LETTERS TO PROGRESS IN PHYSICS

Frank Robert Tangherlini — the Founder of an Alternative Relativistic Kinematics

(On the Occasion of His 85th Birthday)

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Already fifty years ago, Frank Robert Tangherlini, an American theoretical physicist, suggested an original procedure which, targeting the synchronization of clocks located in two different inertial reference frames of the space, was different from that Einstein had introduced. As a result of these, Tangherlini had deduced the so-called the Tangherlini transformations, which are a sort of the transformations of the spatial coordinates and time being moved from one inertial reference frame into another one. The Tangherlini transformations differ from the Lorentz transformations (which can be meant classic ones in the theory of relativity) and, in particular, suggest the velocity of light to be anisotropic in a moving inertial reference frame. The Tangherlini transformations being applied provide adequate explanations to all well-known interference experiments checking of the Special Theory of Relativity.

In this paper I have to present, to the scientific community, the life and scientific achievements of Frank Robert Tangherlini, the prominent American theoretical physicist who meets his 85th birthday on Saturday, March 14, 2009. He started his scientific carrier with a blessed theoretical result, known later as the *Tangherlini transformations*, which was shadowed and unknown to the scientific community for about twenty years. I also give here the direct and inversion Tangherlini transformations, and tell the story how his famous PhD thesis [1] containing the transformations, was written, and how he got a PhD degree on the basis of the thesis.

Frank Robert Tangherlini was born on March 14, 1924, in Boston (Massachusetts, USA) in the family of a worker. His father, Emiliano Francesco Tangherlini (1895–1979) was an Italian-born immigrant: being a young boy, Emiliano was carried out from Italy into the USA by his father Luigi, a marble sculptor assistant. In his young years, Emiliano was employed as an instrumental worker at a machine factory, then, in the years of the Great Depression, he happily found some employment at the Boston Shipyard. What is interesting, one of the flats in the house at Beacon Hill near Massachusetts State House, where Emiliano Tangherlini had residence, was owned by the Kennedy family — the great American family which gave John Fitzgerald Kennedy (1917–1963), the thirty-fifth President of the United States. (Also, John Kennedy's grandfather from the mother's side was the Major of Boston city). In 1947–1952, despite the big difference in the age and in the social status of John Kennedy, Emiliano Tangherlini found a friendship from the side of him when walked somewhere in the park near the home. They spent much time together when talking about everything at the walks. Many years later, when becoming the US President, John Kennedy visited Emiliano Tangherlini when doing an official visit to Boston: John Kennedy stopped his car escort, then went to Emiliano Tangherlini through the crowding people who met him on the street, and shacked Emiliano's hand on the public.

The grandfather of Frank Robert Tangherlini from the mother's side, Barnett Rubinovich (he has changed his family name to Robinson when becoming a US citizen), was born in Krolevetz — a small town near Nezhin city of Chernigov Gubernya of the Russian Empire. He immigrated to the USA in the end of the 19th century, and settled in New York city where he later owned a clothes shop. His daughter, Rose (1894–1953) was born a few years later he arrived in the USA. In 1919 Rose changed her religion from Judaism and took Catholic belief, in order to get marry with Emiliano Tangherlini. She was employed as a bookkeeper then, in the years of the Great Depression, as a waitress in order to survive in the hard conditions of the economical crisis.

In June 1941, Frank Robert Tangherlini completed his high school education, by getting a silver medal (he also had got a bronze medal in the field of the world history). Then, in the Autumn of 1941, he became a student at Boston Jesuit College, where he took education in electrical engineering during five semesters. Being a student, he was set free of military service. He actually had a possibility to continue this "free-of-war time" until the actual end of the World War II. Such a behaviour was not in his habit. In July 1943 he volunteered to the US army, and had the basic training during one year at Fort Beining, Georgia. In the Autumn, 1944, he was sent to Liverpool, England. Being in England he, in common with his two close friends, volunteered to a parachute

Fig. 1: Frank Robert Tangherlini with two paratrooper friends in Auxerre, France, Summer 1945. From left to right: Sergeant Frank Tangherlini, Private James Barlow (he died in Connecticut, in October 2007), Private Joe Rhiley (later he was a major in the US Airforce, and was killed in an aviation accident in Japan while on a training mission with a Japanese pilot; there is an airfield in Nebraska, his home state, named after him). Tanghelini called his youngest son Riley (without "h") in honour of his late friend.

training school at Hungerford, Berkshire, 60 miles West from London city. When visiting London in free time, Tangherlini saw the great destruction in the city and many people killed due to the ballistic missiles V-2 launched from the Fascist Germany through the strait. He observed the people, who actually lived at the London underground railways during many weeks without seeing sunshine, in order to survive under the Nazi's air attacks.

A few months later, the paratrooper corps where Tangherlini continued military service was dispatched into France. Tangherlini had got five parachute jumps into the battle, then was a machine-gunner, and participated in many bloody battles in France, Belgium, Germany. In particular, he fought at the Battle for Ardennes, where many Americans were killed. Many his friends-in-battle were killed there. He met the end of the World War II in Europe being a Paratrooper Sergeant. It was in Ulm, Germany, the patrimony of Albert Einstein. His paratrooper corps was moved to Austria, in order to keep the Austrian-Italian border safely. Then they started preparation to a very risky dispatch known as the "jump at Tokyo", which was happily cancelled due to the capitulation of Japan.

Fig. 2: Paratrooper Sergeant Frank Tangherlini (right) and his youngest brother Burt (left). Los Angeles, the Spring of 1946.

In January, 1946, Frank Robert Tangherlini returned to the USA, and retired from military service. He has several military orders from the US Government.

In close time after his coming back to the USA, Tangherlini continued his education. He moved to Harvard University, where he studied sciences in the same grade that Robert Francis Kennedy (the US Attorney General in the future). Tangherlini was graduated as a BSc at Harvard, then — as MSc at the University of Chicago. In the years 1952–1955 he was employed as a research engineer in Convair-General Dynamics Company, San Diego. It was some ierony that his scientific supervisor was a German engineer, who worked for the Fascist Germany at the Peenemunde Rocket Centre during the World War II, and participated in the V-2 launches at London.

In 1959 Tangherlini got a PhD degree from Stanford University. He continued his post-doctorate studies in Copenhagen (1958–1959), at the Institute of Theoretical Physics headed by Niels Bohr. Then Tangherlini continued his studies at the School of Theoretical and Nuclear Physics, the Naples University (1959–1960). In the same time many other physicists, famous in the future, continued their post-doctorates there. They were Francis R. Halpern (1929–1995), Murray Gell-Mann (b. 1929), and the Japanese physicist Susunu Okubo (b. 1930).

In the years 1960–1961 Frank Robert Tangherlini was employed as a research scientist at the Institute of Field Physics, University of North Carolina. In 1961–1964 he was Assistant Professor at Duke University, North Carolina, then in 1964–1966 — Associate Professor at The George Washington University (four blocks from the White House, Washington, DC). In 1966–1967 he was a research scientist at Danish Space Research Institute, Copenhagen, and in the same time

Fig. 3: Some people pictured at the Institute of Theoretical Physics (now — Bohr Institute). Copenhagen, the fall of 1959. Top row: nine persons to the right, the tall person is Sheldon Glashow of the later Glashow-Weinberg-Salam electroweak theory. Just below him slightly to the right is Eugen Merzbacher, the author of a text on quantum mechanics. The second person in the same row, going to the right, is Frank Tangherlini. Go down two rows to the person almost directly below Tangherlini, with a beard, then move one person to the right , that is "Ben" Sidorov (Veniamin A. Sidorov) who later became the full member of the Russian Academy of Sciences and Director of the Accelerator Centre in Novosibirsk. Now go down two more rows to the first row. In the centre is Niels Bohr. Next to him, to your left, is Felix Bloch, whom Tangherlini had for nuclear physics when he was at Stanford. Four persons to the left of Bloch is Aage Bohr, one of Bohr's sons. Next to Aage Bohr, to your left is Ben Mottelson, who worked with Aage Bohr on nuclear physics. Go back to Niels Bohr, and count three persons to your right, that is Leon Rosenfeld who co-laborated with Bohr, particularly later on Complementarity. Finally, the next to the last person on the right is Magnusson. He was from Iceland, and worked with Prof. Møller on the gravitational energy-momentum tensor. Møller himself is not in the photo because he was then Director of NORDITA, a separate institute devoted mainly to assistance in research of Scandinavian physicists.

— a lecturer at the Technical University of Denmark. A long time from 1967 to 1994 he was Associate Professor at the College of the Holy Cross, Worcester (Massachusetts). Commencing in 1994 he is retired. He has residence in San Diego, California, where he is still active in science and sport.

Frank Robert Tangherlini is a member of the American Physical Society, and is also a member of several other civil and sport clubs. He is enthusiastic in tennis and foot racing. In particular, he participated, until the least time, in the annual marathon runs in California. He journalist reports are requested to publish by San Diego Union-Tribune. In 1947 he published a roman [2]. He survives by four children and seven grandchildren (four girls and three boys).

Frank Robert Tangherlini has a wide field of scientific interests: the Special Theory of Relativity, the General Theory of Relativity, relativistic cosmology, Mach's principle, and many others. He authored many publications in the peer review scientific journals. W. K. H. Panofsky (1919–2007) was one of his co-authors in science [3].

In already 1951, Tangherlini paid interest to the possibility of the superluminal objects — the objects whose velocity exceeds the velocity of light. He discussed this problem in 1951–1956 with Hermann Weyl (1885–1955), Gregor Wentzel (1898–1978), Wolfgang Pauli (1900–1958), John Wheeler (1911–2008), Julian Schwinger (1918–1994). He also had a talk with George Gamov (1904–1968), on the connected theme — the ultimate high ratio "signal/noise" which could be possible in radiowaves. All those considerations concerning the principal possibility of superluminal motions have led Tangherlini, in the future, to his own version of the transformations of the spatial coordinates and time being moved from one inertial reference frame into another one, which is different from the Lorentz transformations.

These transformations — at now they are known as the *Tangherlini transformations* — were deduced in 1958 while Frank Robert Tangherlini worked on his PhD thesis, and were

Fig. 4: Frank Tangherlini in 1959 at Copenhagen, after he has defended his PhD thesis where the Tanghelini transformations and the other important results were first introduced into theoretical physics.

the main part of the thesis. Tangherlini himself called these the *absolute Lorentz transformations*.

His PhD supervisor was Sidney D. Drell (b. 1926), who had became the best friend of Andrew D. Sakharow many years later. At the initially stage of the development, Tangherlini had also another supervisor who consulted him: it was Leonard Isaac Shiff (1915–1971), with whom Tangherlini closely co-laborated commencing in 1955.

June of 1958 was met by Tangherlini at Stanford University. He gave a public presentation of his PhD thesis [1] then, in September, he put his thesis on the desk of the Physics Section of the Graduate Division, Stanford University. Positive review on his PhD thesis were given from the side of Sidney D. Drell and Leonard Isaac Shiff, while Albert H. Bouker, the Dean of the Graduate Division, clarified that the PhD thesis is enough ready to be defended. Tangherlini's PhD thesis was considered in the absence of the author himself, because at that time he, in common with Drell, was with Niels Bohr in Copenhagen, in the Institute of Theoretical Physics (this Institute was called later Bohr Institute). On December 9, 1958, Florine H. McIntosh, the Secretary Committee on Graduate Study, informed Tangherlini that his PhD thesis has met a positive reaction from the side of the Committee's members — Joshua L. Soske (Geophysics), chairman, Walter E. Meyerhof (Physics), and Menaham M. Schiffer (Mathematics) — who considered the thesis. On January 9, 1959, Harvey Hall, the Registar of the Committee, provided a hardcopy of the Stanford PhD Diploma to Tangherlini. Later Tangherlini produced a microfilm of his PhD thesis [1], then gave presentations, based on the microfilm, at Copenhagen. In particular he provided the microfilm to several theoretical physicists such as Oscar Klein (1894–1977), who noted that he met a similar method of the synchronization of clocks while he read the lectures at Stockholm [4].

Being in 1959 at Copenhagen, Tangherlini composed a detailed paper on the basis of his PhD thesis, then submitted the paper to *Annals of Physics* (New York). Philip McCord Morse (1903–1985), the founder and first editor of the journal, however declined Tangherlini's paper. He argued that this paper was so large (it was 76 pages of the typewriting) for such a journal, and suggested, in his letter to Tangherlini sent on September 23, 1959, that Tangherlini should truncate it or, alternatively, split into two segregate papers. In his next letter to Tangherlini (September 28, 1959), Morse hoped that the requested version of the paper will be submitted in close time. Unfortunately, there was no chance to do it, because Tangherlini was very hurry of time while his post-doctorate studies at Naples. Undoubtedly, it was a big mistake made by Tangherlini that he ignored such a lucky chance. If that paper would have been published in that time, the end of the 1950's, his theory [1] was wide known to the scientific community so that the next fifty years of his life and scientific carrier were much glorious than it was in his real life.

Meanwhile, a very brief contents of his main scientific results, in particular — the direct and inverse Tangherlini transformations, were published in 1961, in a very short Section 1.3 of his large paper [5] spent on the applications of Mach's principle to the theory of gravitation. This paper got so much attention from the side of the scientific community, that was translated into Chinese by Prof. P. Y. Zhu, the famous Chinese theoretical physicist, then published in China [6]. A short description of Tangherlini's PhD thesis was also given in Appendix to his paper of 1994 [4].

The direct and inverse Tangherlini transformations are introduced on the case, where the clocks, located in two different inertial reference frames, are synchronized with each other by the signals of such a sort that they travel at infinite velocity (for instance, these can be superluminal-speed tachyons, the hypothetical particles). One regularly assumes that such an instant synchronization is impossible in practice. However this becomes real in the case where all clocks of the resting and moving reference frames are located along the same single line. To do it, one can use the so-called "light spot" B. M. Bolotovskiĭ and V. L. Ginzburg suggested [7], because it has to travel at a superluminal phase velocity. (In paper [8], I already considered the problem how two clocks, distantly located from each other, can be synchronized by means of such a "light spot", and also the auxiliary problems connected to it.) In his PhD thesis [1], Tangherlini suggested also another method how to synchronize the clocks: this is so-called the "external synchronization", where the clocks, distantly located from each other, become synchronized in a resting ("preferred") inertial reference frame, then these already synchronized clocks are used for synchronization of the other clocks, which are located in the moving inertial reference frames distant from each other. With these, each of the moving clocks are synchronized at that moment of time, when they meet the resting clocks. This method of synchronization leads however to the non-equality of different inertial reference frames: the "preferred" inertial reference frame is such that got the first synchronization of the clocks. The direct and inverse Tangherlini transformation are

$$\left.\begin{array}{ll} x' = \gamma(x - vt), & x = \gamma^{-1}x' + \gamma v t', \\ y' = y, & y = y', \\ z' = z, & z = z', \\ t' = \gamma^{-1}t, & t = \gamma t, \end{array}\right\} \tag{1}$$

where v is the velocity (it is directed along the x-axis) of the inertial reference frame K' with respect to the preferred inertial reference frame K, $\gamma = 1/\sqrt{1 - v^2/c^2}$ is the Lorentz-factor, while c is the velocity of light.

It is obvious that the direct Tangherlini transformations have the sequel that time t' of a moving inertial reference frame has to delay in γ times with respect to t that is the same that the transverse Doppler-effect in the Special Theory of Relativity. The direct Tangherlini transformations (1) differ from the Lorentz transformations in only the transformation of time (this is due to the difference in the synchronization method for the clocks in different inertial frames). Proceeding from (1), Tangherlini obtained the velocity of light in vacuum, c', measured in the moving inertial reference frame K' [1]

$$c' = \frac{c}{1 + \frac{v}{c}\cos\alpha'}\,, \tag{2}$$

where the angle α' is counted from the x'-axis in the moving inertial frame K'. Formula (2) means that the velocity of light in the moving inertial frame K', i.e. the quantity c', is anisotropic to the angle α'. This is a direct result of the synchronization procedure suggested by Tangherlini [1].

Tangherlini's formula (2) gives an explanation to the results obtained in the Michelson-Morley experiment [9] and also in the Kennedy-Thorndike experiment [10], because, according to Tangherlini's formula, the common time of the travel of a light beam toward and backward doesn't depend on the velocity v the inertial reference frame K' moves with respect to the "preferred" inertial reference frame K. Moreover, it is possible to show that the Tangherlini transformations provide an explanation to all interferention experiments checking the Special Theory of Relativity, in particular — Sagnac's experiments [11]. (Read more on the Sagnac effect and explanations of it in my recent papers [12, 13].) It should also be noted that the Lorentz transformations lead to the relation $c' = c$, which differs from Tangherlini's formula (2). Another important sequel of the Tangherlini transformations is that they keep Maxwell's equations to be invariant [1].

Fig. 5: Prof. Frank Robert Tangherlini at the present days. San Diego, California.

First time after Frank Robert Tangherlini suggested these transformations, they met actually no attention from the side of the scientific community. However just the anisotropy of the cosmic microwave background was found in 1977, the scientists have understood that fact that our inertial reference frame, connected to the Earth, moves with a velocity of about 360 km/sec with respect to a "preferred" inertial reference frame, where the microwave background radiation is mostly isotropic so that the common momentum of all space masses of our Universe is zero. After that experimental discovery, many suppositions concerning the anisotropy of the velocity of light were suggested, and the Tangherlini transformations became requested. The first persons who called the Tangherlini transformations in order to explain the Michelson-Morley result in the presence of the anisotropy of the velocity of light were R. Mansouri and R. U. Sexl [14]. Then many papers concerning the Tangherlini transformations were published.

There were several papers produced by the other authors where the Tangherlini transformations were "re-discovered" anew. Just two examples with the papers by S. Marinov, 1979 [15], and by N. V. Kupryaev, 1999 [16]. What is interesting, Frank Tangherlini met Stefan Marinov at the *General Relativity 9th Meeting* in Jena, in 1980. Tangherlini wrote me in his private letter on October 14, 2006, how this happened [17]:

> "I met Marinov under a most curios circumstance: He had put up over doorway of a hall where many of passed through, a poster of about 1/3 meter width and about 2 meter long in which he criticized me, in artistic calligraphy, for not having folloved on my transformation. I

> found this very strange behaviour. After all why did't write to me, or arrange a meeting at conference? So I suspect than he was somewhat crazy, although possibly artistically talented. In any crazy, one should't spend too much time on him except as an example of how people in science, just as in every day life, can astray."

During more than the hundred years after the Special Theory of Relativity was constructed, the most researchers were filled in belief that the Lorentz transformations originate in two postulates of the Special Theory of Relativity: the equality of all inertial reference frames, and the isotropy of the velocity of light in all inertial reference frames, including the independence of the velocity of light from the velocity of the source of light. If however using another procedure synchronizing the clocks, we obtain other transformations of the coordinates and time. In particular, if using the procedure synchronizing the clocks through the infinite-speedy signals, as Tangherlini suggested [1], we obtain the Tangherlini transformations. In other word, the synchronizing procedure suggested by Tangherlini leads to the kinematic relativistic transformations of the spatial coordinates and time (1), which are unexpected, but very adequate in the description of the transfer from one inertial reference frame into another one.

In this concern, I would emphasize the very important difference between the Tangherlini transformations and the Lorentz transformations. In the Tangherlini transformations, c' (2) is the velocity of light in the inertial reference frame K' measured by an observer who is located in the inertial reference frame K. An observer located in the inertial reference frame K' will found that $c' = c$. On the contrary, in the Lorentz transformations, given any inertial reference frame (K', K, or any other inertial frame), there is $c' = c$ and, hence, the velocity of light in the inertial frame K, being measured by the observers located in the inertial frames K' and K is always the same. The anisotropy of the coordinate velocity of light $c' = c$ in the inertial reference frame K' is the fee paid for the absolute simultaneity in all inertial reference frames [18].

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References

1. Tangherlini F.R. The velocity of light in uniformly moving frame. PhD Thesis, Stanford Univ., Sept. 1958, 135 pages.
2. Tangherlini F.R. Catholic girl and atheist: a story of the battle of ideas (the Letters of Paul). Girard (Kansas), Haldeman-Julius, 1947, 58 pages.
3. Lazarus A., Panofsky W.K.H., Tangherlini F.R. Photoproduction of positive pions in Hydrogen in angular range $7^\circ <$ c.m. $< 27^\circ$ and proton energy range 220 Mev $< k < 270$ Mev. *Phys. Rev.*, 1959, v. 113, 1130–1138.
4. Tangherlini F.R. Light travel times around a closed universe. *Nuovo Cim.*, 1994, v. B109, 929–951.
5. Tangherlini F.R. An inroduction to the General Theory of Relativity. *Suppl. Nuovo Cim.*, 1961, Ser. X, v. 20, 1–86.
6. Tangherlini F.R. An inroduction to the General Theory of Relativity. Transl. by P. Y. Zhu, Shanghai Science & Technology Press, Shanghai, 1979.
7. Bolotovskiĭ B.M., Ginzburg V.L. The Vavilov-Cerenkov effect and the Doppler effect in the motion of sources with superluminal velocity in vacuum. *Soviet Physics Uspekhi*, 1972, v. 15, no. 2, 184–192 (translated from *Uspekhi Fizicheskikh Nauk*, 1972, v. 106, 577–592).
8. Malykin G.B. On the possibility of experimental verifying the second postulate of special relativity. *Physics-Uspekhi*, 2004, v. 47, no. 7, 739–742 (translated from *Uspekhi Fizicheskikh Nauk*, 2004, v. 174, 801–804).
9. Michelson A.A., Morley E.W. On the relative motion of the Earth and the Luminiferous Ether. *Am. J. Sci.*, 1887, Ser. III, v. 34, 333–345.
10. Kennedy R.J., Thorndike E.M. Experimental establishment of the relativity of time. *Phys. Rev.*, 1932, v. 42, 400–418.
11. Sagnac M.G. L'éther lumineux démontré par l'effet du vent relatif d'éther dans un interféromètre en rotation uniforme. *Comptes Rendus des Séances de l'Académie des Sciences*, 1913, t. 157, 708–710.
12. Malykin G.B. The Sagnac effect: correct and incorrect explanations. *Physics-Uspekhi*, 2000, v. 43, no. 12, 1229–1252 (translated from *Uspekhi Fizicheskikh Nauk*, 2000, v. 170, 1325–1349).
13. Malykin G.B. Sagnac effect in a rotating frame of reference. Relativistic Zeno paradox. *Physics-Uspekhi*, 2002, v. 45, no. 8, 907–909 (translated from *Uspekhi Fizicheskikh Nauk*, v. 172, 969–970).
14. Mansouri R., Sexl R.U. A test of Theory of Special Relativity. *General Relativiy and Gravitation*, 1977, v. 8, 497–513; 515–524; 809–814.
15. Marinov S. The coordinate transformation of the absolute space-time theory. *Found. Phys.*, 1979, v. 9, 445–460.
16. Kupryaev N.V. Extended representation of the lorentz transformations. *Russian Physics Journal*, 1999, v. 42, no. 7, 592–597 (translated from *Izvestia VUZov*, *Fizika*, 1999, no. 7, 8–14).
17. Private communication with the author, October 14, 2006.
18. Cavalleri G., Bernasconi C. Invariance of light speed and nonconservation of simultaneity of separate events in prerelativistic physics and vice versa in special relativity. *Nuovo Cim.*, 1989, v. B104, 545–561.