

The publication of the *Physics Encyclopedia* has been completed

Physics Encyclopedia Vol. 1 (Moscow: Sovetskaya Entsiklopediya, 1988) 704 pp; Vol. 2 (Moscow: Sovetskaya Entsiklopediya, 1990) 703 pp; Vol. 3 (Moscow: Bol'shaya Rossiiskaya Entsiklopediya, 1992) 672 pp; Vol. 4 (Moscow: Bol'shaya Rossiiskaya Entsiklopediya, 1994) 672 pp; Vol. 5 (Moscow: Bol'shaya Rossiiskaya Entsiklopediya, 1998) 704 pp.

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An important event in the scientific side of life in Russia took place relatively recently, at the end of 1998. Without risk of exaggeration, I will even classify it as a major event in the cultural life of the country. The publication of the 5th and last volume has completed the project of creating the *Physics Encyclopedia* (Moscow: Bol'shaya Rossiiskaya Entsiklopediya, 1998)¹. The first volume of the *Physics Encyclopedia* (PE) appeared in 1988. The publishing house was then named differently — the 'Sovetskaya Entsiklopediya'. The next three volumes were produced according to plan: one every two years. The fourth volume arrived in 1994, in fact against tremendous odds. The change of name of the publisher is shown already on the title-page of volume 3 — it was published by 'Bol'shaya Rossiiskaya Entsiklopediya'. Four years separate the publication dates of volumes 4 and 5. The factors that caused this delay are plainly obvious. Everyone involved in the creation of the PE, and even more so the readers many of whom possess the preceding four volumes, were anxious about the future of the project. The absence of one volume out of five does not merely reduce the value of the set by 20% but virtually nullifies it. True, 80% of all the entries are found in the other four volumes. However, in any encyclopedia most entries, and especially spacious review-type articles, refer the reader to entries elsewhere in other volumes — the PE is no exception. Many times in recent years I sadly realized, opening the incomplete PE, that I sorely missed volume 5. Furthermore, the last volume contains an important summarizing reference material. Now everything is in place. We can access all the data that the physics editorial board wished to give the reader. And the PE is now accessible for evaluation — for both criticism and praise.

As was emphasized in the preface to volume 1 of the PE, the publication of encyclopedic literature on physics has appreciable traditions in this country. The *Physics Dictionary* was published in 1936–1940, the *Physics Encyclopedic Dictionary* in 1960–1966 (both in five volumes) and the one-volume abridged *Physics Encyclopedic Dictionary* appeared in 1983–1984.

In the same years, a series of three 'small' encyclopedias were printed. The series was opened by *Quantum Electronics*

¹ The encyclopedia contains entries for about 13,000 terms, of which about 4000 are specially written articles; the subject index is also in Vol. 5 (pp. 692–757).

(editor-in-chief A M Prokhorov, scientific editor S M Shapiro). It was followed by one-volume *Space Physics* (editor-in-chief S B Pikel'ner, scientific editor Yu N Drozhzhin-Labinskii) and *The Physics of Microscopic World* (editor-in-chief D V Shirkov, scientific editor N G Semashko). This list shows that encyclopedias were prepared in a continuous fashion. Nevertheless, the 30-years interval that separates the arrival of the fifth volume of the PE from the closing date of publication of the five volumes of the *Physics Encyclopedic Dictionary* is a conclusive sign of the importance for the PE event. Multivolume encyclopedic sets are snapshots of the changes that have taken place in physics. Physics' priorities did change in this interval. Most attention in the late 1930s (at the time of the first edition of the *Physics Dictionary*) was directed to radiophysics, in the 1960s — to nuclear physics, plasma and solid state physics, including the physics of semiconductors. Finally, in the 1980s and 1990s physicists were tuned especially to the events in laser physics, astrophysics and cosmology, and at the other end of the 'distance scale' — to the world of elementary particles. This inevitably affected the contents of the PE.

The scientific space to which all encyclopedic publications are targeted, including the PE, is not limited to Russia. The Russian language was and, in my opinion, still remains the language of scientific communication for all those who have lived within the former Soviet Union. Moreover, the Russian language was more than the language of the official international scientific communications between scientists within the so-called Socialist Commonwealth (the semiofficial 'socialist camp' was a better reflection of the actual relations between member countries). Most physicists from these countries were trained on textbooks and monographs published in Moscow and Leningrad. Many of them went for traineeship in the scientific centers of the former USSR.

The PE is definitely the product of intense work of the physics editorial department of the 'Bol'shaya Rossiiskaya Entsiklopediya' publishing house. The concluding 5th volume lists the staff of the editorial department. It is nice to find *all* the staff members, not only those who prepared the last volume. Three editors-in-chief headed the department during the time of publication of the PE: D M Alekseev until 1990, Yu G Rudoĩ from 1990 to 1995, and R Z Durlevich from 1995 onwards. It is just as clear that the PE is a creative result of the work by a large team of professional scientists. The scientists' team was shaped gradually. Authors were assigned different roles. Some are *ad hoc* participants that the editorial staff attracted for writing an entry or two. Such authors are, I think, a minority. There exists (or existed) a group of permanent authors. Finally, there were consultants and members of the editorial board. We immediately notice that both the consultants and the members of the editorial board (the respective lists of the two groups are given) were at the same time permanent authors of entries to the PE. All these years Academician A M Prokhorov was the chairman of the editorial board (and also of the Science and Editorial Council of the publishing house).

The concentration of scientific organizations in the ‘capital’ cities naturally resulted in the majority of authors representing Moscow and Leningrad (St.-Petersburg). But we also find authors from Khar’kov, Kiev, Novosibirsk, Tbilisi, Minsk, Kishinev...

Physics is a very dynamic field of science. New facts that must find their way into the PE appear virtually every day. On the other hand, physics abounds with a huge amount of scientific material accumulated over centuries, and the PE cannot go without this. Classic and modern physics are to be found and actually find their places in the pages of the PE. One might think that authors must accordingly be of two types: those who teach physics and those who do active physics research. However, this separation between teaching and researching physicists is known to be very crude. As far as articles on modern physics topics were concerned, the unbending rule applied by scientific editors to the choice of authors was for the author to be one of the creators in the field. This requirement was the main force behind widening the geographical distribution of authors. The participation of non-Moscow and non-St. Petersburg authors only made the work more complicated for the editors (exchange of letters instead of arranging a meeting) but the wish (or need) to commission an article from beyond the former Soviet Union created enormous hurdles, owing to the closed nature of the socialist society of the time. Nevertheless, some scientific editors tried very hard and sometimes involved an author from abroad. For example, a well-known Harvard professor N F Ramsey co-wrote a large and very substantive article “Molecular and atomic beams” for the PE.

The physics editorial department and the entire Encyclopedia Publishing House kept close ties with scientific establishments outside Moscow and Leningrad, and not only by inviting scientists from research centers in other cities to contribute PE entries. The physics editorial staff not only shared their accumulated experience with colleagues in publishing houses in Ukraine and other republics of the former Soviet Union but also attempted to involve all research teams of the country in discussing the planning of encyclopedias and in compiling glossaries that would serve as synopses of the future publications.

It is therefore relevant to mention, when discussing the completion of the PE, that in 1998 the 2nd volume of a two-volume encyclopedic dictionary *Solid State Physics* was published in Kiev (Kiev: Naukova Dumka, 1998). This encyclopedic dictionary (ED) was published in Russian. Its first volume appeared in 1996 but the work on it must have started sometime in the 1980s. The Kiev encyclopedic dictionary complemented the series of thematic scientific dictionaries that was outlined above. The ‘family tree’ connecting the Kiev and Moscow publications manifests itself, among other things, in the gratitude to A A Gusev, expressed by the editorial department of the Ukrainian ED when listing the members of the editorial board who did not live to see the encyclopedia completed. A A Gusev was for many years the deputy of A M Prokhorov who chaired the editorial board of the PE. Gusev never sat on the editorial board of the ED but the brief “Editors’ introduction” that opens the ED (Vol. 1, p. 5) assesses his role as very important: “...[Gusev’s] consulting was a master class in the art of creating encyclopedias”.

A publication that takes many years to mature will most inevitably see some of the people who informed the project depart to a better world. The lists of members of the editorial

board and its consultants make sad reading. Eight of the 19 members of the editorial board are now dead: A S Borovik-Romanov, B K Vaĭnshteĭn, S V Vonsovskii, I I Gurevich, A A Gusev, D N Zubarev, B B Kadomtsev, I S Shapiro — nearly a half! They all played exceptional roles in the creation of the PE, and not only as the organizers of the project but also its authors. They wrote some fundamental articles (each in their respective field) that defined the forming, the structure and the contents of large branches of physics in the PE (A S Borovik-Romanov — antiferromagnetism, B K Vaĭnshteĭn — crystallography, B B Kadomtsev — plasma physics, etc.). One of those who generated the idea of creating specialized encyclopedic volumes of physics, R Ya Shteĭnman, also died too early to see the completion of the PE. He was the first head of the physics editorial department. R Ya Shteĭnman not only assembled the editorial staff and hand-picked scientific editors, he also tried to work out the unified criteria of treating articles from different fields of physics — which is one of the toughest tasks, ideally implemented by the editorial department via scientific editors, consultants and a respected editorial board (see below).

The opening creative step in the work on any encyclopedic publication, and this is of course true for the PE, is the building of the Glossary that includes all the terms that will become the entries of the final encyclopedia. The terms are not arranged alphabetically in the Glossary but obey the order that reflects the structure of physics as a science. Furthermore, the entries in the Glossary are ranked: from review-type entries that describe an entire field, to short definitions that contain references to more detailed entries. The Glossary is created by scientific editors, consultants and invited authors. Generating the Glossary and deciding on the right size of entries are difficult, genuinely creativity-demanding tasks which require from the participants of the project not only the knowledge of the subject but also the ability to oversee the future volumes in the mind’s eye (I write this knowingly since I had greatest difficulties trying to be useful at this stage of creation of the PE and of other encyclopedic publications). The editorial department tried to involve the maximum possible number of the best-qualified physicists. The draft of the Glossary was forwarded to the leading research centers of the country and readers’ conferences were organized there. Responses to questions and proposals were summarized and discussed. If necessary, corrections were made in the project. The next step was to write all entry terms in alphabetic order and distribute them over volumes, taking into account the projected sizes of entries and entire volumes. This would create the outline of the encyclopedic publication — what we referred to above as its synopsis.

The Glossary is an extremely important document. It served as a guide for commissioning of articles, for determining the required deadlines for submission of articles by authors, and dictating the rate with which the team had to work on their texts. This ‘bureaucratic order’ is undoubtedly inevitable. Now imagine (and those who took part in the work, please recall) the feelings of an author who was to write an article explaining a term mentioned in a review article which, owing to the dictatorial power of the alphabet, had not yet been written and furthermore not commissioned; and how this article could be evaluated by the scientific editor or the refereeing consultant who read the article in question. It is all right if they shared the same idea of the future review article, but what if their points of view (on the review article that did

not yet exist!) were different? The opposite situation is also possible: some time after a volume has been printed the situation in a field of physics has somewhat changed. The review article on this field has already been published. A new term that has been coined recently (or perhaps forgotten when the Glossary was being compiled) should have been included in a volume that has already been published (again tricks of the alphabetical ordering!). One has to search for a stratagem to name a phenomenon or property in such a way as to add the entry without violating the alphabetical order.

It should be emphasized that, in my opinion, the editorial department was generally able to handle such difficulties well. Without hunting for examples, I can recall one case of undoubted shifting of an article: the article on *high-temperature superconductors* was given the title “*Oxide high-temperature superconductors*”. In reality, the title thus invented made searching for the article difficult. I have deliberately painted the situation in dramatic colors but the problems due to the alphabetic ordering of terms in a multivolume publication always existed and will haunt the creators of any new encyclopedic work.

Encyclopedic publications are never tied to important discoveries but any new encyclopedia makes (or is intended to make) a record of all important results that had been obtained after the issuing of the previous edition. In this sense each novel encyclopedic work creates a summary of the field and becomes a new frontier. Ideally, there must exist an attitude that states: physics today is what you find in the PE. Indeed, its creators make an effort to select, and do select all known facts (both experimental results and theoretical constructions) that have withstood the test of time. It might seem, therefore, that the PE could pretend to embody and enact the physics paradigm of its time.

When people are in doubt about the spelling or usage of a word, the ultimate authority is the last edition of a dictionary (of the type relevant to the query — explanatory or orthographic): what the dictionary writes or explains, goes. Can the PE play the same role in physics? Unfortunately, it can not. The reason is that physics changes much faster than languages. It leaves the PE naturally lagging behind: some *already* important facts are not *yet* in it while other facts that seemed impeccable yesterday are in doubt today. Furthermore, most physicists, if asked “What is physics?”, will insist that it is what physicists are doing *today*, what has *not* been included in the PE, but what has been included is archaic: it is physics’ yesterday. Despite its respectful age (more than 400 years if we start with Galileo Galilei), physics is a young area of science, very much alive, and it essentially cannot be turned into a dogma by ‘herding’ it into an encyclopedia. In a situation like this, the selection of the material and its assessment become an especially important criterion for any encyclopedic product. The reader must be informed of a doubt if there are grounds for a reasonable doubt about a result. The reader must feel that the compilers do not turn physics into a dogma, that they treat physics as a growing science which has not exhausted its potential and also that the last decades confirm this, as those preceding them did.

The other side of any physics encyclopedic publication is (as I have mentioned above) to fix the ‘grains’ of absolute truth unearthed by the labor of physicists over the centuries of existence of their branch of science. This means fixing what cannot be changed or invalidated by the further progress of physics. The word ‘grains’ is put in quotes since it is not easy to apply this term to the known laws of physics that describe

the motion of matter on the infinite expanses of spacetime and at the same time allow us to understand the scenario of the evolution of the Universe on the whole as well as the structure of nucleons. In spite of its extremely dynamic nature, physics is a very conservative area of science. A most serious foundation must be created for reconsidering any of physics’ constituents. If this expression will be forgiven, physics is a compact science. Try to remove even a seemingly minor element and the whole structure crashes to the ground. This can also be noticed in the PE — in the numerous cross-references among its articles. This interlinking of articles shows that the unquestionable separation of physics into branches is a matter of convention: physics is a unified science.

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This article of mine belongs to the congratulatory type. I was stimulated to write it by the wish to mark an important and pleasant event. However, as I browse through the PE and read entries in the fields of physics that are far from mine or reread those articles that I authored, refereed or consulted on, I notice that the PE is not free of shortcomings. Of course, it would not be possible to referee the entire PE, even if limiting the scope to the vast (key) entry articles. This job could only be done by a group of first-class experts. Nevertheless, it would be appropriate to share a few remarks.

Not only careful reading but even cursory browsing of PE articles discovers a spread in the quality levels of entries. Some are very detailed, others very condensed; some articles are written in a language that drifts towards that of physics-popularizing brochures, while others are difficult to understand even to an expert in a not very distant topic. What *should be* the proper level of PE entries then? An answer to this question assumes certain knowledge of the level of readership of the encyclopedia. One should not forget, of course, that different readers apply various criteria to the PE. Some of them (may be sometimes) need the PE as a primer in a new field, others (or may be in a different situation) wish the PE to be the source of concrete, very special information. Ideally, the PE must satisfy both groups. The general ‘admission criterion’ for a reader of the PE is a general university-level physics and mathematics education, and this leaves a wide range for assessing and choosing the level of a specific article. The situation is somewhat alleviated by the correct feeling that the university background must and can help the reader to decide whether he or she is at a level to ‘crack’ the article of interest.

My experience (I was an author and a consultant for many years) tells me that the desire to set the unified level to all articles is doomed to failure. First, there are objectively less complex and more complex topics. Different physical theories require mathematical approaches of various levels of complexity. Experimental techniques have become much more sophisticated in the past few decades. To understand modern experiments, one needs to have a knowledge of electronics that was unknown to graduates in previous generations; quite a few classical experiments in physics were implemented with ‘string and wax’ equipment and can therefore be described without going into any technical subtleties. Nevertheless, it does seem to me that editors’ idea of the range of readers painted it wider than it really was (and is). As a consequence, scientific editors often tried, when working on an article, to somewhat lower the level, make the article simpler and easier to understand, sometimes even at the price of reducing the

amount of data or, if a theoretical paper was involved, paying the price of mathematical rigor of presentation. I should confess (this is an important confession) that not infrequently, after repeated and stressful discussions, altercations and mutual concessions, the article would definitely improve.

However (this unavoidable ‘however’!), I was always irritated by the *a priori* notion that existed among the editors that articles on solid state physics can be, and even should be, simpler than in other parts of physics. It may be regretful, of course, that the times will never return when solid state physics was one of the simplest fields in physics, based on theoretical tools that used either semiphenomenological, semiempirical concepts or the simplest model concepts of motion of microscopic particles in a solid body. The solid state physics of today possesses a profound and, one has to acknowledge, very complex theory which hardly suffers popular interpretations. Theory of phase transitions and cooperative phenomena or the theory of disordered systems are good examples. A great many experiments in solid state physics are at least as complicated as in other fields.

My lamenting about this underestimation of the level of complexity of solid state physics may not be only connected with the feelings accumulated from years of work for the PE. In fact, I was always ‘haunted’ by requests (and sometimes demands) to simplify papers on solid state physics whenever I tried to write about solid state physics for non-‘solid state’ people, and sometimes even to my experimentalist colleagues. “Can’t it be explained in simpler terms, by ‘a rule of thumb’?” was a frequent question. And I often had to answer that no, it can’t.²

We can compare the levels of entries that differ not in topics but in the place in the PE volumes. Browsing through the concluding 5th volume I noticed that it contains articles that, in my opinion, are disproportionately large and speak in a voice different from that in previous volumes (e.g., ‘Ergodic theory’, ‘Hubbard model’ and some others). I thought that a shift in the entry levels was perhaps caused by changes in the editorial staff. It became clear, though, that I was wrong as most of the principal contributions to the 5th volume were already in the editorial portfolio by the time the composition of the staff and their managers were last modified. What I say here about entries should not be regarded as objective evaluation. This is a remark that records my first impression.

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The five-volume encyclopedia needs some serious analysis. I wish to emphasize that no encyclopedic publication on physics was ever seriously refereed even though it would be difficult to overestimate the usefulness of a detailed critical acquaintance with its contents and the principles of structuring the PE. Obviously, only time will reveal the true significance of this latest edition of the PE for the progress of physics but an assessment by experts could come ‘ahead of time’ and help get an idea what this significance could be.

Whatever the result of evaluation, the PE is a component of our (Soviet, Russian) physics of the 1980-90s. This is what makes it an interesting object of study for historians of science. First of all, this is a chance to clarify what I referred to above as the physics paradigm, to understand what was the

legitimized (in a sense, dogmatized) paradigm. The availability of earlier, equally detailed physics encyclopedias may help us to fix the changes that the paradigm undergoes. Since the set of terms used by a science offers valuable information, a historian of physics will be interested in comparing the glossaries (the lists of terms) of encyclopedias published in different periods. Even such (relatively superficial) acquaintance with the publications would undoubtedly reveal a great deal of information.

Much importance was attached in recent years to the citation index. The CI may help in understanding whether the PE ‘is a participant’ in the advance of physics. In other words, is the PE cited in journal papers and how often? In my opinion, though, there is no tradition of citing encyclopedias. If necessary, people cite specialized reference publications.

The team of authors of the PE may be a telltale source of information. If the list of authors of the PE were compiled and carefully examined, it would show that many of them are currently working in the West, in research centers of highest reputation. Of these physicists, many (of interest is how many) naturalized in their new countries. The relatively massive outflow of high-class scientists has drastically changed the geographical distribution of the authors’ team of the PE.

The authors’ team is a very peculiar sample from an almost boundless swarm of research physicists. I tend to think that these authors are special in their extreme professionalism. This statement is justifiable because the PE’s authors typically publish in prestigious physics journals: *JETP*, *Physics of Solid State*, *Physics-Uspekhi*, and so on. It could be nice to find quantitative correlation between two subsets: the sample of PE authors and authors of prestigious journals. A stamp of the highest professionalism of PE authors is nowadays provided by the fact that many of them (how many?) work in very prestigious universities and research institutes in the West.

An important ‘detail’ must be kept in mind when analyzing the group of PE’s authors. Namely, Academician Sergei I Vavilov, who in the past was one of the chief scientific editors in the Sovetskaya Entsiklopediya Publishing House, set a tradition that when selecting authors, physics editorial department was to be guided only by work-oriented arguments. For many years scientific editors successfully stayed clear of the ill-famed personnel policy of Soviet-era structures of the type of staff management departments (notorious ‘otdel kadrov’). These departments played no or almost no role for author selection.

It would be interesting to select among the authors of the PE the members of the Russian Academy of Sciences and national Academies of other republics of the former Soviet Union and try to determine the role of the elite of the physics community in the creation of the PE. There is no doubt that full and corresponding members of the Academies did take part (see, for example, the remembrance list given above). Finer points would be of interest. How many authors (and what fraction of the total) are academy members? How many academy members (and what fraction of the total number of physicist members) are authors of the PE?

The participation in the creation of the PE or other encyclopedic publications as authors, consultants, referees — any nonstaff capacity — was very reminiscent of the Soviet-style ‘participation in community affairs’ but differed in its inherent usefulness. The infinitesimal remuneration

² I realize that sometimes my answer actually meant not “it can’t be done” but “I don’t know how” to explain it in a simpler way. I am quite certain, nevertheless, that my dissatisfaction with those who insist on solid-state physics articles to be made simple at all costs, is well founded.

(even compared with the wages) was absolutely out of proportion to the time and labor it demanded. Even though directors of some research institutes took part in the work on the PE (look again at the memorial list), I think that the participation of scientists in an encyclopedic project was practically never regarded by their colleagues as something adding to the professional standing of these scientists or the institute where they worked. I cannot recall a single case when an official characterizing description of a scientist mentioned, as a positive point, the authorship in an encyclopedic publication.

A considerable number of authors passed away before the PE was completed. A sad feeling creeps up on you when, having read an entry, you see the signature and realize that the author is unable to enjoy the praise or respond to a critical remark. A tradition demands that a posthumous publication of a book or review paper display its author's name in a black-bordered frame. This does not seem to be the case with encyclopedias. It is unfortunate that the concluding volume does not list the names of those who were gone before the last volume was ready. Worse still, the PE fails to give an authors' index! With all due respect to those whose names are listed on the title-page and its reverse (editor-in-chief, editorial board, scientific consultants, the staff of the editorial department and those among the technical support group of the publishing house who 'took part in preparing the publication of the encyclopedia'), the *true creators of the PE are its authors*. More is the pity that their names are lacking from the encyclopedia.

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The completion of the work on the PE is a cause of optimism. To be optimistic means, among other things, a wish to dream and to hope that some day the dreams may come true. The last part of this article can have "Dreams" for the title.

My dreams are naturally pulled toward the ground by the knowledge of the prevalent situation with the publication of science books. However, one wishes to hope — very much so — that effort will be applied and possibilities will open. That we will browse with interest news science editions that will look just as good as other books that catch one's eye on every today's bookstand. Future publishers of scientific literature must be aware of the fact that many of the books in bright dust jackets are truly good books. People obviously buy them otherwise they would not be printed. Perhaps people are waiting to be offered new science books; perhaps they fail to be published not because of the lack of customer demand but because of the organizational morass?

But back to the dreams. It would be wonderful if the PE was translated into English — the universal language of international communication between scientists. As far as I know, the PE is a unique product, without analogs in world scientific literature. The PE can be offered to the global physics community. I do think substantial interest will be shown.

Now I will attempt to formulate my principal dream. The five-volume encyclopedia has been printed, we have it. However, physics keeps advancing. New facts and new theories are born, and the attitude towards old ones changes with time. It would be wonderful if the encyclopedia was able to monitor the changes occurring in physics and these changes along with additional pieces were added to the PE, while the

undetected blunders were wiped out. The readers of the PE must be notified about any changes or additions by publishing a kind of bulletin.

The readers should not wait until a new edition of the PE is created.

Ancient wisdom says: 'The best is the enemy of the good'. I am afraid that the (current) impracticability of the dream of a permanently improving encyclopedia may distract attention from the main emotion of my article — the joy in the completion of the work of many years on the publication of the unique five-volume *Physics Encyclopedia* in Russian; physicists awaited this event many a year!

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Belmont, MA, USA

P.S. I am sincerely grateful to S M Shapiro for her critical reading of the first draft of this article and for a number of constructive suggestions which led to its substantial reworking. As I was writing this article, and especially when I was rewriting it, I recalled with pleasure and not without nostalgia the dozens of papers that I wrote under the skilled guidance of Sof'ya Matveevna Shapiro.