The first years of relativity in Italy and the defeat of the "vectorialists" in Marcolongo's correspondence

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1. Introduction

In the most fruitful years of Relativity the Neapolitan mathematician Roberto Marcolongo plays a fundamental role in its diffusion (in Italy), following the setting (of the absolute differential calculus) and the beliefs of Tullio Levi-Civita. However from his correspondence[1], as we will see, yes infers that he posed serious obstacles to the development of the formulation invariant (or of the dyads) proposed in vain by Tommaso Boggio of the University and Cesare Burali-Forti of the Military Academy, both from Turin. Marcolongo, in fact, was considered the main exponent of the so-called "vectorialists" or those who considered the formulation invariant, that is in terms of vectors and their suitable generalizations, as the only one formulation that can be proposed to legitimize any physical theory. On the other part, in trying to discover the weaknesses of the absolute differential calculus of Levi-Civita, he ends up becoming passionate about the covariant formulation and ne becomes the main disseminator, especially at conferences[2] held at the Mathematical Seminary of Rome in 1919. The vectorist followers, and in particular Boggio, will try in various ways to convince and bring back from their part Marcolongo, but in vain. Marcolongo that he had initially done spokesperson

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[1] Fondo Marcolongo (FM) Library of the Department of Mathematics "G. Castelnuovo", University of Rome "La Sapienza".

[2] See Cattani 1996a, 1998, Tortoriello 2004.

for vector artists, traditionally linked to the Italian school of elasticity, authoritative defender of the concept of invariance (at the expense of covariance), ends up becoming the most listened to popularizer of relativity in its "classical" covariant formulation.

Furthermore, clear signs emerge from the correspondence between Marcolongo and Boggio of a bitter debate also on the unclear distinction between invariance and principle of relativity that agitated the community of Italian mathematicians aligned mostly with Levi-Civita in favor of the covariant formulation (coordinate dependent) and against vectorists. Marcolongo in this one controversy played a key role[3] especially for his lectures of 1919. In this year, Castelnuovo, Volterra and Silla organize a Mathematical Seminary of Rome a series of conferences on relativity, with the main purpose of clarifying the methods of absolute calculus, by the mouth of Marcolongo (and not of the author of these, i.e., Levi-Civita), and trusting in the its exhibitor clarity. The conferences, on the other hand, are accompanied by harshness controversy[4] and by a general indifference of the scientific community[5].

Clear signs of uncertainty, which make Marcolongo oscillate between both the positions, are found not only in his correspondence but also in the its publications. In 1921, at the moment of maximum popularity of the relativity in Italy, with the arrival of Einstein in Italy[6] Marcolongo publishes a book of relativity with a moderate diffusion[7]. At the same time, together with Burali-Forti, presents the second edition of

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3 See Cattani 1996, 1996a.

4 For a general analysis of the impact of relativity on mathematicians, see also Goodstein 1983, Maiocchi 1985, Reeves 1987, Cattani 1992, 1993, 1996, 1996a, 1998, Brigaglia et al. 1998.

5 See Cattani 1996a, 1998, Tortoriello 2004.

6 See Maiocchi 1985.

7 Marcolongo 1921.

a book on vector calculus[8]. but while in the first edition, already in the introduction, he hopes for the possibility to formulate the fundamental equations of any mathematical model arguing

"the enormous superiority of absolute vector calculus over the ancient and indirect methods of the coordinates"[9]

in the new edition the criticism disappears from the preface (of the second edition) but it is found here and there in the text and, in particular, in the appendices. Pushed Burali-Strong and with greater evidence from Boggio, Marcolongo he begins to study the works of Levi-Civita and Einstein perhaps with the intention to find a vectorialist approach to general relativity, but once he understands the methods of absolute calculation, Marcolongo convinces himself of the goodness of the covariant method and becomes one of the main defenders and popularizers (although he remains convinced of the reasons of the vectorists). In in fact, if Marcolongo can easily translate the fundamental equations of the special relativity in terms of vector invariants, because the class of inertial references and the space is that of Minkoski pseudo-euclidean, not as immediate is translated (in a manner simple and meaningful) the equations of general relativity. For this reason, Marcolongo loses the role of defender of the vectorists and, in the 1924, Cesare Burali-Forti turns to Boggio to publish with him the book "Espaces Courbes-Critique of Relativity" [10] mainly dedicated the theory of homographs in n-dimensional curved spaces and the inverting formulation of Einsteinian equations. Only in a small final part (developed in about 10% of the total pages) are proposed Einsteinian

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[8] Burali-Forti and Marcolongo 1909, 2nd and. 1921.

[9] Cf. Burali-Forti and Marcolongo 1909, p. V.

[10] Burali-Forti and Boggio, 1924

equations in terms of vector homographs and in a form of which

"One must observe the simplicity of the calculations….and compare them with the complication of those that are made by means of multiple systems".[11]

In reality the calculations are not at all simple (indeed quite obscure) if even Levi-Civita writes to Boggio that reading his works

“he only managed to glimpse the results without appreciating their importance and the range”[12].

The main objective that Burali-Forti and Boggio set themselves is to demolish the covariant formulation of the field equations (fact through the use of the "multiple systems" to which they allude) and what is surprising it is that, writing in French, they seem to address a community foreign to the national one (and obviously to the pro-German one). The strong criticisms (of Relativity) they set out in the introduction did moreover to suppose that this book represented the epilogue of a controversy of which it represented the only trace. This is just one episode of a much deeper controversy that pits the vectorists from a side and the supporters of the absolute differential calculus on the other, the defenders of the principle of invariance against those who relied on a relative invariance that is subordinated to the choice of coordinates, and, last but not least, juxtaposed those who claimed the primacy of Italian culture over German culture. Unfortunately the formalism of Boggio and Burali-Forti is obscure and heavy, but they express the "Italian way to relativity" and essentially propose a method similar to the dyadic and spinorial which is only about 40 years older later it will be taken into consideration by the scientific community for the relativistic applications[13].

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[11] See Burali-Forti and Boggio 1924, p. 230.

[12] T.Boggio to R.Marcolongo, 28.5.1919, (postcard), FM.

[13] Sachs 1964, Pirani 1957.

2. Marcolongo "vectorist"

Marcolongo belongs together with Boggio, Burali-Forti, and Pietro Burgatti (from the University of Bologna) to that Italian school of vector artists, supporters of the importance of vector calculus and invariants in each matter of physics-mathematics and therefore in their intentions also in relativity. They (and others) constituted the conservative wing of mathematical physics Italian, who supported the priority of vector formalism and calculus homographic, classic method of Italian vector artists. Marcolongo was the greatest exponent, and was open to relativistic questions from the point of view of interpret them in an invariant way, i.e., in terms of vectors and quantities absolute values independent of the choice of reference. This position was open contrast with the relativistic covariant formulations they favor the choice of the coordinate system and base the considerations of invariance on the formulation of laws of transformations by covariance (o contravariance). His involvement in special relativity dates back to 1906 when among the first in Italy he exhibited in an article on the transformations generals of Lorentz (Marcolongo 1906) the fundamental concepts of relativity focusing on the invariance of the equations.

Thanks to his work on vector calculus and the benevolence of Guido Castelnuovo he is nominated on the occasion of the IV Congress International of Mathematicians (held in Rome in 1909), in one International Commission to standardize vector notations[14]. In the same year he published a book together with Burali-Forti[15], in which supports the primacy of vector calculus over differential calculus (by LeviCivita) proposing to show in form

14 G. Castelnuovo to R. Marcolongo, 25.1.1909. See Cattani 1996a, 1998, Tortoriello 2004.

15 Burali-Forti and Marcolongo 1909.

> "absolute or autonomous….as the appropriate use of vectors and vector components, present Analytical Geometry in absolute geometric form and eliminate that ordinary indirect algorithm which, born with coordinates, must necessarily disappear as soon as geometric entities can be considered free from the fixed system of reference"[16]

Knowledge of the invariant formulations of vector calculus, according to the two authors,

> "now imposes itself not only on the physicist and electrical engineer, but also on the enthusiast of pure mathematics"[17]

However, Marcolongo is, with good reason, recognized as the leader of the vectorialists, but he is also concerned with giving legitimacy to vector calculus showing its physical-mathematical applications. Some years later, returns to the Lorentz transformations[18], and states that

> "in the study of Lorentz transformations and the equations of electrodynamics, it is of considerable importance is the search for the laws by which some entities are transformed physical"[19.]

Applying the methods of vector calculus and homographs, he expresses in the more general and intrinsic form the Lorentz transformations and the laws of transformation of electric, magnetic field, etc. It can therefore be argued Marcolongo arrives at (restricted) relativity, dealing with questions of electromagnetism, which sought to express with the intrinsic methods of vector calculation, regardless of the choice of coordinates.

3. The role of Levi-Civita in the years before the war

Tullio Levi-Civita, in an article by resigna[20] on the Italian contribution to the extension and evolution of mathematical physics from 1860 to 1910, he cites Marcolongo for his expositive clarity as "also as a tractatist, he has rendered eminent services to scholars"[21].

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16 Ibid, p. V

17 Ibid.

18 Marcolongo 1912a, 1912b, 1913a, 1913b

19 Marcolongo 1913a, p. 349.

20 Levi-Civita 1911.

21 Levi-Civita 1911, p. 11.

After sketching the story special relativity Levi-Civita mentions Abraham's contribution to the dynamics of electrons and concludes on the merits of Einstein for having formulated a

> "principle of relativity, intrinsically unassailable, though it our usual insights"[22]

and hints at the

> "lush developments....that they had in Marcolongo a shrewd precursor".[23]

The rest of the Italian scientific community begins to be interested in relativity with the Scientia controversy (1912-1914) Thomas Abraham and Einstein[24]. It is precisely because of this and some inaccuracies of Einstein in the formulation of the first theory of general relativity[25], which in 1915 Abraham involves Levi-Civita in a direct correspondence with Einstein marking a decisive turn both in the formulation of the theory and in the diffusion in Italy of general relativity[26]. In this correspondence, Levi-Civita has a fundamental role in demonstrating the inconsistency (from the point of view of mathematical view) of the first Einstein theory[27] and in spreading the general relativity in Italy. Unlike special relativity relativity in Italy (and not only) a general indifference if not even open hostility. Mathematicians show a cautious interest,

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21 Levi-Civita 1911, p. 11.

22 Levi-Civita 1911, p. 17.

23 ibid.

24 For Abraham's role in the spread of relativity in Italy, see Cattani and De Maria 1989b, Cattani 1992,1996.

25 Einstein and Grossmann 1913,1914, Einstein 1914.

26 cf. Cattani and De Maria 1989a.

27 cf. Cattani 1996, 1996a, 1998. The Einstein-Levi-Civita correspondence had a fundamental role both in bringing Einstein back to a correct variational formulation the gravitational equations (cf. Cattani and De Maria 1989c, Cattani 1992,1996) focus attention on the question of the energy of the gravitational field (cf.Cattani and De Maria 1989a, 1993). On the variational formulation Levi-Civita also had the the fundamental merit of pushing Palatini to the generalization of the Hilbert principle (cf. Cattani 1993).

although, for obvious reasons, during the war period (1915-1918), the spreads in scientific circles (as well as in the rest of Italian society) a growing rejection of Germany and all its cultural expressions and scientific. On the other hand, the fundamental equations of general relativity and the principle of relativity makes the methods of absolute differential calculus its own which, perfected by Gregorio Ricci-Curbastro and Levi-Civita at the end of the nineteenth century after about twenty years (1919), it was unknown by the majority Italian mathematicians.

4. The correspondence between Marcolongo, Boggio and Levi-Civita (1917-1918)

At the beginning of the summer of 1917, Marcolongo had hopes that the homographies applied by him to Lorentz transformations can be generalize also to general relativity and writes to Levi-Civita:

"I have some hope that the methods of homographies, whose effectiveness I experienced

> In the study of Lorentz transformations, may they render some service in the field you, with the usual acumen, explored. I know little about the latest works Einstein because I Rend. of Berlin here do not arrive but I hope your works I they will illuminate completely".[28]

Marcolongo is convinced that the methods of vector calculus already applied to the special relativity can also be extended to general relativity, which does not know. For this he asks Levi-Civita about Einstein's latest works and allegedly Levi-Civita sends Marcolongo not only the works of Einstein but also the necessary explanations to allow its understanding as witness Maggi himself. In a letter to Marcolongo, Maggi claims that he is Levi-Civita himself to explain to him the theory of relativity:

> "Our excellent Levi Civita seems to find it easier to navigate through those spaces than what has succeeded me and others .... At my request, with the usual concern, me he

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[28] R. Marcolongo to T. Levi-Civita, 20.7.1917, p.1, Box 5, Property Levi-Civita (FLC) Lincei Academy, Rome.

> traced, in a letter, the main lines of Einstein's theory, and this certainly it has benefited me."[29]

In a letter dated 1917, Burgatti confesses to Marcolongo that he was interested of the theory of relativity and in particular

> "of Einstein's general relativistic theory. About which I will tell you that slowly I have read the most important memoirs; but it is difficult for me and it seems to me very complicated. Philosophically and mathematically considered it is certainly very beautiful, but from the point from a physical point of view it leaves me somewhat skeptical. The success relating to the variations of the perihelion [of Mercury] does not seem decisive to me, since they can be explained in other ways. We will have to wait for agreements with observations and experiences."[30]

Burgatti also expresses perplexity about the physical basis of Einstein's theory and does not hide, like the majority of mathematicians, his incapacity a understand the mathematical passages. Meanwhile Levi-Civita, continuing in the his work of persuasion, finds in Attilio Palatini and Umberto Cisotti two valid ones allies leading them both to produce substantial contributions[31].

At the end of the war (1918) the resentment and hatred of the Italians for all that it could have come from Germany and from the German culture it expressed itself in directly and without intermediaries. Boggio did not hide his rejection of any other expression of German mathematical culture been "Italianized to the highest possible degree"[32]. He deals with calculus vector and homographies with particular regard to problems of elaselasticity and to convince Marcolongo to be the spokesperson for the criticisms of the vectorialists, for the recognized international role of Marcolongo. Actually, Marcolongo who is interested in the works of Levi-Civita also at the request of Boggio, ends up studying the methods of differential calculus of Levi-Civita and, after having understood them, he gives up on pursuing the controversy

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[29] G.A.Maggi to R.Marcolongo, 9.25.1917, p. 4, FM.

[30] P.Burgatti to R.Marcolongo, 10.7.1917, p. 4, FM.

[31] Cisotti 1918a, 1918b, 1918c, Palatini 1919a, 1919b. See Cattani 1992,1993, 1996,1996a, 1998.

[32] T.Boggio to R.Marcolongo, 7.27.1918, (postcard), FM.

triggered by Boggio. Indeed, at the end of the summer of 1918, Marcolongo wrote to Levi Civita:

> "I dedicated my summer idleness to studying your notes on general relativity, with a taste and infinite pleasure. How many obscure points have been clarified for me by your beauties, very elegant notes! I had the desire to go deeper and, somehow, show them in class. And I restarted the minute study of the *calculation methods* differentiel absolue. But how terse the exposition is! To many demonstrations, with a little patience, I made up for it myself; in others I got tired or cheated like a schoolboy."[33]

It was Levi-Civita who kept his colleague informed and sent him his notes with the calculations, and Marcolongo thanks him for this:

> It was Levi-Civita who kept his colleague informed and sent him his notes with the calculations, and Marcolongo thanks him for this: "Thanks for the indications for the absolute differential calculus...I confess that many things, especially in some details, are still obscure to me; but I hope to overcome even these difficulties, deepening more and more your notes which have me on many points illuminated by bright light."[34]

Boggio also follows the works of Levi-Civita with interest and in particular commenting on the article by Levi-Civita[35] of 1917, he wrote to Marcolongo

> "Levi-Civita's treatment, from the Cartesian point of view, is certainly elegant; However, as you have already observed, it must be possible to do the treatment by imitating that which she has already done"[36]

Then follows a formal criticism of the methods used by Levi-Civita who, according to Boggio, deviate from the usual methods of the Italian mathematical school of elasticity and mechanics, in fact according to him

> "What Levi-Civita calls divergence of the energy tensor is nothing other than the gradient of a certain homography. Since last year I had this observed in Levi-Civita, showing how wrong the divergence denomination was, as he had to speak of gradient. He replied (as I expected) that he used the same notations as Einstein! Which means that the error, although recognized as such, must be perpetuated, because it came from a German pig!"[37]

But despite the hatred for the Germans, the theory of relativity interests Boggio who writes

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[33] R.Marcolongo to T.Levi-Civita, 9.3.1918, p.3, box 5, FLC.
[34] R.Marcolongo to T.Levi-Civita, 9.14.1918, p.1, box 5, FLC.
[35] "On the analytic expression of Einstein's tensor", Levi-Civita 1917.
[36] T.Boggio to R.Marcolongo, 9.21.1918, FM.
[37] T.Boggio to R.Marcolongo, 21.9.1918, pp. 2-3, FM

> "I too would like to do here [in Turin], in another school year, the theory of relativity"[38]

In 1917-1919, Levi-Civita publishes together with the correct formulation covariant of the Einsteinian equations[39], a series of interesting research on Einsteinian statics[40] and on the form of the metric in fields of Newtonian type, that is, of first approximation[41]. Assuming stationarity of the manifold and the existence of a suitable coordinate system (adapted coordinates) Levi-Civita manages to deduce a simplified form of the metric and to reduce the number of gravitational potentials making the addiction disappear time explicit. In other words, the structure of space-time is not flat but retains most of the properties of Euclidean space-time. In this way Levi-Civita manages to deduce a limited number of equations independent for the gravitational field and to bring back a problem mechanical to an exclusively geometric one. The ten notes of Levi-Civita on Einsteinian statics are the core of a vast research project on the integration of Einstein's gravitational equations in the first and second approximation that attracts the interest of Italian (and non-Italian) mathematicians alone). In particular, the possibility of interpreting, not only formally, the Einsteinian theory with the homographic calculation pushes Boggio to interact more directly with Levi-Civita and he mentions this in a letter of the year always following Marcolongo:

> "Levi-Civita wrote to me that having set about studying my latest works, without having in mind the whole algorithm of vector homographies, only ad glimpsing the results without appreciating their importance and scope"[42]

and addressing Marcolongo directly, he begged him again to intervene being

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[38] T.Boggio to R.Marcolongo, 21.9.1918, p. 3, FM.

[39] Levi-Civita 1917a.

[40] Levi-Civita 1917b.

[41] Levi-Civita 1917/19.

[42] T.Boggio to R.Marcolongo, 28.5.1919, (postcard), FM.

"therefore it is necessary for you to set out the main results obtained in some Note by Levi-Civita in his 10 and more Notes on Einsteinian ds2, and which he has developed completely the rest by some pupil, by means of vector homographies. As we hope you will be convinced.....If you have the notes of your course available this year on relativity, I will be happy to let you have them at your convenience; so i can get me an exact conception of these matters. [43]

Once again Boggio relies on Marcolongo in the hope that the latter will can deduce the equations of the general theory of relativity. Instead, Marcolongo who studies the works and relies on the understanding of the topics thanks to Levi-Civita's explanations, he is convinced that the calculus approach absolute differential is the most natural environment for the geometric theory of gravitation. The esteem that Boggio di Marcolongo has, as profound connoisseur and clear disseminator of relativity also appears in the letters later and in particular at the end of the same year he wrote to Marcolongo:

> "Thank you for your letter and for the Memoir on Dynamics, which I read with great pleasure interest. It seems to me that it is the work of a true Italian to highlight how much the Science owes to the Italians of past centuries, who were forgotten for too long, robbed, and mocked. And in my opinion such searches, very tiring and difficult, are worth more of ten notes, the so-called original ones, printed in the Academies.....I am glad that You still deal with relativity, and I ask you, if possible, to interest some of yours student, as long as you send me the notes of your lessons, because in the next year I too would like to develop such theories.[44]

In 1919, Levi-Civita tries to reconcile the possibilist attitude of the conservatories with the new mechanics[45] but it is also held in the Seminary Mathematician of the Faculty of Sciences of the University of Rome, of which he is director Vito Volterra, a series of conferences on relativity that will mark a moment of reflection and heated debate in the scientific community[46]. Marcolongo entered as a supporter of vectorists comes out as the main defender of Levi-Civita.

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[43] Ibid.

[44] T.Boggio to R.Marcolongo, 12.4.1919, (postcard), FM.

[45] Levi-Civita 1919. See Cattani 1996a, 1998.

[46] Cattani 1996a, Tortoriello 2004.

5. Marcolongo's book of relativity (1921)

The idea of writing something about relativity was born in Marcolongo several years before 1921. In fact, when the first volume of Meccanica di Marcolongo, Armellini suggests to Marcolongo to add to the last one part of the second volume

> "finally a very brief note on the principle of Relativity and on the foundations of Mechanics of Einstein, Minkowski etc. condensing - as you know how to do so well - all the various theories in a few pages. Since Rational Mechanics is studied not only by Engineering students, but also by those of pure Mathematics and Physics who this note would be very useful and especially appreciated by the latter".[47]

Marcolongo subsequently publishes a volume on the problem of the three bodies and a history of dynamics. In 1921, around sixty, he confessed to Levi-Civita a feeling of distrust in one's own abilities, believing that one already has given everything he was allowed, writing

> "In about a year I will be 60, what more do you want me to do for the science?"[48]

but publishes the first Italian book of Relativity[49] printed in Italy simultaneously with the translation of the text of Einstein[50] with a preface by Levi-Civita. In the preface of his book Marcolongo acknowledges the merit of Castelnuovo and Levi-Civita to the diffusion of relativity:

> "The new theories also had an honest welcome in Italy, if not a great one diffusion; eminent scholars have brilliantly introduced the new trends of ideas and have made substantial contributions to their development (just mention the Castelnuovo and Levi-Civita)."[51]

Marcolongo also recognizes the importance of the debate following the conferences of the mathematical seminar in which

> Marcolongo also recognizes the importance of the debate following the conferences of the mathematical seminar in which "there were discussions, conferences (especially those promoted by the Senator Volterra in the Mathematical Seminary of the Faculty of Sciences of Rome) and yes they dictated university courses".[52]

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[47] Armellini to R.Marcolongo, 7.30.1914, pp. 3-4, FM.

[48] R.Marcolongo to T.Levi-Civita, 10.6.1921, p.3, box 6, FLC.

[49] Marcolongo 1921.

[50] Einstein 1921.

[51] Marcolongo 1921, p.III.

[52] Marcolongo 1921, p.IV.

But he is forced to admit that

> "in general, however, physicists, astronomers and mathematicians (and not only among us) have showed a cautious reserve towards the new theories ..... the biases remained equally or are slowly dissipating. Not a few then .... got scared of the formidable analytical apparatus on which the most beautiful, most suggestive, most part is based recent development of the theory."[53]

In the same preface Marcolongo regrets the fact that

> "the most beautiful theories of analysis and mechanics, broader than the classical one (which becomes the mechanics of slow motions) and that by causing modifications quantitatively very slight, conceptually grandiose should silence the scruples and doubts of the gods more tenacious conservatives and push them to enthusiasm and admiration."[54]

In the text Marcolongo confesses that he has

> "also, to the general theory of relativity are applicable, with complete success, I use methods of vector homographies that we have been using and striving for for many years disseminate, Prof. Burali-Forti and me".[56]

In reality, Marcolongo's statement is more of principle than of fact. In the second edition of the book on vector calculus written together with Burali-Forti of the same year[57] he is forced to acknowledge the existence of opponents stating

> "what a great development vector methods have had….the importance of these methods is established by the fact that they have been adopted in almost all universities Italian; importance that the few systematic opponents do not diminish, quite the contrary increase"[58]

and in the appendix to the first part he reaffirms the primacy of vector calculus

> "*Vector calculus* (or, in general, *geometric*) must place the mathematician in condition of being able to solve *directly* any question of geometry, of mechanics, of physics, in *absolute form*, that is *independent from any system of reference* (with *zero* coordinates); otherwise, as occurs for vector systems municipalities, instead of *operations* and *operators* for geometric-physical-mechanical entities, you simply have *tachographs* for the coordinates and they *continue* to be *indispensable elements of calculus*. Now, it is obvious that any question of

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53 Ibid.

54 Marcolongo 1921, p.VI.

55 Ibid.

56 Ibid.

57 Burali-Forti and Marcolongo 1909, second edition 1921.

58 Ibid, p. IX.

geometry, mechanics, physics is independent of an arbitrary system of reference and therefore can, and should, be treated independently of coordinates."[59]

Once again Marcolongo shows his dual attitude (partially contradictory) towards relativity: on the one hand the popularizer of mathematical methods, the defender of new physical theories and the convinced supporter of the importance of relativity for the progress of science; on the other, the shy conservative who appeals to the classical tradition Italian, the defender of vector calculus methods so dear to opponents of Levi-Civita and relativity.

However, the reactions to Marcolongo's relativity book are general appreciation. Thanking him for the book received, Maggi wrote to Marcolongo:

"You break the reader a piece of bread, by its very nature soft, with such grace and skill,

> that if he does not digest it properly, he has only to blame his own stomach weak. Sure to fully penetrate the Einsteinian conception, it helps metaphysical considerations (so to speak), which in your book are just you mention. But you proposed the exposition of the mathematical construction, thank you to which, and not otherwise, those considerations take shape. The reader can draw them in the booklet by Einstein himself, whose Italian translation has been released at the same time as your volume."[60]

Among the most enthusiastic readers of Marcolongo's book is Armellini who writes to Marcolongo:

> "I received the volume of Relativity from Zanichelli and I threw myself upon it as a thirsty person who finally finds a source of pure and fresh water. I had it in the evening and I stayed up until two after midnight to read much of it. In the morning I finished the whole book afterwards. My impression was really good and excellent .... You have solved the problem of giving scholars a book of relativity that meets three requirements, namely to be easy to read at the same time, ben condensed and perfectly rigorous.[61]

Unfortunately from this moment on Marcolongo, while continuing to produce works of relativity[62] , is no longer able to validly stand side by side with Boggio and Burali-Forti who instead begin to work intensely on the formulation in homographic terms of the Einsteinian equations.

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[59] Ibid, p. 97, the italics are found in the original text.
[60] G.A.Maggi to R.Marcolongo, 11.20.1921, pp.1-2, FM.
[61] G.Armellini to R.Marcolongo, 11.24.1921, pp.1-2, FM.
[62] Marcolongo 1919a, 1919b.

6. Somigliana's article

In May 1922, Somigliana who had never been a proponent of the new ones principles, publishes an article [63] in which he believes he can demonstrate how Lorentz transformations can be placed in ordinary mechanics Newtonian. Starting from the wave propagation equation, and from his D'Alembert's classic integral, shows how the equation is invariant for the more general transformation of the solution. Special case of transformation of the solution is the Lorentz transformation, similar yes he then asks what is the meaning of this transformation in mechanics ordinary, (transformation already determined by W. Voigt [64] in 1887). There is transformation of the solution, which keeps the equation unchanged, corresponds to the case of a wave source which is mobile with uniform motion. Therefore Somigliana concludes

> "all the properties which in the theory of relativity result from the transformation Lorentziana, are generally susceptible to such interpretation, of character distinctly Newtonian.[65]

In reality, it escaped Somigliana that the spherical wavefront advances with a speed which is the speed of light and from his considerations it follows that the speed of light is invariant under coordinate transformations from him considered but this invariance is irreconcilable with the postulates of Newtonian mechanics. However, he concludes:

> "As obvious as the considerations made in this Note may appear, it is seemed to present some interest to place in its right light, from a mechanical-analytical point of view, the Lorentz transformation, fulcrum initial of all relativity; as also it seemed to me they could carry some contribution to that critique of relativistic theories which now seems like this properly initiated".[66]

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[63] It resembles 1922.

[64] Voigt 1887.

[65] Somigliana 1922, p. 412.

[66] Somigliana 1922, p. 414.

In September 1922, Maggi received from Somigliana his note on the Lorentz transformation with “prayer of careful reading”.[67] May he confesses to Levi-Civita that he has already carefully read Somigliana's work when he had appeared in the Rendiconti dei Lincei and that he had already sent his reflections on the subject at Somigliana. Maggi's main observation is that

> “to reconcile the consequences of the Lorentz transformations with mechanics Newtonian, one must first of all, deduce from the Newtonian principles with meaning for the subordination of the value of the reference time adopted for the representation of phenomena."[68]

In 1923, Maggi replied[69] to Somigliana's observations by observing substantially that the Lorentz transformation, although framed by similar in Newtonian mechanics it does not receive the same in that area profit he receives in the theory of relativity; in the latter in fact the Lorentz transformation is deeply connected with the elements intrinsic of the problem (and with the principles that underlie it) unlike what happens in the Newtonian theory and according to him this is enough to prevent a any comparison.

7. The critique of relativity

Somigliana's polemic on Lorentz's transformations reinvigorates the criticisms of vectorialists and constitutes the starting point of a volume of Burali-Forti in which the major criticisms of relativity are exposed. In actually the volume is almost entirely devoted to vector calculus and calculus of vector homographies and contains only a few final pages in which Somigliana's arguments on the transformations of

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[67] G. A. Maggi to T. Levi-Civita, 19.9.1922, p. 3, Box 7, FLC.

[68] Ibid.

[69] Maggi 1923.

Lorentz. According to the two authors, Einsteinian general relativity must be considered both under the physical-experimental aspect and for its relations with the classical mechanics

> "significant scientific heritage, which should not be left to a wave revolutionary and irrational.[70]

Its most impressive philosophical aspect should also be taken into account people without scientific preparation and finally for its mathematical aspect in which, according to Burali-Forti and Boggio, the arbitrariness is more noticeable and the irrationality of the foundations. According to them the negative result of the experience of Michelson and Morley may be due to either a pressure effect in the solar atmosphere either to the origin of the light from the center or from the edge of the disc but not to gravitational phenomena. As for the movement of the perihelion of Mercury the difference of 42" per century is illusory due to the perturbations generated on Mercury by the other planets of the solar system. The experimental confirmation of the deflection of light rays is also illusory in the vicinity of the sun, since the hypothesis of material light rays is only a hypothesis, instead according to them we must consider that such a gap can be produced by refraction in the traversing of the solar photosphere, and all this leads us to state that

> "*Relativity is a mechanical system in complete experimental contradiction with the real mechanics of the physical world*".[71]

Taking up Somigliana's criticism, the two argue that the transformations of Lorentz thanks to which the usual ideas of space and time are modified, give rise to illusory modifications and that to the relativistic explanation of a phenomenon can also be associated with a Newtonian explanation having the same value and therefore "*the bases of the theory of relativity are very uncertain.*"[72]

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[70] Burali-Forti and Boggio 1924, p.V.

[71] Burali-Forti and Boggio 1924, p.VII.

[72] Burali-Forti and Boggio 1924, p.VIII.

Even heavier are the criticisms of the philosophy of relativity

> "the fusion of time with space (achieved how?) at each point in space ordinary (which?) generates space-time or universe; definition, or explanation, of indisputable (!?) clarity!."[73]

and add in a note

> "there is someone who hopes that tact can be given such sensitivity (naturally relativistic!) able to perceive the fourth dimension of space-time or universe. We send him our most sincere wishes."[74]

Burali-Forti and Boggio believe they have found a different covariance than that Einsteinian and therefore believe that the only element that can characterize the phenomena is the invariance and not the covariance

> "by means of vectors and homographies one can obtain, and in absolute form, everything that relativists obtain by non-absolute methods, that is to say all that they obtain with the use of coordinates, any, general or not".[75]

In the second part of their book Burali-Forti and Boggio after reporting the Somigliana's work on Lorentz transformations, propose their own interpretation of local time, space-time or universe, of covariance and gravitational equations. The existence of local time is rejected due to the existence of fixed geometric spaces and rigid motions eliminate the contraction of the lengths. The relativistic contradiction according to them, is that since there is no fixed point it makes no sense to consider a fixed segment and continue citing other examples of contradictions, for example one derives with respect to local time as if it were Newtonian time; they talk about constant and maximum speed but according to them if everything is relative this is a contradiction. Another contradiction is identified in the Einsteinian space-time which according to them cannot be determined by physical phenomena, because it is the representation of space that depends on metric but not

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[73] Burali-Forti and Boggio 1924, p.IX.

[74] Burali-Forti and Boggio 1924, p.X.

[75] Burali-Forti and Boggio 1924, p.XII

the space itself, just as a definition cannot be given analysis of the fusion of space with time and conclude

> "philosophy will be able to justify the space-time of Relativity, but mathematics, experimental science and common sense do not absolutely justify it".[76]

Conclusions

Analyzing Marcolongo's correspondence, we fully recognize the main reasons for the delay in the diffusion of general relativity in Italy. Italian mathematicians ignore the methods of absolute differential calculus and then of the mathematical foundations of relativity and a minority group but seasoned (the vectorists) propose an alternative method, relying on the Marcolongo personality. Marcolongo, on the other hand, takes the side of LeviCivita, condemning the intrinsic calculation of Boggio and Burali-Forti to oblivion. In consequence of the theoretical framework and the difficulty in formalism mathematician, unknown to mathematicians of the time, several concepts yes confused and aroused controversy. Not only the equivalence principle yes confused with that of relativity but also the principle of invariance yes contrasted with that of the covariance. Actually an invariant formulation it remains so in form only if one remains in generality. When general equations specialize or rather are reformulated for one specific problem then the invariance must be understood as restricted (relative) to that class of phenomena. Levi-Civita who followed this approach[77] did not would never have accepted Boggio's pragmatism. However the work of Burali-Forti and di Boggio stands as a first attempt to free the relativistic field equations from the use of coordinates as will proposed, about 40 years later, with the spinor calculus and dyads.[78]

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[76] Burali-Forti and Boggio 1924, p.222.

[77] Cattaneo 1975

[78] Pirani 1957, Sachs 1964.

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