



Unified Field Theory: Post-Einstein-Journey So Far

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Abstract

Following Einstein's vision of Unified Field Theory (UFT) in the last issue of this journal, this paper is a brief narrative of the efforts towards achieving a consistent UFT during the post Einstein era extending till today. After Einstein, a limited effort has gone in towards UFT based on classical methods. Major efforts have been made in the direction of developing Grand Unified Theories (GUTs) and Theory of Everything (TOEs), the last one trying to combine general relativity and quantum mechanics. In spite of lots of efforts, the theoretical physicists are yet to approve a consistent TOE, which is the modern equivalent of UFT.

Keywords: *Unified Field Theory, Post Einstein era, Grand Unified Theory, Theory of Everything.*

Introduction

Seventy years have passed by after the legendary world-famous scientist Albert Einstein left for his heavenly abode in 1955. By this time, volumes of knowledge have entered into the ocean of theoretical physics which was his domain of research, with scores of people researching in the area of unified field theory (UFT), one of his dream subjects which was already well-founded by him as discussed in the last issue of this journal [Paramguru 2025]. This research have also been widely covered in a number of research papers [Beichler 2015, de la Cuesta and Grok 2025, Cao et al 2015, Ellis 1996, Ho 1995-1 and -2, Moffat 1979, Pati and Salam 1974, Bergmann, 1979, Popli 2003, Tiwary 2011] and books [Hlavaty 1957, Felker 2005, van Dongen 2010, Eckardt 2022]; besides one noteworthy historical coverage in *Living Reviews in Relativity* by the German theoretical physicist Hubert Goenner [2014] and two books by the French counterpart Marie-Antoinette Tonnelat [1966 and 2014]. Goenner has rightly summed-up through the statement that '(T)he idea of unifying all fundamental physical interactions in one common representation is as alive today as it was in Einstein's times' [2014, 195]. This research position with such a vast literature base calls for a review which is being aimed here.

After Einstein's ground-breaking special relativity theory in 1905, general relativity theory in 1915 and his utterances about UFT during 1920s, many theoretical physicists and mathematicians enthusiastically jumped into research to unify the then-known fundamental physical interactions. Tonnelat's book [1966] and Goenner's review [2014] purposefully describe the state of research on UFT till mid-1960s. Interestingly,



Goenner states that '(I)n total, about 150-170 scientists did take part in research in UFT between 1930 and 1965' [183], and as regards the knowledge production in UFT during this period is concerned, 'a yearly average of 18 papers' (630 papers during 35 years) have been reported [183]. This period is supposedly the most productive period of research on UFT. From mid-1960s started the modern era of UFT with advent of quantum field theory, electroweak interaction, Higgs mechanism, spontaneous symmetry breaking, and many more, which make the UFT research still attractive. The present review will make an honest attempt to briefly discuss the UFT research subsequent to mid-1960s in lines of UFT in classical direction, UFT and quantum theory, Grand Unified Theories (GUTs), and Theory of Everything (TOE).

UFT in classical path

Practically speaking, the classical path of UFT, for all purpose, has ended with the demise of its creator Albert Einstein without producing a concrete result. In the original words of his former assistant P. G. Bergmann 'Einstein spent the last five years of his life investigating this theory (the 'asymmetric' theory) without arriving at clear-cut answers' [Goenner 2014, 195]. Of course, by that time, Einstein was already isolated from the main stream physicists, and Goenner himself has stated, referring to his last years at Princeton, USA, that '(N)evertheless, while highly respected, Einstein and his theories lived there in splendid scientific isolation' [2014, 178]. Even then, Einstein had his followings and many researchers kept working on his theories during the subsequent years; one quite often finds a title 'The Einstein unified field theory completed' [Beichler 2015]. Also, each of Goenner and Bergmann, had similar opinion in their statements; the former: '(I)n the 1970s and 1980s, many papers on exact solutions of the Einstein-Schrodinger theories and alternatives were published by Indian scientists' [Goenner 2014, 181]; the later: '—the theories concerning the unavoidability of singularities in the standard theory were all discovered long after Einstein's death —' [Bergmann 1979, 15]. This section is scheduled to present some of these stories.

Though Goenner has termed 'Indian scientists' as mentioned above, he has actually done so in a context of geographical expansion of research on UFT with researchers involved from 'all continents' spreading over 'more than twenty different countries' including England, France, Italy, Australia, Japan, India and others [2014, 181]. American physicist James E Beichler (1931-2025), interested in physics of consciousness, has given a comprehensive overview of unified field theory from beginning till now [2015]. He has given a total pictorial view 'unification tree' [101]; also details about 'the evolution of classical unified field theories' separately [20 and 36]. A couple of contributions, one from the Danish-Canadian physicist John William Moffat [1979 and 1995] and another from the Vietnam born Australian physicist Vu B Ho [1995-1 and -2] are mentioned here. In the first one, the author proposes 'a new theory of



gravity' 'in which the geometry of space-time is determined by a nonsymmetric field structure' [Moffat 1979]. One of the claims of the author is 'the theory agrees with all the classical (weak gravitational field) tests of Einstein's general relativity' [3554]. Later on, the author presented 'a new version of nonsymmetrical gravitational theory – which has physically consistent perturbative expansion for weak fields, and does not have singularities and black holes' [1995]. In the other one, the author Ho provided 'a geometric formulation of strong interaction which is assumed to be described by the Yukawa potential' [1995-1]. He has also shown that 'by defining a suitable energy momentum tensor, the field equations of general relativity admit a line element of Yukawa potential as an exact solution [1995-2]. Beichler has duly referred these contributions [20]. There are some other researches which have associated Einstein's name such as 'Einstein-Cartan-Evans unified field theory' [Felker 2005 and Eckardt 2022] which, in fact, fall under the purview of other sections, and hence, will be discussed there.

As regards the contribution of Indian scientists to UFT, Goenner [2014] has covered well about publications during 1950s and early 1960s by Satyendra Nath Bose (1894-1974) of 'Bose-Einstein statistics' and 'Boson' fame, Ratan Shanker Mishra (1918-1999), worked and published with V. Hlavaty at Indiana University on UFT, Gaganbihari Bandyopadhyay and others. Their contributions were significant, and they also continued to research and publish afterwards till they were active. Further, in case of stalwarts like Bose and Mishra, even after their demise, their students and followers highlighted their research through memoirs or similar volumes. For example, in these two categories one can list the followings: Books published by Mishra are – *Structures in a Differentiable Manifold* in 1978, *Structures on a Differentiable Manifold and Their Applications* in 1984, *Almost Contact Metric Manifolds and Hyper-surfaces of Almost Hermitian Manifolds* both in 1994; memoirs such as: *Padmashri Prof. Dr. R. S. Mishra* in 2018, *S N Bose: The Man and His Work – Part I: Collected Scientific Papers* in 1994, and 'S. N. Bose (1894-1974) and the Bose quantum statistics a centennial tribute' by Lokenath Debnath in *International Journal of Mathematics and Mathematical Sciences* 16 (4) 1993: 625-644. All these volumes have certainly enriched the subject area covered by them. Besides, these scholars and their work have motivated other Indian workers to research and write in these fields. Just two examples are cited in this direction: one, Indian nuclear physicist Rakesh Popli (1952-2007) has come up with a book *A Stroll Through Space-Time: A Leisurely discourse on Einstein's Relativity Theory* [2003], where he has described all the details about Einstein's theory for, not scientific discourse, but public consumption and fittingly ended with the famous Princeton anecdote 'Yes, I will recognize you'; two, Dhananjay Tiwari, an associate professor in Maths education, comes up with 'fundamental particles, their classifications on the basis of Bose - Einstein statistics, Fermi – Dirac statistics and quark theory along with four types of existing fundamental forces' to finally explain how they reflect in



unified field theory [211, 16]. Another case may be mentioned – that of the American Indian Jagdish Mehra (1931-2008), prominent historian of modern physics and the author of *The Historical Development of Quantum Theory* in six volumes during 1982 to 2000, though has not worked directly on UFT, Einstein was his childhood idol and he has penned down important books: *Einstein, Hilbert, and The Theory of Gravitation: Historical Origins of General Relativity Theory* in 1974 and *Einstein, Physics And Reality* in 1999, the former has found place in the references of Beichler [2015, 2].

UFT and quantum theory

The first issue in a discussion connecting quantum theory with UFT would be the stand of Einstein on this issue, rather than the issue itself. Goenner, in his discourse, first of all, brings out a section on 'UFT and quantum theory', that too just before the section on 'A glimpse of today's status of unification'; further, most importantly, mentions in the first line 'Einstein's position with regard to quantum mechanics, particularly his resistance to the statistical interpretation of it is well known' [2014, 191]. Though 'Einstein', along with 'Planck', originally founded the quantum theory and others namely, 'Bohr, Born, Schrodinger, Heisenberg, Hilbert, Dirac, Compton, Pauli and de Broglie' continued to develop it further; even he attempted few times to include this theory in his effort of developing UFT; yet, he was never in favour of this theory be part of UFT [Felker 2005, 56, note 14]. Probably, he was looking for a day when quantum mechanics will develop into a complete deterministic theory, instead of an incomplete probabilistic one; he would accept it whole-heartedly, because he was well aware of this theory's relevance to UFT.

Now, let us come to its relevance to UFT. Felker reports that 'Among the things which up until now relativity has not been able to describe while quantum mechanics has, are the quantum packets of energy, the particle-wave duality of existence, and the angular momentum (spin) of particles' [2005, 56]. Basically, quantum mechanics describes the basic particles such as photons, electrons etc which are also parts to be unified into UFT along with the fundamental forces. As regards the particles present in the complicated structure of all matter we see, Indian physicist Professor Niranjana Barik provides a clear picture in his article published in the last issue of this journal [2025]. Primarily 'two kinds of fundamental particles' called 'fermions and bosons' constitute all matter; 'quarks and electrons belong to this class of fermions which provide the material content', and the bosons include another class of 'force-carrying particles called gauge bosons' 'which provide all types of bindings to these material contents necessary for various structure formations' [132]. Further, he goes ahead – '(B)esides these fundamental fermions and bosons, science has discovered a zoo of subatomic particles and their mirror world of antiparticles revealing a far greater structure – these subatomic particles display contradictory dual behaviour as waves and particles – the location of



such a particle is only probabilistic –. These quantum particles do not have any definite property of their own including any definite location or motion at any instant of time before observation – these constituent parts are in a constant state of flux and the propeller of this flux is energy – they are nothing but discrete packets of energy’ [132]. Then he brings in the abstract notion of field ‘where the matter fields of fermions and the force fields of bosons seem to be more primary than matter itself, since these fields behave as the breeding ground for the so-called elementary particles’ [133]. Very soon, Prof. Barik nears his conclusion – ‘Thus, science seems to have found the most crucial elements of existence in quantum vacuum by comprehending this intrinsic fundamental reality of our cosmos in support of the concept of the ‘one source’ – the nothingness or sunyata of Buddhism or the ‘Brahman’ of the Vedantic tradition [134]. He is not the only physicist to have this view.

Where does quantum mechanics stand today? According to Felker [2005], quantum mechanics is the foundation incorporating into it ‘quantum electrodynamics which includes electromagnetic phenomena and quantum chromo-dynamics which adds the quark color theory’ [56]. Utilizing Planck’s parameters, it has developed full-fledged ‘mathematical ability to make most precise predictions of the results of experiments concerning the mutual interaction between particles,’ and even polarization of the ‘vacuum’ [57]. Starting from the development of particle physics from its foundations till the discovery of Higgs boson, bringing in phenomena like scattering matrix or S-matrix and spontaneous symmetry breaking, quantum field theory and Standard Model have arrived to take care of present-day complexities [Mulders 2008 and Schwartz 2014]. In this context, Goenner’s statement – ‘—already at the time suggestions for a ‘unitary’ field theory in the framework of quantum (field) theory were made’ [2014, 192]; and Beichler’s mention – ‘During the 1970s the tables started to turn and quantum theorists became interested in unifying physics’ [2015, 1] bears a lot of significance. Specifically, Beichler stresses on two points regarding the quantum theorists’ claim that ‘quantum theory was more fundamental than relativity’ and ‘the quantum and relativity are mutually incompatible’; then, he says, that is the reason why they are set to replace relativity completely by quantum once and for all [1].

Grand Unified Theory (GUT)

The period beyond mid-1960s can be counted as the period of modern UFT. In 1963, American theoretical physicist Sheldon Lee Glashow (1932-), for the first time, proposed that the weak nuclear force, electricity and magnetism could arise from a partially unified electroweak theory. Within four years, in 1967, Pakistani theoretical physicist Abdus Salam (1926-1996) and American theoretical physicist Steven Weinberg (1933-2021), ‘working independently’, revised Glashow’s theory to hypothetically unify ‘the weak and electrical forces into a single entity ‘the electroweak



force” [Tiwary 2011, 19]. This model (unified theory) ‘given by Glashow, Salam and Weinberg is commonly known as ‘Standard Model’, and ‘according to this model, all the leptons and quarks are also mass-less and below the symmetry breaking scale they have their masses. – The standard model predicts the existence of new particles like w^+ , w^- , w , z and Higgs bosons’ [19]. This theory got the first experimental support when discovery of weak neutral currents was made in 1973, then in 1983, Italian particle physicist Carlo Rubbia (1934-) came up with the discovery of w and z bosons at CERN by using the reactor erected based on stochastic cooling by Dutch physical engineer Simon van der Meer (1925-2011). All these five people received Nobel Prize for their discoveries, the first three, Glashow, Salam and Weinberg in 1979, and the later two, Rubbia and Meer in 1984. Later in 2012, two theoretical physicists Francois Englert (1932-) from Belgium and Peter Higgs (1929-2024) from Great Britain discovered Higgs boson in the ATLAS and CMS experiments at CERN’s Large Hadron Collider; and both of them received Nobel prize in 2013. Further, Dutch theoretical physicist and Nobel Laureate (1999) Gerardus’t Hooft (1946-) showed that this theory is mathematically consistent; thus, this theory was thoroughly established.

In the meanwhile, in 1974, Glashow with American theoretical physicist Howard Mason Georgi III (1947-) brought out what is called Georgi-Glashow model, the first Grand Unified Theory (GUT). According to Goenner, at first, GUTs were ‘unifying only the electromagnetic, weak, and strong interactions’ that is ‘with gauge group $SU(5)$ ’ [2014, 195]. They would have observable effects for energies much above 100 GeV. Subsequently, many proposals for GUT have emerged; one of them is Pati-Salem Model. (Jogesh) Pati (1937-), an Indian-American theoretical physicist, has contributed in collaboration with Pakistani Nobel Laureate Abdus Salam to formulate a GUT proposal called Pati-Salam model. John Ellis, from the Theoretical Physics Division of CERN, reports – ‘Even before the discovery of neutral currents, the restless spirit of Abdus Salam have led him and Jogesh Pati to propose the idea of grand unification of the strong and electroweak interactions --. They are the first to propose, in a motivated way, that quarks and leptons should be treated together in a common theory’ [1996, 3]. The specialty of Pati-Salem model is its suggestions such as the symmetry of $SU(4)$ -color, left-right symmetry, and the associated existence of right handed neutrinos. They provide some of the crucial ingredients for understanding the observed masses of the neutrinos and their oscillations. After discoveries of gauge coupling unification and neutrino-oscillation, Pati himself says – ‘(I)in this context, it is remarked that with neutrino masses and coupling unification revealed, the discovery of proton decay, that remains as the missing link, should not be far behind’ [1998, 1]. Alas, after so many years, proton decay still remains eluded.

Another GUT, the authors call it Grand Unified Field Theory, GUFT, that is Einstein-Cartan-Evans (ECE) Unified Field Theory will be briefly discussed here. This



theory has been developed by the Welsh chemist and physicist Myron Wyn Evans (1950-2019), and being with him for almost 30 years and moving the theory ahead after him is the noted physicist and computer engineer of Germany Horst Eckardt (1954-). Laurence George Felker (1946--) in his book *The Evans Equations of Unified Field Theory* [2005] tells us – ‘The combination of general relativity and quantum theory into one unified theory was Einstein’s goal for the last 30 years of his life. ---. This has been achieved by Professor Myron Wyn Evans using Einstein’s general relativity as the foundation, Cartan’s differential geometry to define the space-time, and his own wave equation to describe both relativity and quantum mechanics’ [4]. Then follow a series of claims such as – ‘Evans does not reject quantum theory, he shows that it emerges from general relativity and with a few paradigm changes, unification occurs’ [57] – ‘The Evans principle of least curvature indicates that there is a calculable minimum volume for every particle’ [67] – ‘This is a wonderful example of how general relativity and quantum electrodynamics can work together’ with the mathematical methods coming ‘from quantum theory and the minimum volume is defined in general relativity’ [67] – ‘The term Grand Unified Field Theory (GUFT) describes the combined theories - The Evans equations are equations of GUFT’ [68] – ‘Quantum gravity is any of a variety of research areas that have attempted to combine gravitational and quantum phenomena’ [68] – ‘The Evans equations show that the 3-dimensional quantum descriptions emanate from Einstein’s general relativity’ [69] – ‘Only four dimensions are needed’ [69] – ‘The Evans Wave Equation mathematically combine the two theories rigorously’ [69] – ‘The Evans equations indicate that $R = -kT$ applies to all radiated and matter fields, not just gravitation. This was Einstein’s unfinished goal’ [126] – ‘The development of the Evans Wave Equation in Chapter 7 unites general relativity and quantum theory, completing unification’ [145] – ‘The Evans metric of spacetime has both curvature and torsion – gravitation and spin’ [154] – ‘Einstein shows the gravitational field is space-time curving. Evans shows the electromagnetic field is space-time spinning’ [155] – ‘The Evans Wave Equation of unified field theory: (equation 2). It is the link between general relativity and quantum mechanics and is the unification equation’ [157], and finally - ‘The Evans equations complete Einstein’s unification goal’ [266]. Apparently, Felker’s claims have not yet been accepted by mainstream physics community.

Theory of everything

Besides the major problems faced by GUTs such as, the experimental verification of predictions at extremely high temperatures, as well as, proton decay; even if GUTs become successful in these ventures, they still cannot include gravity. Therefore, there was an attempt by some physicists to unify the quantum mechanics, that describes the very small, with general relativity, which describes the very large, into one constituent theory named ‘Theory of Everything (TOE)’; which is, in the words of Goenner ‘as the modern equivalent to UFT’ [2014, 196]. The first candidate of this



attempt was string theory which attempts to unify all gauge interactions with gravity following string phenomenology, that is, search for the standard model of elementary particles in super-symmetric string theory. The other candidates for TOE are superstring theory, M-Theory, Loop Quantum Gravity (LQG) brane-world scenarios, and many more. In fact, there are vast literatures; however, only two of them will be briefly discussed below.

The first one is a paper 'Theory of Everything' by Cao et al [2015], where the authors mention – 'The Torque Grid is the fundamental unit of universe. It is driven from gravity forces as result of space-time-energy-force unification. --. UFT unifies four major forces by resonance conditions with help of an arbitrary 3D prime wave model in which the twist/stretch ratio is 137. The resonance condition (distortion equals original size) of the gravity force decides the size of universe and UFT concludes that the Grand universe is hierarchical' [31]. The authors claim this UFT theory as Theory of Everything (TOE), the final theory of the Physics. In the second paper, the authors Javier Munoz de la Cuesta and Grok [2025] present an UFT 'that integrates gravity, electroweak, and strong interactions, alongside cosmological phenomena into a single coherent framework'. They claim – through use of 'layered structure of interacting fields and resonance mechanism', the UFT 'bridges General Relativity (GR) and Quantum Mechanics (QM), unifying all fundamental forces – at the Grand Unification Theory (GUT) scale.' – 'Through 200 trials involving mathematical analysis, 3D simulations, and real-data-validation', they 'refined the theory to achieve an error margin below 0.0001%' [1]. They conclude that – by 'addressing the incompatibilities between GR and QM and offering a novel mechanism for force unification, the UFT positions itself as a robust candidate for a Theory of Everything' [17].

In spite of vast literature, claims and criticisms, theoretical physicists have not yet accepted a consistent TOE; besides the still unexplained elementary particle mass-spectrum, they cite combining the graviton with the strong and electroweak interactions, and incompatibility between GR and QM as major reasons. As regards the incompatibility between GR and QM is concerned, Beichler provides an interesting observation; he writes – 'Relativity is first and foremost about form (structure) and the quantum is primarily all about function, which come together as one of the most fundamental dualities (known as non-commuting quantities in physics) in nature, but there is always a bit of each in other. However, these two ideas, form and function, are not necessarily incompatible since there is always a little of one in the other at a higher level of understanding' [95]. Here, most interestingly, the author puts a picture of the ancient Chinese symbol called '*T'ai-chi T'u*', or 'Diagram of the Supreme Ultimate', meaning – GR and QM can combine the same way as '*yin and yang*', the universal archetypal opposite poles of nature combine.



Conclusion

At the outset of the conclusion, an honest submission may be made that in spite of availability of vast literature on the selected topic; only a very brief paper is presented using arbitrarily chosen limited literature. The reason for this approach is to put up the facts in a clear and concise manner; against the background that no concrete final result has yet emerged. There have been efforts after efforts to advance UFT following *Grand Unified Theory*, as well as, *Theory of Everything* path. Volumes of results are already generated, though the theoretical physicist fraternity is yet to approve one theory as consistent and accepted theory. Here, it is apt to conclude the way Beichler has concluded – ‘The unified field theory is now a done deal. If it is not taken seriously now, it will be in the future’ [2015, 100].

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