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of Modern Physicsjournal homepage: www.elsevier.com/locate/shpsbThe origins of the research on the foundations of quantum mechanics
(and other critical activities) in Italy during the 1970sAngelo Baracca^a, Silvio Bergia^b, Flavio Del Santo^{c,*}^a University of Florence, Italy^b University of Bologna, Italy^c University of Vienna, Staudgasse 33/7, 1180 Vienna, Austria

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ABSTRACT

We present a reconstruction of the studies on the Foundations of Quantum Mechanics carried out in Italy at the turn of the 1960s. Actually, they preceded the revival of the interest of the American physicists towards the foundations of quantum mechanics around mid-1970s, recently reconstructed by David Kaiser in a book of 2011. An element common to both cases is the role played by the young generation, even though the respective motivations were quite different. In the US they reacted to research cuts after the war in Vietnam, and were inspired by the New Age mood. In Italy the dissatisfaction of the young generations was rooted in the student protests of 1968 and the subsequent labour and social fights, which challenged the role of scientists. The young generations of physicists searched for new scientific approaches and challenged their own scientific knowledge and role. The criticism to the foundations of quantum mechanics and the perspectives of submitting them to experimental tests were perceived as an innovative research field and this attitude was directly linked to the search for an innovative and radical approach in the history of science. All these initiatives gave rise to booming activity throughout the 1970s, contributing to influence the scientific attitude and the teaching approach.

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1. Introduction: motivation and goals; a turning point in Italian scientific research

In the successful book *How the hippies saved physics*, published in 2011 (Kaiser, 2011)¹, David Kaiser describes how in the second half of the 1970s, after a long period of almost total indifference, the physicists' interest towards the Foundations of Quantum Mechanics (FQM) experienced a revival in the US. Kaiser reconstructs in great detail and with an abundance of documents and witnesses the origin of this revival, which derived from the cuts to research funds, and the consequent identity crisis among the young generation of physicists; a crisis that particularly animated the *Fundamental Fysiks* Group (FFG) in Berkeley, California. Surprisingly, it appears that this revival was rooted in a totally unconventional

* Corresponding author.

E-mail addresses: baracca@fi.infn.it (A. Baracca), bergia@bo.infn.it (S. Bergia), delsantoflavio@gmail.com (F. Del Santo).

¹ The book won the Davis Prize from the History of Science Society.

atmosphere of the widespread New Age mood, the Oriental mysticism, even the use of psychedelic substances, with the goal of achieving psychokinesis, transmission of thought and superluminal communication.

In spite of these somewhat metaphysical goals, "The group's intense, unstructured brainstorming sessions planted seeds that would eventually flower into today's field of quantum information science" (Kaiser, 2011, Introduction, p. xvi).

Our present research (see also Baracca, Bergia, & Del Santo, 2016) has been motivated by the lesser-known fact that in Italy these interests and this field of research, not only survived the postwar years, but in fact had a revival at the turn of the 1960s, well before its manifestation in the US. As the two eldest between us were amongst the protagonists of that revival, we deem it relevant to leave a direct testimony, and to attempt a reconstruction of these events, even if much less ambitious than Kaiser's. In particular, it seems relevant to us that, although this anxious endeavour for renewal was, in Italy as in the US, rooted in the uneasiness of the youngest generation of the physicists for the

prevailing mood of physical research (characterised by the race towards high energies), the Italian physicists had nevertheless a more realistic and concrete physical attitude than their successive American counterparts. Their aim was no less ideological, but at the same time more ambitious and yet more restricted. In fact, the young Italian physicists caught hold of the recently introduced *Bell's inequality* aiming at the possibility that Quantum Mechanics (QM) could show limits of validity. This could have opened the possibility of a new physical framework, and legitimised their criticism to the prevailing scientific attitude. The downside of their critique of QM was that they did not look, contrarily to their successive FFG colleagues, for new implications of *quantum entanglement*, which stimulated the basic results of the “third quantum revolution”, albeit in rather unphysical terms.

It seems revealing in this respect that one of the pioneers and most influential representatives of the Italian line of research on the FQM, Franco Selleri (1936–2013), expressly cited by Kaiser (Kaiser, 2011, pp: 40, 208, 219, 270), became sympathetic with the unphysical proposals of the FFG (Herbert's “FLASH” experiment: Herbert, 1982; Kaiser, 2011, pp. 210 ff.), instead interpreting it as a possibility of falsifying QM.

Gian Carlo Ghirardi – who was the Italian physicist who anticipated the new implications of QM (Kaiser, 2011, pp. 208–215, 221–225, 233, 235, 270), actually focused later his attention to these interests (from the mid 1970s, therefore subsequent to the period that we will analyse), and had a less radical point of view, which objectively resulted to be more fruitful. This will be addressed in further detail in Section 13.2.1, dedicated to a summary of the Italian research activities after this significant decade devoted to the FQM.

Nevertheless we deem that our although partial reconstruction of the new upswing of the research on the FQM in Italy between the end of the 1960s and the beginning of the 1970s can help to shed light on the ideological-political mood of the young generation of the Italian physicists at the time. It also aids to highlight their active involvement in the social-political events of that crucial period, as well as the aspect of their cultural and ideological engagement, which objectively renovated the public attitude towards science and its historical and social interpretation. In our opinion, the deep ‘entanglement’ of these stimuli, elaborations, and concrete initiatives in multiple fields was an important, and rather particular aspect of Italian history, which has affected Italian science, and possibly society, more deeply than it can be perceived by the prevalent sphere of the current Italian scientific community. In this respect, it seems to us that at present the future of scientific research, as well as that of the new generations of physicists, appears quite uncertain, with the apparently illogical and self-destructive choices of the Italian ruling class.

We must declare from the outset that our reconstruction is (probably inevitably) biased by the (although full of gaps) personal recollections of the two eldest authors (A. B. and S. B.). Furthermore, our recollection of archive documents is unfortunately far from complete. We hope that this contribution will stimulate more in depth research on this crucial period of Italian history.

The revival around the turn of 1970s of the interest towards FQM in Italy, and the first phase of its evolution, was rooted in a growing uneasiness of the new generation of the physicists towards the setting and the aims of the existing scientific theories but developed however mainly in institutional contexts, specifically in the environment of the Italian Society of Physics (SIF). In fact, the problem of the FQM had explicit repercussions on the decisions of the Steering Committee of SIF. In light of these facts, we have conducted careful research in the SIF archives in Bologna.

With the growth of independent research activities and autonomous forms of organization within the young generation of Italian physicists, approximately after 1972, their relationship with SIF was losing relevance. For this subsequent phase, no systematic recollection of documents and records exists. The correspondence and documents of important Italian physicists, now disappeared, like Marcello Cini and Franco Selleri, are conserved in archives which unfortunately are not yet adequately organized or accessible for specific research.

2. Italian precursors: academic interest towards the FQM during the 1950s and 1960s

In the immediate post-war years, it was specifically the engagement of Edoardo Amaldi (1908–1989) and his initiatives, mainly devoted to nuclear and particle physics, which breathed new life in the research into physics within Italy (Amaldi, 1979; Amaldi, Battimelli, & Paoloni, 1998).

Among the young post-war and post-Fermi Italian physicists, Piero Caldirola (1914–1984) was a scientist-humanist, with philosophical concerns,² who was active in Pavia and then professor of theoretical physics in Milan. He was entrusted with the editing of the entry “Quantum Mechanics” (*Quantistica, Meccanica*) for the *Enciclopedia Italiana* (Caldirola, 1961), which resulted in a review of the proposals and problems of the interpretation of QM and especially of the measurement theory. The entry was published in various versions (also coauthored by Angelo Loinger) and also as a separate booklet, which circulated among the students of his course on theoretical physics and consequently personally stimulated one of the present authors, A. B., who studied and graduated in Milan.

Caldirola transmitted interest towards the FQM to his pupils, who, competent also in statistical physics, proposed in 1962 a mechanism to explain the reduction of the wave packet based on the stochastic irreversible behaviour of the macroscopic measuring device (Daneri, Loinger, & Prosperi, 1962).³ This interpretation has fallen into disuse at present, but for several years was widely discussed (see e.g. Krips, 2007; Auletta, 2000, p. 260).

We must remark that Daneri, Loinger and Prosperi, along with the Caldirola's school, did not bear dissatisfaction towards QM and its validity, but only tried to resolve the residual open problems.

Also Bruno Ferretti, professor of theoretical physics at the University of Bologna, cultivated some interests towards the problems of the FQM, although it seems that he has not left any written evidence (as we further explain in Section 3).

One could argue that in 1966 a paper by Bernard D'Espagnat on the theory of measurement in QM appeared in the Italian journal *Supplemento al Nuovo Cimento* (D'Espagnat, 1966), but it did not raise attention among the Italian physicists, as far as we know (the interest toward D'Espagnat's works began later in Italy).

² One should remark that the Italian tradition of physics was double-sided, in the field of the epistemological and methodological concerns. On the one side, the main exponent, Enrico Fermi, was substantially indifferent to this kind of uneasiness: although he was the author of the introduction of QM in Italy, all his lecture notes are practically lacking of such kind of remarks. On the contrary, Ettore Majorana, although prematurely and mysteriously disappeared, exhibited deep concerns about this subject matter (see e.g. Maltese, 2010). On the other hand, Fermi's friend and colleague Enrico Persico authored one of the clearest lecture notes on wave mechanics, with an extremely effective didactic approach, that strongly influenced that by Caldirola.

³ From Freire's comprehensive book on the “Quantum Dissidents” we got acquainted of a controversy between Eugen Wigner and Leon Rosenfeld, that incidentally involved also Daneri's *et al.* paper (Freire, 2014, Sect. 4.4, pp. 156–161).

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