratory, U.S. Air Force, OH

In 1956, one year after the Bern conference, the Wright-Patterson Laboratory of the U.S. Air Force in Ohio established a research group on gravitation headed by Joshua Goldberg (b. 1925), one of the earliest American Ph.D.'s in physics on gravitation theory in the post-WWII period. The main task of this group was to provide financial and logistic support to research centers working on general relativity and related fields (see Sect. 4.2). Besides this activity, Goldberg's section also established an in-house research center in which young physicists had the opportunity to spend a long-term period of research. Those included Newman from 1958 to 1959, Sachs from 1960 to 1961, Kerr from 1960 to 1962, and Havas from 1961 to 1962.

A.14.8 Other American Research centers

The abovementioned centers were those that played a greater or smaller role in the renaissance process and were perceived as the research centers where an active program in areas linked to general relativity and gravitation was pursued. They were not the only ones, however. Other isolated senior scholars, particularly mathematicians, continued to pursue research in areas such as mathematical questions of general relativity and unified field theory, but their research remained

¹¹Dean 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.

quite isolated and relatively unaffected by the renaissance process. To mention only one of most relevant players, the Czech-American mathematician Václav Hlaváček (1894–1969) joined **Indiana University** in 1948 and produced important findings on the unified field theory program in the early 1950s. However, he did not establish a research center working in the field in the renaissance period. A different story can be told for the German-American physicist Alfred Schild (1921–1977). After having earned a Ph.D. with Infeld at the University of Toronto in 1946, Schild accepted a professorship at the **Carnegie Institute of Technology**. Although he did some early work there on the quantization of the Einstein equation with his Ph.D. student Pirani between 1949 and 1951, Schild did not set up a research center. He was only able to establish a real research center on GRG after he moved to the University of Texas in 1957 (see Sect. 4.4).

A.15 USSR

The landscape of scientific institutions and the way they operated in the Soviet Union was quite different from the network of private research universities heavily supported by military funding bodies in the United States. In the Soviet Union, the directors of big institutions had enormous power to decide how to allocate funds and the Soviet Academy of Sciences had the greatest control of resources (Hall 2003). The centralized mode of organization of the Soviet political system shaped the way scientific research activities were structured.

In the field of general relativity, decisions of a philosophical and political nature also had a particularly profound effect on its unhealthy status in the early 1950s. The focus on useful science promoted by Soviet political circles made general relativity even more marginal during the low-water-mark phase than it was in other countries. Furthermore, general relativity, as well as other branches of modern physics, had been under attack for philosophical reasons, as it did not appear to fulfill the requirements of the official ideology of the party, namely, dialectical materialism. The development of the atomic bomb after World War II and the related relevance of physics, and of physicists, to matters of national security radically changed this situation. However, in the mid-1950s, there were no research centers active in the field in the Soviet Union.

Vladimir A. Fock (1898–1974) was the only major figure in physics keeping this research tradition alive, albeit with a very original interpretation of Einstein's theory of gravitation, rejecting its generally covariant character.¹² Fock was a highly respected internationally renowned theoretical physicist and had been elected member of the Soviet Academy of Sciences for his merits back in 1939. At **Lenin State University**, he had since long established a school on theoretical physics specialized in quantum mechanics. Fock began working on general

¹²Jean-Philippe Martinez, Ph.D. dissertation on Vladimir Fock prepared at the University Paris 7 - Paris Diderot, to be defended in 2017.

relativistic problems in the late 1930s and focused more closely on this area in the 1950s, pursuing the attempt to develop his own idiosyncratic approach, which he believed to be consistent with Marxist philosophy. In this period, however, he did not create a research center but worked mostly alone on his non-covariant theory of gravitation. This is not to say that Soviet physicists were not acquainted with the theory. As the second book in their textbook series *Course of Theoretical Physics*, Lev Landau and Evgeny Lifshitz had in fact published in 1941 under the title *Classical Theory of Fields* what was unanimously perceived one of the best presentations of relativity theories for physicists. When translated into English in 1951, the book was extremely successful (Landau and Lifshitz 1951). Nevertheless, by the mid-1950s, apart from Fock's research, the field was not an active one in the USSR.

In the field of pure mathematics, the situation was slightly better. It is, indeed, possible to identify at least one emerging group actively engaging in problems connected to Einstein's theory. At **Kazan State University**, the mathematician Aleksei Z. Petrov (1910–1972) made a breakthrough in 1954 with his research on the classification of Einstein spaces (now known as the Petrov classification). Petrov became professor in 1956 and was on the verge of establishing his own research group. A department under his leadership was finally established at Kazan University in 1960: the Faculty of Relativity Theory and Gravitation (Rabounski 2008). It appears, however, that the implications of his breakthrough for the interpretation of Einstein's theory in physics received more recognition in countries outside the Soviet Union (Pirani 1957).

During the renaissance period, there was increased activity in this area in the Soviet Union. The third major actor was another respected senior theoretical physicist, Dmitri Ivanenko (1904–1994), who had carried out important work in nuclear physics from the late 1920s onward. Ivanenko, a professor at **Moscow State University** since 1943, had a prominent role in establishing an institutional structure aimed at supporting research on gravitational theory in the Soviet Union. Enjoying the prestige he gained through his membership of the ICGRG, Ivanenko was able to establish the Soviet Gravity Committee (SGC) in 1959. Under Ivanenko's leadership, the SGC rapidly became the major centralized institutional framework for activities in the field, along with the Soviet Academy of Sciences, in which Fock was working. In 1961, the SGC promoted the organization of the first Soviet Gravitation Conference, held at the School of Physics at Moscow State University. Chaired by Ivanenko, the conference was the first in a long tradition of national conferences. Almost 80 scientists attended this first conference, where 83 papers were presented, which indicates how fast this field of research had grown in the Soviet Union (Garbell 1963). A few years later, Ivanenko acquired even more power in the coordination of the field by becoming the organizer of the Gravitation Section of the Ministry of Education in the Soviet Union, which organized the activities of universities, probably in rivalry with the dominant Soviet Academy of

Sciences. When the ICGRG was established, both Fock and Ivanenko became members, whereas Petrov joined the committee in 1965. Apparently, the relationship between Fock and Ivanenko was tense, and they did not seem to act in a coordinated manner to promote the field of GRG in the Soviet Union.¹³ One indication of this tension is that Fock was not present at the first Soviet Gravitation Conference.

Departing from this highly centralized status, physics research centers devoted to gravitation theory somewhat similar to the ones seen in other countries did not emerge in the Soviet Union until the 1960s. However, these centers were established by and around other leading figures such as Yakov B. Zel'dovich, Vladimir B. Braginsky, and Vitaly Ginzburg and had stronger links with relativistic astrophysics and experimental gravity physics (Thorne 1994).

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¹³For an extensive and in-depth analysis of the rivalry between Fock and Ivanenko, particularly within the activities of the ICGRG, see Jean-Philippe Martinez, Ph.D. dissertation on Vladimir Fock prepared at the University Paris 7—Paris Diderot, to be defended in 2017. There are also some comments in Ruffini (2010).

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Appendix B

Full text of the letter from André Mercier to Relativists throughout the World, November 1972 ISGRGR, in which Mercier announces the proposal to establish the society, send the draft constitution, and ask for comments and amendments.

November 1972

To Relativists
throughout the World

Dear Colleagues,

At the International Conference GR6 on General Relativity and Gravitation held at Copenhagen in July 1971, an ad hoc Assembly of Scientists adopted a Resolution according to which

- (i) The creation of an International Society on GRG was recommended,
- (ii) a Special Statute Committee was elected and instructed as to prepare a Draft Constitution (Statutes) of the said Society, which has been done,
- (iii) various other steps (election of 8 members of the International Committee on GRG, etc.) were taken.

The said Assembly expressed the wish that the Draft Constitution be circulated among all known interested scientists long before a new Assembly could formally approve the text, in order to allow for amendments to be taken into consideration.

The Statute Committee has instructed me as to submit the Draft to a lawyer in order to have a text which is in agreement with the legislation of the country where the seat of the Society is meant to be chosen. The necessity to have a juridically correct wording is urgent, for in case controversies should arise, and we cannot exclude the case, even among scientists, we must be in a position to apply the Statutes correctly.

It is my pleasure today to send you all a copy of the Draft Constitution as it stands now.

If a friend of yours unknown to us wants to have a copy, let him simply ask for it at the above address.

You are all invited to comment upon this Draft. But please think first that if I receive a few hundred amendments, the task will be quasi impossible to revise again. The Statute Committee has taken care of the general wishes of the Assembly and considered carefully the limit conditions under which such a Society shall work. The lawyer, who is juridic Counselor of one of the foreign Embassies at Berne (Switzerland) has quite an experience of these things. It is possible that the English needs still some improvement.

Hence, be moderate, please, in your suggestions, and consider that our Society has to work for Scientists from all countries of the world.

The International Committee on GRG shall meet in June 1973 in Paris. You are welcome to send your comments until the end of April 1973 to me. Thank you.

Finally, I may recall that our colleagues in Israel will invite to the GR7 International Conference in 1974. This conference has been announced to IUPAP (International Union of Pure and Applied Physics).

We cannot yet make final announcements as to exactly how the Assembly which shall ratify the foundation of the new Society will be invited to convene. The Committee on GRG will decide upon that at its Paris meeting.

In the meantime, I send you all my best wishes and remain,

Sincerely yours,
André Mercier
Secretary to the International
Committee on General Relativity
and Gravitation