The Collected Papers of Albert Einstein – Volume 6 – The Berlin Years: Writings, 1914–1917. English Translation, Princeton University Press, Princeton, New Jersey, 1997.

The series of volumes of *The Collected Papers of Albert Einstein* have been appearing over the past few years in two streams: the Documentary Edition, where all documents are reproduced in their original languages, which at least in the early phases is mainly German; and the English translations, brought out by Princeton University Press, with a short time lag. Volume 6 of the former, volumes 1, 2, 3 and 5 of the latter, have been reviewed in *Current Science* (1997, **72**, 413; 1996, **71**, 78; 1995, **69**, 882). With volume 6 of the English translations series, highlights of which are reviewed here, for the first time only selected items from the Documentary Edition have been taken up for translation (31 out of 49); and in some cases translations existing for many years have been directly reproduced.

The period covered is 1914–1917: It opens with Einstein on the long road to his final formulation of the general theory of relativity. Already behind him were his contributions to the quantum theory of specific heats, the wave–particle duality of light based on his energy fluctuation formula, and the realization of the need to go beyond special relativity in order to encompass gravitation; and earlier to these, the photon concept, special relativity and the theory of the Brownian motion.

The final form of the general theory of relativity is dated 25 November 1915. But the way there was tortuous. In this volume we see the successive stages and false steps in Einstein's thinking about the formal requirements to be placed on the field equations of matter and of gravitation. In a joint paper of May 1914 (Document 2), he and Grossmann argued that while the equations for matter should be generally covariant, those for gravity should definitely *not* be so. It was a strange hybrid: much greater symmetry for the description of matter and its coupling to gravity than for gravitation itself! The physical reason given was causality: since any fully covariant field equations for the metric tensor $g_{\mu\nu}$ would necessarily leave this tensor underdetermined, one *had to* limit the covariance group for these equations. They also introduced the concept of adapted coordinate systems, imposing a nontensorial or noncovariant condition which would today be called a gauge condition.

This point of view remained even in the lengthy review (Document 9) that Einstein wrote in October 1914. While the motivations for going beyond the Lorentz invariance of special relativity towards general covariance are beautifully expressed, for gravity itself limitations are argued and imposed. For a while it was linear coordinate transformations alone; and then those general coordinate transformations which have unit Jacobian determinants. Many deep physical insights are of course expressed on the way: in small space time regions special relativity is always recovered; the demand of general covariance can never limit the possible physical systems and their laws within special relativity, but will only tell us how such systems should couple to gravity (the germ of the idea of minimal coupling); and the realization that with general covariance space time coordinates are merely event markers not directly related to measurements ('general covariance ... takes away from space and time the last remnant of physical objectivity ...').

By 4 November 1915 (Document 21) he was ready to admit the error, for he says: 'In this pursuit I arrived at the demand of general covariance, a demand from which I parted, though with a heavy heart, three years ago when I worked together with my friend Grossmann.' The final resolution came in the paper of 25 November 1915 (Document 25). Here at last he would say that the field equations for gravity should also be generally covariant, and that special choices of coordinate systems or of transformations with unit Jacobian determinant are merely conveniences in certain circumstances. And the physical ideas mentioned in the previous paragraph were clearly stated again: 'Every physical theory that complies with the special theory of relativity can, by means of the absolute differential calculus, be integrated into the system of general relativity theory – without the latter providing any criteria about the admissibility of such physical theory.'

The first full-fledged account of the general theory appeared in the *Annalen der Physik* in March 1916. An English translation of this classic of science has long been available, originally as a Methuen publication, and then since 1952 as part of a Dover Collection titled *The Principle of Relativity*. This latter is reprinted here in full as Document 30. Not much needs to be said about this well-known and well-read piece except that one can only marvel at the lucidity, depth of understanding and expression that Einstein displays at every stage. The physical reasons to go beyond special relativity, the very special role of gravitation—'... gravitation occupies an exceptional position with regard to other forces, particularly the electromagnetic forces, since the ten functions representing the gravitational field at the same time define the metrical properties of the space measured'—the formal mathematical apparatus of the absolute differential calculus, and then the applications and arguments leading to gravitational and other field equations are so beautifully and compellingly conveyed. And here is the power of general covariance: '... it makes us acquainted with the influence of the gravitational field on all processes, without our having to introduce any new hypothesis whatever.' There is also by now complete understanding, acceptance and justification of the fact that generally covariant field equations for $g_{\mu\nu}$ must leave them underdetermined! All the fundamental physical effects of gravity – generally covariant form of Maxwell's equations, bending of light, the red shift, slowing down of clocks, perihelion advance of Mercury – are derived and explained just at the very end of the exposition.

Soon after, in a short June 1916 article (Document 32), a perturbative treatment of the field equations, the recovery of the Newtonian limit and the first corrections, are again given. Here is the first ever mention of gravitational waves, and also this remarkable sentence: '... it appears that quantum theory would have to modify not only Maxwellian electrodynamics, but also the new theory of gravitation.'

Documents 34 and 38 comprise Einstein's fundamental contributions in 1916 to the understanding of the processes of emission and absorption of radiation by matter. Here he introduces the concepts of stimulated and spontaneous emission of radiation, as part of his attempt to give a new derivation of Planck's law by bringing in the ideas of Bohr's atomic theory. With Einstein one can never stop quoting, so here is another: '... the sim-

plicity of the hypotheses, the generality with which the analysis can be carried out so effortlessly ... seem to make it highly probable that these are basic traits of a future theoretical representation.' Indeed that is just what happened with Dirac's quantum theory of emission and absorption of radiation in 1927.

Document 42 is a full-scale translation of a book on both special and general relativity which Einstein wrote in German in 1917 for the lay public. It runs into 178 pages, and what we have here is the 1961 translation by Robert W. Lawson. How seriously Einstein took the task of carrying science to the intelligent if non-expert reader is seen in these words from his Preface: 'The author has spared himself no pains in his endeavour to present the main ideas in the simplest and most intelligible form, and on the whole, in the sequence and connection in which they actually originated.' Sadly, such noble traditions are the hardest to maintain!

Any listing of the jewels in this Volume would include these: the derivation of the perihelion shift of Mercury (Document 24); the final 25 November 1915 formulation of the gravitational field equations (Document 25); the A and B coefficients in the matter–radiation problem (Documents 34 and 38); the concept of gravitational waves (Document 32); and the first application to cosmology (Document 43). On political matters there is the October 1914 'Manifesto to the Europeans' (Document 8) arguing for a united Europe – '... the time has come where Europe must act as one in order to protect her soil, her inhabitants, and her culture' – which one cannot resist comparing with later historical developments and even with the situation today. And Document 20 from late 1915 titled 'My opinion on the war' has this telling sentence '... I consider so called aims and causes of war as rather meaningless, because they are always found when passion needs them.'

One piece unfortunately omitted is the set of lecture notes of the Winter 1914–1915 course on relativity Einstein gave at the University of Berlin. But with a book so full of riches, one should not complain at all!

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Gearing for Patents: The Indian Scenario. Prabuddha Ganguli. University Press, Hyderabad. 1998. pp. xvi + 288. ISBN: 81 7371 105 4. Price Rs 205.00; outside India $ 17.50 + $ 2.50 (s&h).

The first of the several quotations used by the author is from Eric Hoffer: 'In a time of change it is the learners who inherit the future. The learned find themselves in a world that no longer exists.' Sounds similar to the basic lesson in evolution that those species which were slow in adapting to change just vanished. As I have pointed out often, most Third World countries remain Third World not because they are poor (well, it is one of the reasons, let me admit), but because they are unable to adapt to change. Now times are achanging and changing rapidly. Within a short decade, we saw the disappearance of the Soviet empire leaving the world unipolar, and the emergence of new trade regimes. The economies around the world suddenly became global and Narasimha Rao and Manmohan Singh had no option but to fall in line, and now Vajpayee and Yashwant Sinha cannot change course. In the globalized economy, Indian industry can no longer live in a protected cocoon. It has to survive open market competition with far more resourceful players from the industrialized countries. The WTO and TRIPS have come to stay.

Survival in the WTO and TRIPS led world depends largely on our ability to patent our inventions both here and abroad and exploit patents and intellectual property rights (IPR) of others. How well are we geared to meet the challenge? Let me quote from the Foreword to this book by Raghunath Mashelkar, the CSIR chief: 'It is no exaggeration to say that there has been no culture of patenting in India, and even the awareness about the need and significance of patenting has been abysmally low, not only in the lay public but even among the researchers and technologists who create intellectual property, and the law professionals who would be drafting, defending and challenging patents.' Not very encouraging. We need to launch a patents literacy mission with a sense of urgency, says Mashelkar. No one can disagree with him.

In such a mission, Prabuddha Ganguli will be in the vanguard. He has the knowledge – almost entirely self-taught – and more than that the willingness to share it. He has been on the faculty in many workshops conducted by organizations such as the Administrative Staff College of India (where he teams up with B. Bowonder), TIFAC and the CSIR, and he has handled many cases. Working for a highly patent-conscious transnational company, he has acquired rich experience. And in this primer, especially written for the Indian audience, he has made a clear and coherent presentation of the subject, interspersed with examples and real cases. He has made some online searches, with the help of Makarand Waikar, especially for this book. Needless to say, even novices can go through the book and learn the basics.

Apart from the main text, divided into 17 chapters, there are nine appendices. The last appendix is an annotated reading list prepared by John Peter of ASCI, Hyderabad. There is a glossary and a list of countries which are signatories of WTO. Examples of complete patent specifications, selection patent, main patent, patent addition and how a patent appears in the Gazette of India are given. The author emphasizes the need for acquiring skills for searching patents and draws attention to the role patents play in competitiveness. In general, the book owes its strength to the many examples and practical suggestions. I wish the author had drawn attention to Francis Narin's work on patent-based indicators, which had been reported more than once in the *New York Times* and *Business Week International*. A chapter on international patenting would have greatly enhanced the value of the book.

There are some minor lapses. For example, Amaco, an American oil major, is spelt Amco (an Indian battery manufacturer) and Abbott is spelt with a b short. Boxes which could have been printed in a single page are split into two parts and appear in two pages. The text in the boxes could have been set in a font different from that of the main text. Surely these will be taken care of in the next edition, which I expect to come out soon. In bringing out the second edition, the publishers will have enough time for an editor to go through the text to remove the few problems that would remain in the first edition of any book with a deadline to meet. Let me assure the readers that these lapses in no way detract the tremendous relevance of the