TOWARD A HISTORY OF EINSTEIN'S THEORY OF GRAVITATION

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In this short introduction, I just intend to give a detailed "secondary" bibliography of the history of general relativity. The primary bibliography is to be found in the historical papers themselves or, better, in the literature itself.

Since no general handbook on the historical developments of general relativity is presently available, I intend to provide the most important references in this area to those physicists termed by Einstein in 1918 "relativists".

Not every subject of the history of the theory will be found in the bibliography, far from it ! First because it is no much more than some ten years that scholars are working in such a field and it remains much to be done. Secondly, I apologize in advance for references that I could have missed and I would appreciate greatly any new information in this matter.

The history of the general theory of relativity can be divided roughly into four main parts. In 1907 (two years after the birth of the special theory of relativity), Einstein made the first step toward a relativistic theory of gravitation, a theory which will not emerge before the end of 1915. Up to the middle of the twenties - 1925 is a good date - the first developments arose : main results, early calculations, and publication of the first handbooks in 1918 by Eddington and Weyl. Cosmology emerged in 1917 with the static Einstein universe

and underwent a regular development quite independantly of the life of the theory itself. After that and up to the end of the fifties (1955, the year of the death of Einstein is too the year of the Bern conference, the first international meeting on the general theory of relativity) the theory will go through a difficult period, something as a desert crossing. After roughtly the beginning of the sixties, we entered in what has been called the "renewal" of the theory.

The bibliography given here has been divided into nine sections. Of course, such a division is questionable since many informations concerning some particular points can be dispersed in several sections.

1 - General Bibliographies.

General bibliographies are listed and also specialized ones that refer to a particular thema. Bibliographies concerning primary sources can be found in the handbook by Arzeliès, more particularly for the first developments, or in the books by Synge or by Misner, Thorne and Wheeler for the classical period and the renewal. The Einstein Archives that contain any writing by Einstein, are to be consulted in Boston, in Princeton or in Jerusalem.

Arzeliès, H. 1963. Relativité Généralisée et Gravitation. Paris : Gauthier-Villars.

Cassidy, D.C. 1979. Biographies of Einstein. In Einstein Symposion Berlin. Ed. H. Nelkowski et al., 490-500. Berlin : Springer-Verlag.

Combridge, J.T. 1965. Bibliographie of Relativity and Gravitation Theory : 1921 to 1937. King's College London.

Detweiler, S. 1981. Resource letter BH-1 : Black-holes. Am. J. Phys. 49 : 394-400.

Heilbron, J.L. and B. Wheaton. 1981. Literature on the History of Physics in the 20th Century. Berkeley : Univ. of California.

INSPEC. 1974. Black Hole : 1970-74. London : Inspec bibliography series n°1.

Lecat, M. 1924. La Bibliographie de la Relativité. Bruxelles : Lamertin.

Mercier, A. 1979. Birth and Role of the GRG organisation and the cultivation of international relations among scientists in the field. In Albert Einstein : his Influence on Physics, Philosophy and Politics. Ed. Aichelburg and Sexl, 177-188. Braunschweig : Vieweg und Sohn.

Misner, C.W., K.S. Thorne and J.A. Wheeler. 1973. Gravitation. New-York : W.H. Freeman and C°.

Nell Boni et al. 1960. A Bibliographical Checklist and Index to the Published Writings of Albert Einstein. Paterson, N.J. : Pageant Books.

Stachel, J. 1980. Guide to the Duplicate Einstein Archive and Control Index. Princeton N.J.

Synge, J.L. 1960. Relativity : the General Theory. Amsterdam : North-Holland Publishing Company.

2 - Remembrances and Biographies.

In this section one finds a few references concerning writings on Einstein and on Einstein's theory by collaborators and friends. Only the main titles are listed here. More can be found in the books edited for the centenary (sec. 3). In a second listing, I added the main biographies written by scholars on Einstein and on some "distinguished" relativists.

Bergmann, P.G. 1956. Fifty years of relativity. Science 123 : 487-494.

Einstein, A. and M. Born. 1969. Briefwechsel 1916-1955. München : Nymphenburger Verlag.

Frank, Ph. 1968. Einstein, sa Vie, son Oeuvre. Paris : Albin Michel.

Infeld, L. 1950. Albert Einstein. His Work and its Influence on Physics. New York : Ch. Scribner's Son.

Infeld, L. 1955. Die Geschichte der Relativitätstheorie. Naturwissenschaften 42 : 431-436.

Lanczos, C. 1932. Stellung der Relativitätstheorie zu anderen physikalischen Theorien. Naturwissenschaften 20 (7) : 113-116.

Lanczos, C. 1974. The Einstein Decade. New York : Academic Press.

Langevin, P. 1922. L'aspect général de la théorie de la relativité. Bulletin Scientifique des Etudiants de Paris : Avril-Mai 1922.

Von Laue, M. 1956. Einstein und die Relativitätstheorie. Naturwissenschaften 43 : 1-8.

Okamoto, I. 1981. Albert Einstein in Japan 1922. Amer. J. Phys. 49 (10) : 930-940.

Schilpp, P.A. 1949. Albert Einstein Philosopher-Scientist. New-York : Harper Torchbooks.

Seelig, C. 1956. Helle Zeit ; Dunkle Zeit ; in Memoriam Albert Einstein. Zürich : Europa Verlag.

Vallentin, A. 1954. The Drama of Alfred Einstein. Garden City, N.Y. : Doubleday and Comp. Inc.

Clark, R.W. 1973. Einstein : the Life and Times. London : Hodder and Stoughton.

Chandrasekhar, S. 1982. Eddington : the Most Distinguished Astrophysicist of his Time. Cambridge Un. Press.

Feuer, L.S. 1974. Einstein and the generations of science. Basic Book Inc.

Godard, O. 1984. The Scientific Work of Georges Lemaître. In The Big Bang and G. Lemaître. Ed. A. Berger, 393-397. Dordrecht : Reidel and C°.

Guth, E. 1970. Contribution to the History of Einstein's geometry as a branch of Physics. In Relativity. Ed. M. Carmeli et al., 161-207.

New-York : Plenum Press.

Kirsten, C. and H.J. Treder. 1979. Albert Einstein in Berlin 1913-1933. Berlin : Akademie Verlag.

Kox, A. H.A. Lorentz and General Relativity. To be published in : Proceedings of the First International Conference on the History of General Relativity. Ed. J. Stachel. Dordrecht.

Pyenson, L. 1985. The Young Einstein. Bristol : Adam Hilger Ltd.

Stachel, J. 1985. Eddington and Einstein in The Prism of Science. Ed. Edna Ullman-Margalit, 225-249. Humanities Press.

Vibert Douglas, A. 1957. The Life of A.S. Eddington. London : Thomas Nelson.

Wali, K.C. 1982. Chandrasekhar Vs. Eddington an unanticipated confrontation. Physics Today, Oct. 82 : 33-40.

Whitrow, G.J. 1967. Einstein : the Man and his Achievement. British Broadcasting Corporation.

3 - General Handbooks, Reviews.

No general history of general relativity has been written so far, but, some reviews are aimed at presenting a global view of Einstein's work or of this theory of gravitation. Much has been published at the occasion of the centenary of his birth. The proceedings of the First International Conference on the History of General Relativity will contain much information and is to be edited by J. Stachel.

Aichelburg, P.C. and R.V. Sexl. 1979. Albert Einstein : his Influence on Physics, Philosophy and Politics. Braùnschweig : Vieweg und Sohn.

French, A.P. 1979. Einstein : a Centenary Volume. Cambridge : Harvard Un. Press.

Holton, G. 1973. Thematic Origins of Scientific Thought. Cambridge : Harvard University Press.

Holton, G. and Y. Elkana. 1982. Historical and Cultural Perspectives. The Centennial Symposium in Jerusalem. Princeton : Princeton Un. Press.

Goldberg, S. 1984. Understanding Relativity. Boston : Birkhäuser.

Miller, A.I. 1981. Albert Einstein's Special Theory of Relativity : Emergence and Early Interpretation (1905-1911). Reading (Mass.) : Addison Wesley Pub. C°.

Nelkowski, H. 1979. Einstein Symposion Berlin. Lecture Note in Physics : n° 100. Berlin : Springer-Verlag.

Pais, A. 1982. "Subtle Is the Lord...". Oxford : Oxford Un. Press.

Sanchez Ron, J.M. 1980. Relatividad Especial. Relatividad General 1905-1923. Universidad Autonoma de Barcelona.

Stachel, J. Proceedings of the First International Conference on the History of General Relativity. Dordrecht : to appear.

Syrovatkin, S. 1979. Einstein and the Philosophical Problems of 20th Century Physics. Moscow : Progress Publishers.

Tonnelat, M.A. 1971. Histoire du Principe de Relativité. Paris : Flammarion.

Williams, L. Pearce. 1968. Relativity Theory : Its Origins and Impact on Modern Thoughts. New-York : J. Wiley and Sons.

Whittaker, E.P. 1953. A History of the Theories of Aether and Electricity. Vol. 2. London : Nelson.

Woolf, H. 1980. Some Strangeness in the Proportion. Reading (Mass) : Addison Wesley Pub. C°.

4 - The Genesis of the General Theory of Relativity.

The discovery of what we call now "general relativity" demanded to Einstein almost ten years. Much historical work has been done in this area ; it concerns mainly the search for the field equations.

Earman, J. and C. Glymour. 1978. "Lost in the tensors : Einstein's struggle with covariance principle 1912-1916". Stud. Hist. Phil. Sci. 9 : 251-278.

Earman, J. and C. Glymour. 1979. Einstein and Hilbert : two months in the history of general relativity. Arch. Hist. Exact. Sci. 19 : 291-308.

Medicus, H.A. 1984. A comment on the relations between Einstein and Hilbert. Am. J. Phys. 52 : 206-208.

Mehra, J. 1973. Einstein, Hilbert and the Theory of Gravitation. In The Physicist's Conception of Nature. Ed. Mehra, 92-178. Dordrecht-Holland : D. Reidel.

Norton, J. 1984. How Einstein found his field equations : 1912-1915. Hist. Stud. Phys. Sci. 14 : 253-316.

Stachel, J. 1979. Einstein's odyssey. The Sciences, March 1979 : 14-34.

Stachel, J. 1979. The Genesis of General Relativity. In Einstein Symposion Berlin. Ed. H. Nelkowski et al., 428-442. Berlin : Springer-Verlag.

Vizgin, V. 1983."Die Schönste Leistung der Allgemeinen Relativitätstheorie : the Genesis of the Tensor-geometrical Conception of Gravitation. In Nature Mathematized. Ed. W. Shea, 299-317. Dordrecht, Holland : Reidel Pub. C°.

Vizgin, V.P. and Ya A. Smorodinskii, 1979. "From the equivalence principle to the equations of gravitation" Sov. Phys. Usp. 22 : 489-519

5 - Reception and Diffusion of the Theory

There, I have listed the secondary litterature concerned with the reception, the diffusion but also with the development of the theory. Those papers have been mainly written by scholars ; however in some domains not yet studied so far, I give references of reviews and opinions by relativists.

Biezunski, M. 1981. La Diffusion de la Théorie de la relativité en France. Paris : Thèse 3e Cycle.

Cattani, C. and M. de Maria. 1985. The 1915 epistolar controversy between A. Einstein and T. Levi-Civita. To be published in : Proceedings of the First International Conference on the History of General Relativity. Ed. J. Stachel.

Chandrasekhar, S. 1972. The increasing role of general relativity in Astronomy. Observatory 92 : 160-174.

Chandrasekhar, S. 1979. Einstein and general relativity : historical perspectives. Am. J. Phys. 47 (3) : 212-217.

Chandrasekhar, S. 1974. Development of general relativity. Nature 252 : 15-17.

Crelinsten, J. 1980. Physicists receive Relativity : Revolution and reaction. The Physics Teacher, 18 : 187-193.

Crelinsten, J. 1980. Einstein, physicists and the press : The myth of incomprehensibility. The Physics Teacher 18 : 115-122.

Crelinsten, J. 1981. The Reception of General Relativity among American Astronomers : 1910-1930. Ph. D. : Un. Montreal.

Eisenstaedt, J. 1986. La relativité générale à l'étiage : 1925-1955. Arch. Hist. Exact Sci. 35(2) : 115-185.

Glick, Th. 1987. The Comparative Reception of Relativity. Dordrecht : to appear.

Goodstein, J.R. 1975. Levi-Civita, Albert Einstein, and relativity in Italy. Atti. Nazionale dei Lincei. Atti dei convegni 1975 : 43-51.

Goodstein, J.R. 1982. The Italian mathematicians of relativity. Centaurus 26(4) : 241-261.

Ivanenko, D.D. 1967. Fifty years of Sovietwork on gravitation. Izv. VUZ fizica, 10 (10) : 30-38.

Pyenson, L. 1973. The Göttingen Reception of Einstein's General Theory of Relativity. Ph. D. : Johns Hopkins Univ.

Synge, J.L. 1957. How stands the theory of gravitation today. Advancement Sci. London 14 : 207-214.

Weyl, H. 1949. Relativity theory as a stimulus in mathematical research. Proc. Am. Phil. Soc. 93 : 535-541.

6 - Observations and Experiments

Two types of sources are mixed there, papers on the history of relativistic tests by scholars and articles written by physicists. Of course more can be found in handbooks and in specialized reviews.

Crelinsten, J. 1984. W.W. Campbell and the "Einstein Problem" : An observational astronomer confronts the theory of relativity. Hist. Stud. Phys. Sci. 14 : 1-91.

Chandrasekhar, S. 1976. Verifying the theory of relativity. Notes and Records of the Royal Society of London 30 : 249-260.

Earman, J. and C. Glymour 1980. Relativity and eclipses : the British eclipse expeditions of 1919 and their predecessors. Hist. Stud. Phys. Sci. 11(1) : 49-85.

Earman J., and C. Glymour. 1980. The gravitational red-shift as a test of general relativity : history and analysis. Stud. Hist. Phil. Sci. 11 : 175-214.

Forbes, E.G. 1963. A history of the solar red-shift problem. Ann. Sci 17 : 129-164.

Hetherington, N.S. 1980. Sirius B and the gravitational redshift : An historical Review. Q. J. R. Astron. Soc. 21(3) : 246-252.

Jaki, S.L. 1978. J.G. von Soldner and the gravitational bending of light with an English translation of his essay on it published in 1801. Found. Phys. 8 : 927-950.

Jaki, S.L. 1978. A forgotten bicentenary : Johann Georg Soldner. Sky and Telescope 55 : 460-461.

Mc Crea, W.H. 1979. Einstein : relations with the Royal Astronomical Society. Q. J. R. Astron. Soc. 20 : 256-260.

Moyer, D. 1979. Revolution in Science : the 1919 Eclipse Test of General Relativity. In On the Path of Albert Einstein. Ed. A.

Perlmutter and L.F. Scott, 55-101.

Roseveare, N.T. 1982. Mercury's Perihelion from Le Verrier to Einstein. Oxford : Clarendon Press.

Watson, W.Z. 1969. A Historical Analysis of the Problem of the Advance of the Perihelion of Mercury. Ph D. Thesis : Un. of Wisconsin.

Will, C.M. 1974. Gravitation theory. Sci. Am. 231(5) : 25-33.

7 - Conceptual problems.

Much has been done concerning this topic since not only relativists but also philosophers have always been interested in principles and concepts. But only a few concepts have been analysed in an historical manner. A detailed bibliography can be found in the book by M. Friedman.

Earman, J. 1974. Covariance, invariance and the equivalence of frame. Foundations of Phys. 4 : 267-289.

Earman, J., M. Glymour and J. Stachel. 1977. Foundations of Space-time Theories. Minnesota Studies in the Philosophy of Science, Vol. VIII. Univ. of Minnesota Press.

Earman, J. and C. Glymour. 1979. The Failure of the Principle of Equivalence in Einstein's 1912 Variable Speed of Light Theory. Proceedings of the Memphis State University Einstein Centenary Conference.

Ehlers, J. 1973. The Nature and Structure of Spacetime. In The Physicist's Conception of Nature 71-91. J. Mehra Ed. 71-91. Reidel Pub. Comp.

Friedman, M. 1983. Foundations of Space-Time Theories. Princeton : Princeton University Press.

Graves, J.C. 1971. The Conceptual Foundations of Contemporary Relativity. Cambridge : M. I. T. Press.

Grünbaum, A. 1974. Philosophical Problems of Space and Time. 2nd edition. Boston Studies in the Philosophy of Science : Vol. XII.

Dordrecht : Reidel

Havas, P. 1967. Foundation problems in general relativity. Delaware Seminar in the Foundations of Physics 8 : 124-148.

Itagaki, R. 1983. Why did Mach reject Einstein's theory of relativity. Hist. Stud. Jap. 22 : 81-95.

Jammer, M. 1954. Concepts of Space. The History of Theories of Space in Physics. Cambridge : Harvard University Press.

Norton, J. 1985. What was Einstein's principle of equivalence. Stud. Hist. Phil. Sci. 16 : 203-246.

Reichenbach, H. 1957. The Philosophy of Space and Time. N.Y. : Dover.

Toretti, R. 1983. Relativity and Geometry. Oxford : Pergamon Press.

Zahar, E. 1977. Mach, Einstein, and the rise of modern science. Brit. J. Phil. Sci. 28 : 195-213.

Zahar, E. 1983. The Mathematical Origins of General Relativity and of Unified Field Theories. In Einstein Symposion Berlin. Nelkowski ed. 370-396. Berlin : Springer-Verlag.

8 - Technical History

Only a few subjects have been worked out on the technical history of the theory. Much is to be done in this area. For example, the very interesting history of gravitational waves has only been studied from his sociological point of view.

Collins, H.M. 1975. The seven sexes : a study in the sociology of a phenomenon, or the replication of experiment in physics. Sociology 9 : 205-224.

Collins, H.M. 1981. Son of seven sexes : the social destruction of a physical phenomenon. Social Studies of Science : 33-62.

Damour, T. 1987. The Problem of Motion in Newtonian and Einsteinian Gravity. To be published in : 300 Years of Gravitation. Ed.

S.W. Hawking and W. Israel. Cambridge : Cambridge Un. Press.

Eisenstaedt, J. 1982. Histoire et singularité de la solution de Schwarzschild : 1915-1923. Arch. Hist. Exact Sci. 27(2) : 157-198.

Eisenstaedt, J. Trajectoires et impasses de la solution de Schwarzschild. To be published in : Arch. Hist. Exact Sci.

Ferraris, M., M. Francaviglia and C. Reina. 1982. Variational formulation of general relativity from 1915 to 1923 "Palatini's Method". Gen. Relativ. and Gravitation 14(3) : 243-254.

Goenner, H.F. 1984. Unified Field Theories : from Eddington and Einstein up to now. In Relativistic Astrophysics and Cosmology. Ed. V. de Sabbata and T.M. Karade, 176-196. Singapore : World Scientific Lab. Prep.

Havas, P. The Early History of the Problem of Motion in General Relativity. To be published in : Proceedings of the First Conference on the History of General Relativity. Ed. J. Stachel. Dordrecht.

Israel, W. 1987. Dark Stars : the Evolution of an Idea. To be published in : 300 Years of Gravitation. Ed. S.W. Hawking and W. Israel. Cambridge : Cambridge Un. Press.

Schaffer, S. 1979. John Michell and black holes. Journal for History of Astronomy 10 : 42-43.

Stachel, J. 1974. The Rise and fall of geometro-dynamics. Ed. K.S. Schaffner and R.S. Cohen, 31-54. Dordrecht : Reidel Pub. Comp.

Stachel, J. 1980. Einstein and the Rigidly Rotating Disk. In General Relativity and Gravitation. Ed. A. Held. Vol. 1. 1-15. New York : Plenum Press.

Tipler, F. J., C. J. S. Clarke, and G. F. R. Ellis. 1980. Singularities and Horizons. In General Relativity and Gravitation. Ed. A. Held, vol. 2 . 97-206. New-York : Plenum Press.

9 - Cosmology

Not surprisingly, cosmology is the only field where quite a lot of books have been published ; nevertheless some technical points deserve a more detailed study.

Berendzen, R., R. Hart, and D. Seeley. 1976. Man Discovers the Galaxies. New-York : Science History Publications.

Bernstein, J. and G. Feinberg. 1986. Cosmological Constants. Papers in Modern Cosmology. New-York : Columbia Un. Press.

Ellis, G. History of Relativistic Cosmology. To appear.

Ellis, G.F.R. and D.W. Sciama. 1972. Global and non Global Problems in Cosmology. In General Relativity, Papers in Honour of J.L. Synge. Ed. L. O'Raifeartaigh, 35-62. Oxford : Clarendon Press.

Hetterington, N.S. 1982. Philosophical values and observation in Edwin Hubble's choice of a model of the universe. Hist. Stud. Phys. Sci. 13 : 41-67.

Hufbauer, K. 1981. Astronomers take up the stellar-energy problem 1917-1920. Hist. Stud. Phys. Sci. 11(2) : 277-303.

Jaki, S.L. 1969. The Paradox of Olber's Paradox. New-York : Herder and Herder.

Kahn, C. and F. Kahn. 1975. Letters from Einstein to de Sitter on the nature of the universe. Nature 257 : 451-454.

Kersberg, P. 1986. Le principe de Weyl et l'invention d'une cosmologie non-statique. Arch. Hist. Exact Sci. 35 : 1-89.

Kersberg, P. The relativity of rotation in the early foundations of general relativity. To appear in Studies in History and Philosophy of Science.

Kragh, H. 1982. Cosmo-physics in the thirties. Hist. Stud. Phys. Sci. 13 : 69-108.

Merleau-Ponty, J. 1965. Cosmologie du XXe siècle. Paris : Gallimard.

North, J.D. 1965. The Measure of the Universe. A History of Modern Cosmology. Oxford : Clarendon Press.

Smith, R. W. The Expanding Universe. Cambridge : Cambridge University Press.

Smith, R.W. 1979. The origins of the velocity-distance relation. Journal for History of Astronomy. 10 : 133-165.

Toretti, R. 1979. Mathematical Theories and Philosophical Insights. In Cosmology in Einstein Symposion Berlin. Ed. H. Nelkowski et al., 320-335. Berlin : Springer-Verlag.

Whitrow, G.J. 1959. The Structure and Evolution of the Universe. New-York : Harper Torchbooks.