The Struggle against Idealism: Soviet Ideology and Mathematics

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For several years now I have been studying the development of semigroup theory (see, for example, [21]). This is a relatively new area within mathematics, most of the major developments having taken place after the Second World War. The fact that there was a particularly strong Soviet school of semigroup theory has meant that I have been drawn into the study of Soviet mathematics more generally. Naturally it is not possible to investigate the latter area without having some awareness of ideological issues within the Soviet Union. The criticism by Soviet ideologues of the theory of relativity, for example, is reasonably well known (see [43]), as is the infamously detrimental effect that the pronouncements of Trofim Lysenko had on Soviet genetics (see [25]). The case of mathematics is, however, perhaps not so familiar in spite of a great deal of scholarship having been carried out in this area and it being a subject of continuing and current interest, as shown, for example, by recent books such as [20]. The present article (which I compiled originally simply as a document for my own reference) is intended as a concise introductory account of Soviet ideology of mathematics through which I hope to bring this fascinating subject to wider attention. In the words of one of the anonymous referees, this article is a "teaser". I must stress at this point that it is merely a survey and does not represent original scholarship.

Although I have drawn upon a range of sources in the compilation of this article, my account is based very heavily upon three excellent articles by Alexander Vucinich on the subject of Soviet ideology and mathematics [45], [46], [47]. These articles no longer represent the most up-to-date material in this area and might indeed be criticized for their slightly old-fashioned viewpoint (in a sense to be described below), but they nevertheless provide a useful framework for a first account of this subject. My purpose in writing a new article on this topic is to provide a shorter, punchier exposition of the material, which I hope will serve as a useful starting point for any reader who wishes to go on to read the greater detail available in the work of Vucinich and other authors. A wide range of references to other published materials on this theme is provided throughout. I have deliberately kept this article somewhat superficial—the study of Soviet ideology of mathematics is far more complicated than could ever be conveyed fully in a short article such as this. Instead, I hope that this article will inspire readers to follow up the references given. I have purposely cited mostly English secondary sources through which the interested reader will gain easy access to the Russian primary sources, particularly the archival material that is increasingly becoming available. The focus here is very much upon ideology rather than the personal stories of mathematicians, to which references will be given throughout. Although there are many fascinating such stories, I have chosen to omit them in order to keep the length of the article down and also because they

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are well recorded elsewhere—what is presented here is the technical framework against which the personal stories are to be understood.

For reasons that will be outlined in due course, the Soviet ideology of mathematics was in fact rather superficial and, ultimately, fairly ineffective: to a large extent, mathematicians continued with their work with little interference from the ideologues. This was in spite of the vast volume of ink that was expended in connection with the construction of a Marxist philosophy of mathematics. The promises that were made for this philosophy, and all that it might do for mathematics, were never realized. Many of the works that were written on this subject are distinctly unsatisfactory to the mathematician's brain: they tend to be somewhat vague, and, where an assertion is to be proved, this is often done as a "proof by examples". It may seem unreasonable to expect a mathematical level of rigor in the discussion of philosophical ideas, but it was the Marxist thinkers themselves who claimed that such precision was possible; however, they were never able adequately to demonstrate this assertion.

A curious effect of the superficiality of the Soviet ideology of mathematics is that it is possible to grasp a great deal of this subject, supposedly a topic within the philosophy of mathematics, with little knowledge either of philosophy or indeed of mathematics—although, naturally, a deeper understanding may be achieved if one knows a little of the underlying philosophy and mathematics. In writing this article, I have assumed that the reader will have a mathematical background but that they may not be well versed in Soviet philosophy. The article proper therefore begins with a very brief sketch of the philosophy which underpinned the ideology of the Soviet state: dialectical materialism. The official Soviet view was that all things (mathematics included) should be explicable in terms of dialectical materialism. Thus, the "Great Soviet Conceit" emerged: the idea that, in light of their conversance with state ideology, it was the Communist Party bosses rather than the appropriate specialists who were best placed to guide the development of any discipline. In the course of this article, we will see their ineffective attempts to do this in mathematics.

To pick up on the comments made above concerning Vucinich's "old-fashioned" perspective, it should be noted that his point of view was rooted firmly in cold war attitudes towards Soviet science, which regarded the ideological question in rather black-and-white terms as a struggle between "good" scientists and "bad" ideologues. Ideological "interference" in science was generally painted as a negative influence and a hindrance to progress: Lysenkoism was held up as the typical example. However, the reality appears to have been considerably more complicated, as many authors have argued in the post-Soviet period. For example, Alexei B. Kojevnikov has noted the use of ideology in clashes, not just between scientists and ideologues but between scientists from rival camps within the Soviet physics community [27]. Slava Gerovitch has written about the ways in which Soviet mathematicians used carefully phrased philosophical language to strengthen their own positions [15]. However, in light of the fact that the primary purpose of this article is to provide a short introduction to Soviet ideology of mathematics, in which I hope to interest the reader who has no previous knowledge of this subject, I prefer to present a simpler narrative even if it appears a little simplistic in places. Nevertheless, the reader should be aware of the above-mentioned issues, and further references will be given in the hope that the reader will then be interested enough to follow the references and fill in the further complications in the picture for themselves.

In his treatment of this subject, Vucinich identified three distinct phases in the development of the Soviet ideology of mathematics: before, during, and after Stalin's period in power. In the present article, I have retained Vucinich's division; the three phases are dealt with in turn. Roughly speaking, the pre-Stalin period was the phase in which mathematicians could safely ignore ideological issues, whereas the Stalinist period was characterized by greater state control of mathematics and mathematicians. In the post-Stalin phase, a certain harmony was reached in which the mathematicians had learned at least to pay lip service to ideology and the ideologues were much less fanatical. The article concludes with some suggestions for further reading.

Dialectical Materialism

Given that it was one of the twentieth century's most touted philosophies, it is perhaps not surprising that there are many books available on the subject of dialectical materialism, some easier to digest than others. One of the easiest that I have found is a rather old, but nevertheless very concise and readable, treatment in Edward Conze's *An Introduction to Dialectical Materialism* [6], where the philosophy is described "in a language that the ordinary worker-student can understand" [6, pp. 5–6]. The account which is perhaps most appropriate in the present context, however, is that to be found in Loren Graham's *Science in Russia and the Soviet Union: A Short History* [18, Chapter 5]. A similar account may also be found in Graham's earlier book, *Science and Philosophy in the Soviet Union* [17, Chapter II]. The present section is a condensed synthesis of the versions of Conze and

Graham, incorporating a few comments made by G. G. Lorentz [34, pp. 183–4]. This section will be kept brief, since, as has already been noted, a detailed knowledge of dialectical materialism is not in fact required for an understanding of the subsequent material.

In describing dialectical materialism, there are clearly two aspects that need to be dealt with: first, the concept of "materialism" and then the function of the adjective "dialectical". *Materialism* refers simply to a philosophical view that is based upon the real world. It asserts that the world is made up of matter and energy and that all of nature may be explained in terms of our understanding of these without recourse to a divine explanation. An objective reality exists outside the human mind, and this reality is subject to natural laws that the human mind is capable of discovering. No aspect of nature is inaccessible to rational explanation. Our knowledge of the world derives ultimately from our experience of it. Materialism sits in contrast to *idealism*, idealistic notions being those which are conjured up entirely from the human mind and have no basis in physical reality.

In some versions of materialism, the universe is regarded as a system that is not subject to overall change with the passage of time, but dialectical materialism is a form of *historical materialism*: a materialist philosophy that not only acknowledges the process of change within a system but also looks to the past development of that system as a means of anticipating its future tendencies. If the process of change is to be incorporated into a philosophical view, then the mechanism by which this change takes place must be identified. In the case of dialectical materialism, this mechanism is provided by the notion of the *dialectic*: essentially, a contrast between opposing notions. Dialectical materialism asserts that, within any given system (be it the universe, society, or any other system of our choosing), there will coexist certain pairs of contradictory ideas: *theses* and *antitheses*. It is the "tension" between a thesis and its corresponding antithesis that drives the process of change, leading ultimately to some sort of reconciliatory outcome (the *synthesis*). We may apply these ideas to society in order to see a very simplistic example of this process: a dialectic exists between the thesis "there are rich people" and the antithesis "there are poor people". The dialectic drives change in society, whereby the rich get richer by exploiting the poor, leading to the (in the Marxist view, inevitable) synthesis that is revolution and the establishment of a socialist state. The application of dialectical materialist ideas to society to develop a theory of social development, in companionship with dialectical materialism as a philosophy of science, forms the basis of Marxism. Marxist thinkers used the close connections between dialectical materialism and (exact) science to imbue their philosophy with what they saw as a greater precision than that present in any other philosophical scheme. This led them to the view that dialectical materialism was the only valid philosophy for the construction of socialism. Indeed, as G. G. Lorentz observes,

> Lenin, Stalin, and the Party had great respect for the exact sciences and mathematics based on the naive belief that the future of communism was ensured by following Marx's prescriptions and having science as an ally. They considered Marxism itself an exact science. [34, p. 198]

With its exalted status as the "one true philosophy", dialectical materialism became an overarching scheme into which all other disciplines needed to be integrated. This view had a highly destructive effect on Soviet genetics, for example, but as we have already noted, its effects on mathematics were much less severe.

Before Stalin

It was only several years after the October Revolution that Marxist thinkers began to turn their attention seriously to the development of a Soviet philosophy of mathematics. As Vucinich explains [45, p. 107], the reasons for this were twofold. First of all, the so-called "Marxist classics" (namely, the writings of Marx, Engels, and Lenin) provided little guidance on how to proceed. Second, the Marxist writers of the 1920s had little mathematical background, particularly when it came to the more recently developed branches of mathematics, such as set theory.[1] For these reasons, the Communist Academy, the Soviet body tasked with "perfecting" Marxism (that is, turning it into a unified and consistent theory) and integrating it with all other disciplines, had made little progress in connection with mathematics.

In the absence of any ability to make detailed dialectical analyses of mathematics, the Marxist theorists of the early days of the Soviet Union occupied themselves instead with the wholesale criticism of the perceived idealism of Western mathematics and its possible unwholesome influence on its Soviet counterpart. Set theory, logic, and the foundations of mathematics came under particular fire. However, as we will see in this section, any action taken against these areas in the 1920s was disorganized, inconsistent, and

[1] *In fact, such ignorance extended beyond mathematics, as Kojevnikov* [27, p. 280] *has commented: "... despite their professed respect towards science, Bolsheviks with very few exceptions did not possess even basic scientific literacy and could be highly suspicious of scientists in real life."*

thus ultimately ineffective. Although the Marxist philosophy of mathematics of the 1920s lacked much cohesion, it was, nevertheless, in Vucinich's view [45, pp. 108–10], based upon certain basic suppositions, which included the following:

(1) *The highly abstract nature of mathematics puts it at risk of developing idealistic leanings; these must be resisted. The following three idealistic tendencies must all be rejected:*
   (a) *Logicism: the reduction of mathematics to a branch of formal logic, detached from reality.*
   (b) *Formalism: the "axiomatic" attitude whereby mathematics is treated as a collection of formulae which have no specific interpretation and are merely manipulated according to certain rules.*
   (c) *Intuitionism: the idea that mathematics may be built upon human intuition rather than pure reason.*

   The Marxist position was that although each of these three approaches had had its own small-scale successes, none of them was strong enough to support an overarching philosophy of modern mathematics. Although logicism and formalism were universally condemned by Marxist thinkers, there was room for debate where intuitionism was concerned: some Marxists were prepared to accept intuitionism, since they felt that this was the mechanism through which cultural and social influences entered mathematics.

(2) *The degree of "mathematization" of a given science gives an indication of the state of development of that science. However, we must also take account of the "qualitative" aspect of science, the extent of which varies from discipline to discipline. This is particularly prominent, for example, in the social sciences.*

(3) *Mathematics should not be deprived of a practical basis: all mathematical notions should be separated from reality only by a well-defined sequence of necessary abstractions. Marxist theorists are to be the judges of the utility of a given branch of mathematics and are to ensure that mathematics addresses both the needs of science and of society.*

(4) *Mathematics consists of theoretical constructions which arise from hypotheses put in place by mathematicians. It is through the choice of these hypotheses that social and cultural influences penetrate mathematics. Conversely, mathematics gives dialectical materialism an exactness not present in other philosophies. Dialectical materialism is therefore the only philosophy that is suited to the needs of society.*

Even with these precepts laid down, Marxist scholarship had little impact on mathematics. As already commented, most Marxist thinkers had little mathematical background and were therefore unable to take on mathematics as a whole simply because there was much in it that they did not understand. They directed some criticism towards the perceived idealism of Cantor's theory of transfinite numbers, for example, but ultimately failed in their attack because they did not have the detailed mathematical knowledge to attempt to offer up a materialistic alternative. Non-Euclidean geometry also caused particular problems for Marxist thinkers. The fact that it had no experimental basis clearly left it open to accusations of idealism, and yet nationalist sentiments begged for the acceptance of such a prominent Russian contribution to modern mathematics. It took many years and much mental gymnastics for Marxist writers finally to integrate non-Euclidean geometry into dialectical materialism. This must have been particularly traumatic for them, since geometry was traditionally regarded as a very practical (and thus philosophically straightforward) branch of mathematics; the comment of one Marxist pundit was that

> [g]eometrical methods and problems have had a wholesome effect upon mathematics by drawing it back to "sinful mother earth". [5, p. 12]

In Vucinich's opinion, two major sources may be identified for the fragmentation of the Marxist analysis of mathematics: "an ideological compulsion to exaggerate the 'idealistic' leanings of many modern mathematicians and a doctrinaire rigidity in identifying the branches of mathematics characterized as impractical and as targets of direct attack" [45, p. 110]. Further division may be found in the Marxist commentators' approaches to Marxism as a whole. Most of those at the Communist Academy, for example, viewed Marxism as "an open theory demanding constant work on improvement and modernization" [45, p. 110]—this was, after all, the reason that the academy had been formed in the first place. The point of view at the academy was that, if Marxist philosophy was to survive, then it must take into account new developments in science. Other thinkers, however, took the opposite line concerning Marxism: that it was essentially a complete, closed theory in which no further improvement was possible. This dogmatic view insisted that science could be on the right track only if it supported the basic tenets of Marxism.

Mathematicians themselves generally, and perhaps wisely, steered clear of the Marxist interpretation of their discipline during this period, though the occasional objection was raised against the peremptory rejection of those areas of mathematics within which hints of an idealistic leaning had been detected [45, p. 111]. V. A. Steklov [41, pp. 37–8], for example, argued against an official ideological line in science: he felt that such would hinder scientific advancement. Steklov was careful not to name the Soviet authorities directly (he expressed these views in an essay about Galileo's clash with the church) [45, p. 111]. Nevertheless, before Stalin came to power it was reasonably safe for leading academics to be critical of the relations between science and Marxist philosophy. S. N. Bernstein [41, pp. 83–4], for example, repeatedly cast doubt upon the possibility of integrating mathematics fully with dialectical materialism. As Vucinich notes, it was probably Bernstein's international standing that saved him from any Party reprisals [45, p. 112]. On the whole, Soviet mathematicians presented a united front against the move towards "practicalism" in mathematics that was advocated by the dogmatic (and often unrealistic) pronouncements of dialectical materialism. A. Ya. Khinchin [41, pp. 267–8] even went so far as to accuse the ideologues of taking too narrow a view of mathematics: they had no appreciation of mathematics as a whole and thus no sense of the future benefits that it might bring [45, p. 117].

Soviet mathematics retained a significant degree of autonomy owing to the lack of any coordinated assault from Marxist theorists. Solidarity amongst mathematicians against interference from the ideologues was particularly conspicuous at the famous Moscow function theory school (see, for example, [9, 37]), which defended its individual members regardless of their philosophical leanings. This unity, coupled with the school's research excellence, gave it a strength with which it was able to resist the efforts to bring it under the control of the ideologues. Despite an encroaching state jingoism, Moscow mathematicians continued to publish in French and German journals. Such foreign publication would become a serious issue for Moscow mathematicians in particular—and for Soviet mathematicians more generally—in the 1930s.

By the end of the 1920s, Stalin was in power, and plans were afoot to bring science under strict state control in parallel with the kind of control exerted within the ongoing five-year plans. Ernst Kolman, a particularly rabid exponent of Stalinist Marxism who came to prominence in the 1930s, asserted that

> [f]or mathematics there is only one way out: conscious, planned reconstruction on the basis of materialist dialectics. [5, p. 11]

At this stage, however, there was still a lack of mathematicians who were well versed in Marxist theory. The authorities therefore took a more militant approach: for example, supposedly "idealistic" journals were banned, and, following a hasty mathematical education, "socialist vigilantes" were sent out to infiltrate scientific organizations, with a view to gathering information on and ultimately exposing those scientists who deviated from the Party line [45, p. 121]. At this point, we enter the Stalinist phase of ideological interference in mathematics.

The Stalinist Period

The beginning of Stalin's period of total authority in the USSR was marked by sweeping societal and economic changes (namely, the collectivization of agriculture and the five-year plans for the development of industry) and also by the beginning of the crackdown on all independent thought. If mathematics had been left largely unaffected by state ideology in the pre-Stalin period, it was beginning to feel the effects a little more from the early 1930s. As John Barber notes,

> [i]ntellectual neutrality and academic autonomy soon ceased to be options. Tolerance of non-Marxist intellectuals who co-operated with the regime was replaced by the demand for unequivocal commitment to the official worldview. [3, p. 141]

There is in fact some evidence to suggest that Stalin himself did not truly believe that mathematics could be integrated into Soviet philosophy (see [15, pp. 33–4]). Needless to say, this opinion was never stated publicly. Under Stalinism the development of a consistent Marxist philosophy of mathematics was more about state control of the scientist than philosophy for its own sake. Gerovitch notes that

> [d]ialectical materialism, once a thriving and productive field of philosophical scholarship, under Stalin gradually "calcified" and was used as a philosophical cudgel. [14, p. 552]

Calls were made for mathematicians finally to conform; Vucinich notes that the Communist Academy criticized the "ideological lethargy and philosophical aloofness of leading mathematicians" when it came to the development of a mathematics that was consistent with Marxist precepts [46, p. 54]. Ernst Kolman, who is described elsewhere by Vucinich as being one of "the most ubiquitous and ardent Stalinist philosophers during the 1930s" [44, p. 251], noted that "under the dictatorship of

the proletariat…no discipline can exist in isolation from politics and Party leadership" [46, p. 54]. In his view, the independence thus far enjoyed by the mathematical community was entirely at odds with the needs of socialist construction. As a self-proclaimed mathematician (though a very superficial one, more interested in the Marxist interpretation of mathematics than mathematics itself),[2] Kolman was especially keen to see mathematics become a "Party science", closely linked to dialectical materialism and Party policy.

During this period, the notion of *partiinost* (партийность = "party-ness") became all important. This is a word that had an innocent day-to-day usage on official Soviet forms, where it indicated a person's Communist Party membership status: their partiinost would either be "партийный" (a Party member) or "беспартийный" (not a Party member). However, during the 1930s, the word took on a slightly different meaning: it came to refer to the adherence to the official Party line, as derived from the principles of dialectical materialism, and the extent to which Party objectives were put before all other considerations [30, p. 296]. Thus the degree of partiinost became a measure of the "soundness" of an individual or of a discipline in the eyes of the state. Bound up with the notion of partiinost was also the idea that there was no such thing as a neutral discipline: if a given subject was not fully behind Soviet ideology, then ipso facto it was against it (see [42, p. 39]). The task of the socialist vigilantes (see the end of "Before Stalin") was to expose those academics whose partiinost was questionable.

Marxists commentators despaired at the mathematicians (particularly those in the Moscow school) who took pride in the purity of their work and its isolation from other branches of science. Such mathematicians were also guilty of the cardinal sin of "philosophical neutrality": it was noted that the word "dialectics" was never used in the meetings of the Moscow and Leningrad Mathematical Societies [46, p. 55]. It was felt that only unity amongst Marxist philosophers of mathematics could rectify this situation and that this could only be achieved through a relentless attack on any perceived idealistic leanings within mathematics. Indeed, a sense of urgency emerged surrounding this issue when Marxist thinkers began to fear that idealism in mathematics could start to infect other areas, such as physics. For example, in an article on the perceived "crisis" in the mathematical sciences, Kolman noted that this concern

> …applies with particular force to present-day physics, with its remarkably abundant mathematical apparatus, with its efforts to formalise physics, to geometricise it, its aim of allowing matter to disappear and of retaining equations only…[5, pp. 1–2]

In 1931 the Communist Academy published the proceedings of a symposium on mathematics and dialectical materialism [28] in which the anonymously authored introduction attacked the Moscow mathematical school (in particular, its leading member, N. N. Luzin) for its avoidance of philosophical issues—this was said to be a mask for the school's idealistic leanings. The Leningrad mathematical school also came under fire, but no single individual was criticized in this instance.[3]

In his article for the proceedings, Kolman advocated the state planning of mathematical research and, in doing so, repeated much of the rhetoric that we have seen already: that mathematics must be integrated into dialectical materialism in order to be acceptable for socialist construction. He warned against the evils of idealism and noted that mathematics could never be incorporated fully into Soviet ideology so long as idealist tendencies were allowed to remain. However, in this and later writings, he gave no indication of how a specifically Marxist mathematics might be achieved; like previous authors, he spent more time criticizing the mathematics of the West.

During the 1920s the attacks of Marxist thinkers were directed almost entirely at mathematics rather than at mathematicians. However, in the 1930s attacks on mathematicians became rather more common, as Stalin sought to weaken the hitherto strongly independent intelligentsia. Amongst the first victims was the Moscow mathematician D. F. Egorov [41, pp. 61–2], who had not only made statements in favor of academic independence but also publicly refused to renounce his Orthodox faith in the face of state atheism. He was fired from his position as director of the Institute of Mathematics and Mechanics of Moscow University and, after a spell in prison, died in hospital. Other prominent mathematicians who found themselves under fire (though not as seriously so as in the case of Egorov) were V. F. Kagan and A. Ya. Khinchin. Even the loyally communist O. Yu. Schmidt came under attack: his article on algebra for the *Great Soviet Encyclopedia* (which he edited) was deemed to be insufficiently Marxist in tenor [46, p. 58]. The criticism of Schmidt, however, may have had less to do with ideology and more to do with a growing trend in Soviet academia that employed ideology, often somewhat cynically, as its weapon: the

[2] *For further details on Kolman, see* [29] *and* [38, Appendix A].

[3] *A more focussed ideological attack was launched against Leningrad mathematicians in 1949; see* [22].

attacks of younger academics, vying for advancement, on their older colleagues. Indeed, ideology was also used as ammunition in struggles between rival academics more generally: some of the most critical ideological attacks on mathematicians, for example, often came from other mathematicians [18, Appendix A].

The most infamous attack on a Soviet mathematician was that launched against N. N. Luzin [41, pp. 17–8] in the mid-1930s; amongst those who spoke against Luzin were a number of his former students.[4] Luzin, a one-time close associate of Egorov, was accused of being anti-Soviet on various grounds, including the accusation that he published his best work in foreign journals. The wider result of this imputation was the fact that Soviet mathematicians began to publish less work abroad.[5] Moreover, as Luzin was also criticized for his strong ties to the Paris set theory school, foreign contacts came to be discouraged more generally, resulting in a certain isolation of Soviet mathematics. The Academy of Sciences found Luzin guilty of all charges, but little punishment was meted out for reasons that remain obscure, although a number of plausible explanations have been given; see, for example, [20, p. 160] and [16, p. 6]. The judgement against Luzin was overturned in January 2012 [32].

Many leading mathematicians tried to adapt themselves to the needs of dialectical materialism without actually participating in the activities of Marxist organizations. P. S. Aleksandrov [41, pp. 223–5] and A. N. Kolmogorov [41, pp. 323–4], for example, contributed articles on mathematics to the publications of the Communist Academy. However, in these articles they simply made positive comments on dialectical materialism without dealing in specifics. Such articles did little to bridge mathematics and Soviet ideology. Nevertheless, the lip service paid to the official line seems to have placated many of the Marxist commentators on mathematics. Indeed, Kolmogorov's article on mathematics for the *Great Soviet Encyclopedia* (1938) was regarded for many years as being the most comprehensive account of the Marxist interpretation of mathematics despite the fact that it spoke of connections with dialectical materialism only in very vague, general terms. As with many mathematicians, Kolmogorov's apparent support of Soviet ideology of mathematics stemmed from pragmatism: Vucinich describes it as "fortuitous and superficial" [46, p. 61]. Nevertheless, Soviet mathematicians had Kolmogorov to thank for a certain reconciliation between abstract mathematics and Marxist thought. In an article of 1936, he argued that, far from being removed from real-world applications, greater abstraction in mathematics enabled one to encompass a wider range of applications in a single theory. Algebra and set theory were thus made more palatable to the Soviet ideologues, though not all of them were convinced [46, pp. 61–2]. For more on Kolmogorov's views, see, for example, [18, p. 118].

Aside from the disunity of Marxist commentators and their lack of deep understanding of mathematics, the international reputation of Soviet mathematics also helped to shield it from ideological interference, since it became a source of national pride and therefore worthy of being "protected. . . from reckless attacks by zealous ideologues" [46, p. 62]. So long as Soviet mathematicians maintained their established standards, their lip service to philosophical issues remained sufficient to appease the authorities. Pride in Soviet mathematics increased during the Second World War as part of the intensified nationalist feeling. The study of the history of Russian mathematics received greater attention, and it was at this point that Marxist thinkers strove to incorporate Lobachevskii's non-Euclidean geometry into their general scheme, even going so far as to claim to have identified embryonic dialectics in Lobacheskii's work [46, p. 69].

Many mathematicians were sympathetic towards Marxist principles but were of the opinion that it was Marxist theory that needed to be adapted to the needs of modern science rather than conversely. As Vucinich comments:

> Mathematics did not produce a Lysenko, that is, a dominant figure in the field who sacrificed the interests of science to the interests of dialectical materialism [46, p. 62].

Instead, Soviet mathematicians based their philosophy of their discipline upon the following four principles, as identified by Vucinich [46, p. 63]:

(1) All mathematical ideas have an empirical basis, but the further removed they are from this basis (the more abstract they are), the wider their scope of applicability.
(2) Western philosophies of mathematics are inherently idealistic and must therefore be criticized, but not all equally so: ideas with intuitionist leanings, for example, may admit a careful integration into the Marxist foundations of mathematics.
(3) Although the demands of science and technology lead to the wider development of "applied" mathematics, this must

[4] *There are many books and articles on the infamous "Case of Academician N. N. Luzin"; see, for example,* [11], [12], [31], [32], [33], [34, §6], [39], *and* [48].

[5] *For more on this point, including comments on nationalistic issues, see* [1].

never replace "pure" mathematics as the mathematician's primary concern.

(4) Mathematics develops both through its own internal logic and in response to technological requirements. However, Soviet mathematics has traditionally been slow in responding to the needs of technology, so more extensive involvement in industrialization is needed. Nevertheless, the growth of practical applications should not hinder work in abstract areas of mathematics.

It seems that most Soviet mathematicians subscribed to these general principles, which allowed them to be seen to be supporting Marxist views, but with the luxury of their own interpretation. The fact that they were permitted this luxury speaks to the continuing lack of a fully comprehensive, state-sanctioned philosophy of mathematics. In another numbered list, Vucinich [46, pp. 70–1] identifies the following three major difficulties experienced by Soviet thinkers in trying to turn mathematics into a Marxist discipline:

(1) The study of the social roots of mathematics never progressed beyond a preliminary stage. No comprehensive Marxist explanation was developed for the evolution of mathematical ideas. Articles were published which trumpeted what Marxism might do for mathematics, but it was never done.

(2) Just as no theory was devised to take care of the external, social development of mathematics, so too was the internal development of mathematics through dialectical processes neglected. Marxist writers identified several pairs of contrasting ideas within mathematics (for example, infinity/finiteness, continuity/discreteness, differentiation/integration, Euclidean geometry/non-Euclidean geometry) but did not attempt to explain how any of these could be viewed as a dialectic, driving mathematical change.

(3) The mathematically untrained Marxist commentators simply put "more emphasis on the foundations of mathematics than they could handle" [46, p. 70]. This resulted in their consistently negative approach: they criticized perceived idealism but never suggested alternative, dialectical approaches.

We have seen in this section that, by the end of Stalin's life, Soviet Marxist thinkers had progressed little from their position at the beginning of Stalin's time in power: they still had no consistent Marxist interpretation of mathematics. In contrast, Soviet mathematicians had become rather adept at either avoiding philosophical issues or reshaping them to suit their own requirements. Abstract mathematics continued to be developed, though with caution: by way of defense, the wider applicability of more abstract theories was often reemphasized. Of Soviet mathematicians, Vucinich notes that "their recognition of dialectical materialism was a tactical concession rather than a substantive accommodation" [46, p. 71].

After Stalin

No less than in any other aspect of Soviet life, Stalin's death in 1953 heralded the arrival of a more liberal period in Soviet mathematics. Mathematicians continued in their presentation of mathematics as a "universal science", in which greater abstraction would lead to wider applications, but they became even bolder in this view: they no longer felt the need to pay lip service to dialectical materialism and explicitly demoted considerations of physical reality to a secondary position. It became possible for areas of mathematics to develop according to their own internal logic rather than merely in response to the often ill-defined "needs of science and society". In this way, for example, non-Euclidean geometry finally became entirely acceptable.

The point of view that many Soviet mathematicians had (cautiously) advocated all along now came to the fore: that Marxist philosophy should be adapted to the needs of modern mathematics specifically and to those of modern science more generally, rather than the other way around. This new, liberal view even allowed for a more rational appraisal of Western mathematics. By the 1960s many Soviet thinkers felt that a Marxist philosophy of mathematics needed to incorporate the more acceptable aspects of Western thought. Fanatical criticism of perceived Western idealism and the view that a Soviet philosophy of mathematics could only be built only upon the ruins of Western thought gave way to a more balanced, case-by-case judgement of Western mathematics. It was now felt that Soviet and Western philosophies could be reconciled. Some Soviet thinkers even believed that Western thought was drifting slowly towards materialism [47, p. 30].

The shift towards a mathematical science that was more open to ideas from the West was largely unhindered by Marxist thinkers, though some, such as Ernst Kolman, persisted in their objections, criticizing the idealism of Western mathematics and lauding the practical grounding of Soviet science. However, such isolated criticism did not deter Soviet mathematicians from seeking to reintegrate their discipline with the international mathematical community. Questions of mathematics and ideology were now the preserve of moderate

thinkers such as the mathematical physicist and loyal Communist, A. D. Aleksandrov [15, pp. 34–6].

Interest in the history of mathematics also grew, and the historical topics studied became broader in scope: rather than concentrating solely on Russian mathematics, more attention was paid to the development of mathematics in the wider world. The nationalist tendency to play up the independence and originality of Russian mathematics gave way to an interest in its place within international science.

This enthusiastic freeing of mathematical thought in the USSR was driven, at least in part, by the view that mathematics had just entered a new, third phase of historical development [47, p. 15]. It was felt that the first phase of the development of mathematics had lasted from ancient times until the seventeenth century and had been based upon the ideas and constructions of ancient Greek geometry and medieval Arabic algebra. The second phase saw the emergence of the notion of a function as being fundamental to mathematics. Finally, the third phase, beginning in the mid-twentieth century, was characterized by the growth of mathematics as a universal science: an abstract discipline in which it was increasingly possible to take in a range of applications with a single theory. It was noted that such a view of mathematics had first emerged in the nineteenth century (indeed, Soviet scholars credited Lobachevskii with its inception) but that it had become a central theme of mathematics only in the twentieth. An important part of "universal mathematics" was the search for "structural unity", where the term "structure" was used in the sense of Bourbaki [7]. It was felt that such an approach enabled mathematics to make qualitative statements about the world rather than merely quantitative ones. The scope of mathematics was thus broadened [47, p. 15].

The acceptance of a structural approach to mathematics, in which such notions as groups, vector spaces, and universal algebras become key, implicitly signalled the acceptance of the axiomatic method, which had been under fire from Marxist philosophers for so long. In the end, it was the success of the method that assured its place within Soviet mathematics and that fended off any residual criticism from the ideologues. A similar development took place in connection with cybernetics. From having been a discipline that was regarded with suspicion in the late 1940s and early 1950s owing to its close links with mathematical logic, which was itself deemed to be too far removed from reality to be acceptable, cybernetics caught the imagination of Soviet scientists from the mid-1950s onwards. Research in this area accelerated where it had been impeded before, and it gained the support of many prominent Soviet scientists—not just mathematicians, but also people in other disciplines, such as biology. Some criticism continued, but it had little impact; as Vucinich puts it, "Philosophical skepticism quickly retreated before the grand promises of cybernetics" [47, p. 17]. Indeed, cybernetics came to be seen as lending support to dialectical materialism, given its ability to provide scientific descriptions of information processes. Cybernetics thus became a heavily state-sponsored science; party leaders looked forward to the benefits to society that increased automation would bring. Some were keen on the idea that what had once been a "bourgeois science" was now being used to achieve communist goals [47, p. 20]. However, as a "party science", Soviet cybernetics eventually became intellectually rather shallow; see [15].

The growth not only of the theoretical side of cybernetics but also of the practical development of electronic computers meant that mathematical logic in turn became a respectable subject. More than this, its admittance to the Soviet mathematical canon was seen as crucial by some thinkers: as set theory became more acceptable, Marxist philosophers began to worry about various set-theoretic paradoxes, which it was felt only mathematical logic could resolve.

As Vucinich comments, in the decade following Stalin's death, "[Marxist] philosophers lost their right to criticize Soviet scientists either on scientific or on philosophical grounds" [47, p. 32]. Instead, they addressed their writings to a more general audience and did their best to adapt dialectical materialism to modern mathematics. Where criticism of Western mathematics did occur, it now tended to be more restrained and also more specific: by this stage, Marxist philosophers seem to have been more conversant with modern mathematics [47, p. 32]. The harassment of scientists (at least on scientific grounds) came to a halt, and by the 1980s, for example, the previously maligned work of N. N. Luzin had been reevaluated and was recognized as an important Russian contribution to mathematics. Nevertheless, scientific freedom did not mean social freedom. The young dissident scientists who, beginning in the 1960s, called for constitutional free thought in the USSR would not be satisfied until the era of *perestroika* in the 1980s.

Concluding Remarks and Suggestions for Further Reading

We have seen how the attempts of Soviet ideologues to construct and enforce a consistent Marxist philosophy of mathematics were ultimately unsuccessful. When approaching this area for the first time, it is difficult to understand how a subject about which

so much was written and to which a great deal of thought was evidently given could apparently end in failure. In fact, in some ways, it did not. Ideology never went away, but instead became less dogmatic and was increasingly adapted by both mathematicians and philosophers to the needs of modern mathematics. Ideological debate existed between mathematicians, and, as noted in the introduction, mathematicians were even able to make careful use of philosophical language to advance their agenda for the "cybernetization" of science. Since this is far too intricate a topic to tackle here, I refer the reader instead to [15].

As noted at the beginning of this article, there are many sources available on Soviet ideology of mathematics and of science more generally. Besides those cited throughout the text, some useful general references are: [19], [26], [4], [24]. For a critique of Soviet science from the inside, see [35]. See also [10] for a guide to further sources on the development of mathematics in the USSR. For other ideological issues, see [13], [14], [15] on Soviet cybernetics; [36] on cosmology; [40] on probability; and [8], [23], [27] on physics. At the time of this writing, one of the most up-to-date sources on Soviet ideology of mathematics is [20], which tells the personal stories of D. F. Egorov, N. N. Luzin, and P. A. Florenskii. The situations of individual scientists are also related in [27] and [2], for example. Life for mathematicians under the later Soviet regime is described in [16].

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