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New book on electrodynamics of magnetic materials

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The growth of any branch knowledge is accompanied by two complementary processes: generalisation, as a result of which the increasing number of facts, phenomena, and observations is combined in one system of explanations; and differentiation, which is separation of a branch of knowledge into more or less independent parts. In a sense, these processes resemble what happens in human society. Thinking about magnetism, I imagine an enormous country. Those who live there are specialists in magnetism. They have their own language. Their system of concepts is quite distinct: they have their conferences, own publishers, own literature, and even art. The 'pictures' produced by magnetic science specialists are immediately understood by their 'countrymen', but produce no emotion in those living in other 'countries', such as physicists who are investigating elementary particles. Large countries have a tendency to form federal structures and sometimes they also break up. Fortunately, this drive to independence in the scientific sense is bloodless. All signs indicate that a special independent region has evolved from magnetism and the citizens of this region are investigating hf properties of magnetic materials. One of the facts helping the emergence of such an independent region is the appearance of monographs which make it possible, without going back to the primary sources, to become acquainted with a 'independent' branch of knowledge. A G Gurevich's monograph *Ferrity na Sverkhvysokikh Chastotakh* (Ferrites at Microwave Frequencies), published in 1960 by Fizmatgiz, seemed to announce that a new sovereign region appeared in the map of science. In 1973 a new edition, expanded and significantly supplemented, of this book appeared under a new title *Magnitnyi Rezonans v Ferritakh i Antiferromagnetikakh* (Magnetic Resonance in Ferrites and Antiferromagnets). Quite recently (last year), A G Gurevich together with G A Melkov published a new monograph entitled *Magnitnye Kolebaniya i Volny* (Magnetic Oscillations and Waves). It can be used as a fairly detailed and objective guide in a country called 'High-Frequency Properties of Magnetic Materials'... .

Probably, the somewhat tiring analogy with the social and political geography would prompt the reader with one more picture: boundaries of the country and its external politics. The physics of hf properties of magnetic materials has relationships with radio engineering and instrumentation. This is a natural relationship and not invented in order to attract material support.

In May 1994 a traditional seminar on spin waves took place in St Petersburg; it is a regular event, organised every two years by the Physicotechnical Institute of the Russian Academy of Sciences. One must admit surprise: the sorrow state of Russian science did not prevent holding of this seminar. Moreover, many participants unable to obtain financial support of their institutes for attendance, were helped with the expenses of the trip by the organisers. However, I was particularly struck by a small announcement that one could buy the book by A G Gurevich and G A Melkov. Moreover, we were told where this could be done. A miracle indeed... .We are all witnesses to how literally the scientific book publishing is dying, although only 5 – 10 years ago it impressed the scientific world with the quality and number of published books. I think that we are underestimating the role that scientific books played (and should play) in our country. Who has counted how many future scientists in the countries of the developing world in the 'socialist' community were educated on books in the Russian language?

Recently, a young man went for postgraduate studies to the United States and, dreaming of return to the mother country at the end of his studies, visited Moscow as a guest. He went around the bookshops and sadly concluded: "What shall I do? How can I live and work in a country where no scientific books are printed?"

How the authors and the publishing firm 'Physico-mathematical Literature' of the Nauka Press were able to achieve this miracle, I do not know. However, the book of A G Gurevich and G A Melkov is now in my hands. It was not even bought, but given to me. I now look at the number of copies printed: it is 2000. Not bad at all. The collected works of I M Lifshitz *Elektronnaya Teoriya Metallov. Polimery i Biopolimery* (Electron Theory of Metals: Polymers and Biopolymers), published with the support of an American sponsor (John D and Catherine T - MacArthur Foundation) appeared in 680 copies. Therefore, the first words should be congratulations to the authors and the publishers.

What is this book I am reviewing? It consists of 462 pages and the list of references has 466 items arranged alphabetically (Russian references first and then those in foreign languages). At the very end there is an index to the references in which the numbers are arranged in accordance with the subjects (to my mind this is a novel feature and it helps in the search for specific items). Looking through the references I found omissions even in the cited review papers. What a pity! These review papers, not mentioned in this fairly detailed monograph, will be missed by many readers

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to whom they might be useful. The book consists of fourteen chapters and two appendices: Appendix I — ''Units and constants''; Appendix II — ''Demagnetising factors for an ellipsoid''.

The first appendix deserves separate mention: it gives all the quantities which are encountered in the subject in two systems (Gaussian and SI). The authors stress that they are addressing different readers: those concerned with fundamental science and those closer to technology... . The contents of the book support this impression. The book has many good drawings and graphs. Turning over the pages in the book we can see that there is a reasonable compromise between the number of formulas and words: the book can be read, but sometimes one needs to pick up a pen or a pencil.

The cover shows a rotating vector in combination with a resonance curve. Unless the memory fails me, this is the symbol used traditionally in the documents of the St Petersburg seminar on spin waves... .

What are these subjects which, combined together, are called traditionally 'hf properties of magnetic materials'?

First of all, we must explain the nature of the material equation relating the alternating components of the magnetic induction and magnetic fields, i.e. calculation (and, in the phenomenological approach, specification) of the magnetic susceptibility tensor. The components of this tensor include quantities (parameters) of fundamentally different nature: some of them describe mechanical undamped motion of magnetic moments and these are the frequencies of oscillations and the oscillator strengths; the others describe dissipation and damping of this motion, which are the relaxation times of frequencies. Calculation of these two kinds of parameters presents different tasks which are of different complexity. In calculation of the oscillation frequencies and the oscillator strengths the difficulties may arise mainly because of the cumbersome nature of the procedures; this is of course true if the structure of a magnetic material is known. In a macroscopic description we are justified in introducing magnetic sublattices: each of them has its own magnetisation (or magnetic moment per unit volume) and their vibrations determine the natural frequencies of the system. The solution of inhomogeneous equations of motion makes it possible to find the magnetic permeability of a body. Naturally, in this approach the fundamental expression is that for the energy of a magnetic subsystem. However, there is an almost generally accepted tradition of introducing the exchange, anisotropy, and Zeeman energies, which make it possible to use knowledge of the structure of a body (the number of sublattices, their symmetry) to deduce uniquely the expression for the energy. Then, a comparison of the exchange and anisotropy constant, which occur in this expression, with the experimental results allows us to determine uniquely the magnetic energy.

Calculation of the relaxation constants requires a more profound and in most cases a microscopic approach, because otherwise it is usually impossible to describe the interaction of oscillations (waves) with one another, with waves of different nature, with impurities, dislocations, and boundaries of a sample. It should be stressed that it is this interaction that is the cause of dissipative relaxation processes.

The knowledge of the magnetic susceptibility tensor allows us to solve electrodynamic problems specific to magnetic materials. Among them the leading place is occupied by those problems in which the gyrotropy of the magnetic susceptibility tensor is significant: this is a consequence of rotation of the magnetic moment about the effective magnetic field (the Faraday and other effects).

The hf properties should naturally include an account of the principles of devices and instruments in which specific hf properties of magnetic materials are utilised: they include waveguides and cavities containing gyrotropic media, etc.

Magnetic materials have specific nonlinear hf properties. Determination of their nature as well as description of, for example, frequency multiplication and conversion, paramagnetic resonance, etc. is gradually growing (and possibly has grown) into the most important part of the physics of hf properties of magnetic materials.

Among the nonlinear phenomena an important place is occupied by the interaction of magnetic oscillations and waves with oscillations or vibrations and waves of different nature. Like all the macroscopic bodies, magnetic materials contain phonons which are acoustic vibrations or acoustic waves. The interaction of magnetic vibrations and waves is separate and a very large chapter among those we are describing here. It has a special name: magnetoacoustics, when it is considered as part of acoustics of solids.

The 'geography' mentioned at the beginning of this review should take into account the points of view of different 'countries'. As in real geography, in the maps of science there are regions with double colouring so that it is not clear to whom this region belongs: the same investigations may be assigned to different departments. Magnetoacoustics is a striking example of this.

In ending this list, it is natural to stress that conducting media (semiconductors and metals) have hf properties so different from those of insulators that they should be treated separately. Perhaps one should stress that historically the studies of ferromagnets began with ferromagnetic materials (those belonging to the iron group) and investigations of antiferromagnets began with insulators. Undoubtedly this circumstance has affected our ideas on these similar but essentially different materials.

The reader of this review possessing the book under discussion can verify that the list is very similar to the description of the chapters of the book. I must admit that when I began to answer the question I set myself, I was planning to present my point of view of what I would include in the concept 'hf properties of magnetic materials' and then to compare my list with the chapter headings. Quite soon I realised that in general the points of view of the authors and my own were identical and this is quite clear from my list... .

A large part of the book is written at the 'macroscopic language' level: the magnetic moments of the sublattices are taken as the starting point and they are used to present the subject. But a microscopic description is also given. We first meet it in the Section 7.4 ''Microscopic theory of spin waves'' and then in Chapter 11 ''Spin–spin relaxation''. This is a very well written chapter which undoubtedly presents correctly the relaxation mechanisms, but in my opinion it would have gained if it had been written (and the book as a whole) in the same style employing the macroscopic terms. This is because, within the precision limits adopted in the monograph under review, the macroscopic and microscopic descriptions give identical results (naturally, provided the wavelengths of the waves

participating in these processes are much greater than the lattice constant; it appears that this is indeed true).

In the preface the authors include a paragraph which should serve as an apology or explanation of why certain topics were excluded. Prutkov warned a long time ago: "One must not try to encompass the unbounded". Nobody should reproach the authors for something they have omitted from this book. Especially, when the authors admit readily that "when decisions were made, [they] could not avoid to be subjective" (p. 7). However, when we become acquainted with the contents of the book, we can reproach the authors for the topics which are included and could have been omitted.†

First of all, this applies to Chapter 3 "Antiferromagnetism and ferrites", which occupies 33 pages, which is quite a chunk of the book! One could ignore antiferromagnets completely. It would seem to me that antiferromagnets are included for reasons of courtesy, to stress that the authors respect those working on antiferromagnetism. However, a little should have been said about ferrites and this was in fact done. But the most important thing that "... the fact that they ... behave as ferromagnets makes it possible to 'forget' their ferromagnetic nature" (p. 101) is stated at the end of the chapter, but in my opinion this should have been the basis of a short description. The space released in this way could have been used for other topics which were omitted to limit the size of the book.

I would have been glad if the hf properties of metals had been given more attention (this is undoubtedly my own weakness, the subjective view of the reviewer). On the other hand, instead of complaining about the briefness of Chapter 14 'Interaction of magnetic oscillations and waves with charge carriers', one should be pleased that this monograph has a section on conducting magnetic materials: in the two monographs mentioned at the beginning of this review there are no such sections.

In Chapter 12 "Magnetoelastic coupling" there is somewhat confusing and brief mention of the magnetoacoustic resonance. Much as been published on this phenomenon and thus more detailed discussion would be very appropriate.

Having begun to list the topics I would have liked to find in this monograph, I am in conflict with my advice given above: "Nobody should reproach the authors ...". Therefore, I will now stop these complaints, which — I must stress again — are largely based on my own predilections.

The remark with which I would like to end this review should, in my opinion, be of relatively general nature and should be useful in, for example, a new edition or translation of the book. The preface contains two comments of methodological nature. The first is that the "presentation is organised so that the complexity increases" (p. 7). Wrong! The book of Gurevich and Melkov is not a popular text. It is intended for specialists or those who should become specialists in the course of studies based on the book. A specialist should not learn from a monograph on hf properties or magnetic materials about the nature of ferromagnetism and antiferromagnetism or (even more so!) what are the actual values of the moments. It seems to me that the gradual approach is unnecessary. One should grab the bull by its horns and from the first page one should speak of the hf properties, starting with the ideas, notations, and scientific level of some source readily available to the readers. I would like to see this source to be Landau and Lifshitz's *Course of Theoretical Physics*. My first impression is that Landau and Lifshitz would be sufficient. Naturally, this does not mean that one should not refer the reader to other textbooks, monographs, reviews, and original papers. Of course, this is essential. And the authors indeed do this ... .

Instead of presentation of gradually increasing complexity, I am of the opinion that one should write a detailed introduction in which the 'ideology' of the book could be presented. This is a fairly delicate question. And I would like to be understood correctly. If we assume that the reader of this book is a radio engineer, an applied physicist, or a developer of new instruments and devices, then such a reader needs an explanation why he needs all that is given in the book and why he should not confine himself to handbooks with the necessary constants of the various materials. The monograph *Magnetic Oscillations and Waves* is not so much a book for radio engineers (for the best of them), as for physicists ... . If this is so (and I believe that the book under review is intended for physicists and that it is a useful book), then we might consider the following scientific test: let us compare the content of the book with papers currently appearing in physics journals. We then find that in the majority of the papers dealing with hf properties of magnetic materials (!) the discussion is no longer about what is written in the book under review (here, the key words are 'no longer'). The physics of the subject has moved on. The interest is now concentrated on hf properties near phase transitions, magnetic materials with a complex noncollinear structure, various fine quantum details (renormalisations, etc), low-dimensional systems, etc.

What am I saying now? That the book is obsolete? No! Without clear, precise, and reliable ideas on the behaviour of classical magnetic materials we cannot deal with the rare cases and the real complex situations. The very concept of the existence of such situations cannot be understood if we do not know that the attempts to use classical representations in some cases do not help such understanding (the reader, I hope, is clear that the words 'classics' or 'classical' do not mean limited to Newtonian mechanics). One more point: the semiphenomenological approach, which is essentially used throughout this book, has now fully recognised precision limits. Therefore, the results should not pretend to that precision which is sometimes encountered in modern quantum physics of solids (for example, in the quantum Hall effect). I did not find the authors exceed those precision limits. I am writing about this because I think that this should have been mentioned in the introduction (and it is not there). However, the main content of the introduction should have been the ideology of the presentation: what is this book about, which objects it deals with (their magnetic and not hf characteristics), and with what precision.

The book has no conclusions, either. It ends with the phrase: "Such an excitation has been observed in a film and in a wire" (p. 437). If the rest of the page had not been left blank, I would have thought that this is some printing error and the last pages have been lost. Unfortunately, this is indeed the end ... .

†Naturally one must include those topics the omission of which would have altered basically the contents of the book. This casuistic comment came to me when I reread the review. I must therefore stress that there are no serious omissions in this book.

The absence of "Conclusions" can be corrected. *Uspekhi Fizicheskikh Nauk* should commission a review from the authors on "Magnetic oscillations and waves: fashion and trends"... .

The last paragraphs of this review are suggestions, in a sense even dreams. They appear during reading of the book of A G Gurevich and G A Melkov, which is a good and useful book. Therefore, I cannot hide my belief that first there should be new editions of this book and then new books. And then perhaps the dreams of the well-wishing reader will prove useful... .