Interview with Igor E. Dzyaloshinskii

Irvine, California, 14-15 December 2001

Igor Dzyaloshinskii has been a professor of physics at the University of California - Irvine since 1992. A student of Lev Landau, Dzyaloshinskii began his career at Kapitza's Institute of Physical Problems, and subsequently became a founding member of the Landau Institute for Theoretical Physics, where he worked for more than two decades before moving to the United States. He has published papers on a wide variety of subjects in condensed matter theory. With A. A. Abrikosov and L. P. Gor'kov, he is author of the seminal textbook *Methods of Quantum Field Theory in Statistical Physics* (English edition, 1963).

IED

Could you tell me, just what are you interested in?

PoS

We are interested in your understanding of the interactions of quantum field theory with solid state physics beginning in the 1950s. We want to learn about your interpretation of the broad sweep of those interactions at the technical level, but at the same time we're also interested in hearing about your own training as a theorist, both beginning at the university and then as a student of Lev Landau, and your early collaborations with fellow theorists at the Institute of Physical Problems, and so forth. If it's all right with you, it would actually be nice to just have a few details about your early life and education, your family background, perhaps.

IED

Well, that will take a long time...

PoS

You were born in 1931, is that correct?

IED

Well, I would say that, unlike my colleagues you have already seen, I in fact came into science from the very bottom of society. My parents, my father...

PoS

Were your parents scientists as well?

IED

Oh, no, they were just simple people. Actually I was the first college-educated person in the whole family. And I even actually am not aware of my father's education at all, because you know, he was born, technically, in Russia, but it was in the nineteenth century, in Silesia, he was a Polish Jew. I am a mixture of Polish Jew and Russian.

PoS

But you yourself were born and raised in Moscow?

IED

Yes. In fact the real vernacular of my father was German, because he was born in Silesia, close to the border with Germany, and at that time in Jewish society, as far as I know, the vernacular was German (well, besides Yiddish).

PoS

But in your own family you did not speak Yiddish.

IED

No, but I learned German from my father. So in fact that was enough for me to pass all possible exams in high school and the university and that sort of thing. That's why I never studied English. But otherwise they were simple people. I do not know much about my relatives from the maternal side, because all of them left there, and so I never saw them. And on the paternal side my great grandparents were serfs. My great grandfather, he became a rich person. But being a typical peasant male of the time, he gave an education only to boys, and my line, the female line from my grandmother, they didn't get beyond a parochial school, and the same thing with my grandfather. He was a peasant boy from the same village.

PoS

How did they make their way to Moscow?

IED

Well, at that time, you know, in Russia -- that means the last quarter of the nineteenth century -- the land was still caste [i.e., people were classified according to "estate" (*soslovie*)].

PoS

But wasn't it difficult to obtain permits to live in Moscow?

IED

Oh, no, it was in Imperial times...

PoS

Yes, I realize, but...

IED

At the end of the nineteenth century, you do not need to have a permit to live there. You go to find a job. My grandfather, he became a metal fitter, and then he rose to foreman. In fact it was a streetcar depot. So actually I am the first, and it's funny, and the last in my family with college education. My cousins, they all graduated...[from vocational schools].

PoS

In middle school and high school, did you have teachers who encouraged you and said, "You should continue taking more calculus," or something like that?

IED

No, not teachers, certainly, but somehow I decided that I... Well, I knew fundamentals of calculus.

PoS

Before you went to university...

IED

In high school. I studied the book that was available, a calculus textbook for engineers. I tried to read more mathematically-oriented books, but it was hard. At that time epsilons and deltas were fancied, as you may already know, and that was hard for me.

PoS

Proof-oriented...

IED

Yes. These days it's impossible, now I cannot read modern mathematics, because they use the silly Bourbaki language. It's impossible to understand. These people, as far as I know, they have contaminated the training of American mathematicians. In fact I have heard about a special Harvard language now, and it's hard to read.

PoS

Now, may I ask... *{A minute or so lost to recording error. The topic was IED's student days at Moscow State University. The gist of the remarks was that the quality of lecturing was not terribly high. IED did not attend many lectures, and studied largely on his own. He passed Lev Landau's Theoretical Minimum in 1952 or 1953. When the recording resumes, the topic of discussion is the dean of the physics faculty, A. Sokolov, and then commentary on other MSU physicists IED did not hold in high esteem.}*

IED

...or they were absolute fools like Iakov Petrovich Terletskii [author of *Paradoxes in the Theory of Relativity*, and *Statistical Mechanics*].

PoS

Yes, Terletskii is an interesting case. I mean, did you have any dealings with him, or...?

IED

Yes, I did, well, I was supposed to attend his lecture course. He was famous -- there was a joke -- he could not memorize even a single line. What he was doing -- his style was this [*gestures to palm*]: he looks at his papers...

PoS

...to check the notes in his hands...

IED

Yes, like this. But the boards were all like this, so everybody knew. So it was a standing joke about him. I am not aware of a single result obtained by him.

PoS

Now, right in the period when you had completed your studies, you had gotten your diploma, and you continued your graduate studies at the Institute of Physical Problems, the curriculum at Moscow State University began to be influenced by the Academy of Sciences.

IED

Yes, but that's already after I left the university. I would say it happened around 1956. It was three years after I left, as a result of Igor Vasilievich Kurchatov, who was extremely influential with the higher-ups. He did it. But before that, it was... Well, they still gave a solid education, but... The physics was good.

PoS

So you never had to pass any exam on dialectical materialism, or...?

IED

Oh, yeah, sure, I passed early. Yes, certainly passed.

PoS

No problem?

IED

Well, but it was so easy.

PoS

A kind of ritual, but that's all...

IED

Passing was not a problem. First of all, I had two years of something like "History of the Party," or "Marxism-Leninism," then it was "Political Economy," then it was "Philosophy." And then I passed everything again to qualify for graduation.

PoS

But that was a mere distraction along the way...

IED

Yes, but that was not hard, it was easy. No, the lecturers there, they were simple people.

PoS

But was it a kind of social ritual you simply took for granted?

IED

No, no, I enjoyed part of it. I've read *Das Kapital*.Well, not all three volumes, but the first and part of the second. That's not bad.

PoS

Was it ever the case that people recognized you as being clearly a superior student, and thought, well, you might be a good candidate for the Komsomol [Young Communist League], or that...?

IED

Oh, no, I did not take part. I was a member of this Komsomol certainly; it was hard not to be. But I did not take part in activities.

PoS

"*Obshchestvennaia rabota*" ["social" or "public work"] and so forth?

IED

No, I always escaped it somehow. I realized, you know, there was a simple trick. If you were asked to do something, then the best way I found was, you do not argue with them, you simply say, "Yes, of course I will," and then you do not do it, and that was OK. But if you start to argue, then you will be reprimanded. It was OK. It's like everything in Russia, you do not argue. You simply... it's much easier not to do anything than to argue. Arguments were offensive, and eventually they might become "anti-party" or whatever. But not doing anything was OK, was not "anti-party."

PoS

So tell me a little bit about this period. You've already passed the Landau Theoretical Minimum, around 1952-1953...

IED

The first of the exams was in 1951. I finished everything in the fall of 1952, I believe.

PoS

Right, and it's not until 1957 that you formally received your *kandidatskaia* [Ph.D.]?

IED

Yes.

PoS

You don't encounter any problems defending your *kandidatskaia*?

IED

No, but the point is that this is where my Jewishness enters in, and in Russia I was a Jew by definition.

PoS

By passport designation?

IED

No. I was Russian, but moreover I'm a baptized Russian Orthodox, because the first thing my grandmother did was baptize me. My maternal part of my family, they were quite anti-Semitic, so when my mother married a Jew, it was quite, I do not know exactly, but the first thing my grandmother did, she baptized me. I am the worst combination, in fact. I was Jewish in Russia, and now I am Russian, say, in Israel. I realized when I was there, I am Russian there, not Jewish.

PoS

Your father was not observant?

IED

No. Well, at that time nobody was. In fact, to be honest, I know a great number of Jews, purely ethnic Jews, but I never met a single observant Jew in my life.

PoS

Could you expand a little bit more, it sounds like this period between 1953 and 1957 was rather unstructured. That is, you would go to seminars and colloquia, but...

IED

Well, no, because of my Jewishness, let's say. You know, after you graduate in Russia, well, specifically at that time, you were assigned a work place. In Russia it was mandatory. The rationale behind it was that education was free, but that means one has to work for society to repay its investment in one's education.

PoS

And your assignment was where?

IED

My assignment was, I work for two years in a construction engineering enterprise, like a materials scientist. The main thing was, you see, at that time, in 1953, to be precise, Landau was still engaged in defense work, actually he would have been involved in the H-bomb. I arrived at the Institute of Physical Problems in the fall of 1954. There was still some work in this defense work. Because of this I needed a clearance even to enter the institute. They would not admit a person without clearance inside. So in fact, it's funny, it's a miracle to me, too, but two years previously I had applied for clearance immediately after I graduated (and before accepting an assignment in the construction industry), but it arrived in two years' time. For two years I worked. In fact at that time I was almost sure that I would never get the clearance.

PoS

So during that entire time you were not able to go to a physics colloquium anywhere in Moscow?

IED

No, basically it was possible to go to the university, but not to any institute like FIAN [Lebedev Physics Institute of the Academy of Sciences], for instance, or the Kapitza Institute [Institute of Physical Problems], where Landau worked; they were closed. And then like a bolt from the sky, a clearance appeared, and then I became Landau's student in the fall of 1954. So I worked a year and a half in industry. Well, it was not bad. I'm rather like any Russian -- I'm absolutely adaptable.

I could easily imagine that I would live my life's possibilities... I simply could not imagine it was possible. I just applied for the clearance because Landau insisted that I should.

PoS

So Landau manages to get you registered as an aspirant [graduate student] at the Institute of Physical Problems?

IED

Yes, so then I enter it, and then basically...

PoS

What is the nature of your training at that stage?

IED

Nothing. Landau, he even... At that time, my idea was that I'd like to do particle physics, field theory. I did not know too much about this area, but I had read Richard Feynman's papers.

PoS

That's what I wanted to ask you, how did you first become acquainted with Feynman diagrams?

IED

By reading his article of 1948, or it was the article of 1950.

PoS

The *Physical Review* articles?

IED

Yes.

PoS

I mean, I think a Russian translation was available in...

IED

No, and basically there was a good review in Russian written by Vladimir Borisovich] Berestetskii. {*"Teoriia vozmushchenii v kvantovoi elektrodinamike" (Perturbation theory in quantum electrodynamics),* Uspekhi fizicheskikh nauk *46 (1952): 231-278.*}

PoS

Berestetskii was the one that was crucial for you?

IED

Yes.

PoS

That was on perturbation theory in quantum electrodynamics, that was *Uspekhi fizicheskikh nauk* from 1952.

IED

I knew this already before graduation, and in fact my diplomate thesis was -- I used in the simplest possible way Feynman diagrams to calculate the decay of V-particles -- at that time they were not called lambda, they were called V-particles. So I did this, easily. So that was my thesis. Then when I got this clearance and came to Landau, my idea was that I will continue in this way. But Landau...

PoS

He discouraged you?

IED

No, he was much more nasty to me. Well, first of all, I do not know how it sounds now, because he made an outrageously -- now you would call it outrageous -- he behaved like a male chauvinist pig, he made a sexist remark, of the sort that 'only women usually run after fashions.' The real men, they are doing what can be done, what has to be done. And then he said, "When you have your own ideas, come to me and I will discuss with you these ideas, but until then, I won't listen to field theory." And in fact that was the end of it.

PoS

Yet along the way, you did master the techniques of field theory.

IED

Yes.

PoS

What kinds of things were you studying in doing so?

IED

Well, I told you that I studied Berestetskii, and in parallel I read some Feynman articles.

PoS

And you also studied the textbook of Alexander Il'ich Akhiezer and Berestetskii [*Quantum Electrodynamics* (1953)]?

IED

No, no, at that time it was not written yet.

PoS

I thought that was the mid-fifties that it appeared.

IED

Yeah. I believe it was 1956 or 1957 or something like that, and so I did not read all of the book ever. It was a really good book, but my real teacher in this way was Berestetskii himself. I read his really good review in *Uspekhi fizicheskikh nauk*.

PoS

The one from 1952.

IED

Yes, and then in the funniest way, Evgeny Mikhailovich Lifshitz, at that time he did the work in 1955 on the theory of Casimir and Van der Waals forces. So he did it using the theory of thermodynamic fluctuations.

PoS

So he's the one who got you started on what eventually became your first published paper?

IED

Yes, well, it was not the first.

PoS

Well, you had an "Account of retardation in the interaction of neutral atoms" [*Soviet Physics JETP* 3 (1957): 977]. You submitted several at once.

IED

Again, there was a backlog of works. Basically, Lifshitz either could not finish it, or he did not know how to do it. He asked me, and it did not take a long time. So I did some technical work on superconductivity. It was rather mathematical work which I easily did ["On the stability of the phase boundaries between normal and superconducting states," *Soviet Physics JETP* 3 (1957): 980]. I think it was justifiably forgotten.

PoS

That was sort of an exercise proving that you could do the calculations.

IED

Yes, sort of. But then he asked me, you know Hendrik Casimir himself, he derived the force between two atoms at large distances using non-relativistic methods, and so actually it was not clear how he did cutoffs and that sort of stuff, because his calculations diverged. So what I did, what I consider my first real work, I derived Casimir's formula using Feynman stuff. And it was absolutely easy seeing directly that divergences were only in the self-masses... So I did this, and after this I switched to magnetism.

PoS

So it was in discussions with Lifshitz that you got interested in antiferromagnetism?

IED

Oh, no, Lifshitz never took that up. The topic somehow arose. Basically with Landau you were supposed to come up with your own idea, what you want to do. He was, I believe, like Arnold Sommerfeld, or something.

PoS

I was very struck by the phrase that you used in your essay from the *Recollections* volume ["Landau glazami uchenika" (Landau through a student's eyes) in *Vospominaniia o L. D. Landau*, ed. I. M. Khalatnikov (1988); volume available in English as *Landau the Physicist and the Man* (1989)]. You nicely summarized the challenge of self-presentation for the young theorist trying to prove himself to Landau. You said, "For the graduate student and aspiring theorist, the rigorousness of Landau's pedagogy consisted in the fact that the poor fellow had to act like he had never received instruction from anyone."

IED

Yes, yes.

PoS

I mean, that says a lot right there.

IED

Yes, and the point is, we learned how to understand, basically without benefit of explanation.

PoS

Yes, but without guidance? That's a severe standard!

IED

That was the hardest part of Landau's school. You attended the seminar, and fundamentally he would not give the reporter [on the day's topic] the opportunity to explain, because he was absolutely selfish. He used seminars for his own edification. He did not read anything, he only listened, and as soon as he understood, then everything stopped.

PoS

Do you happen to recall when you were first, what would we call it, "responsible reporter" at the Landau seminar?

IED

Oh, no, you see, at that time, well, I'm a stutterer now, but the older I become, the easier it is to control my stutter. At that time I could not speak at all [in front of the seminar].

I even could not defend my own Ph.D. thesis; I was not able to speak. At some point I found myself able to give lectures, and when I am speaking in front of an audience, I never stutter, because I know what to do, and I am in control. But at that time I could not. I was listening only. Or listening to discussions, because there was discussion. It was really the best school, but it was a hard school.

PoS

This is at a time when you are still a graduate student, and you've just registered at the Institute of Physical Problems. Landau, Abrikosov, and Khalatnikov begin publishing papers on Green's functions and field theory. What was your sense of the significance of those papers at the time? How did you understand them?

IED

I was terribly interested. At that time we were looking around at what's going on, what everybody was doing, and we discussed everything. It was exceptional. I suspect it was just the same thing as in the Bohr Institute. So the main thing was discussion, but not discussion at seminar time, like with Niels Bohr, but rather... So we discussed a lot among ourselves. You could not discuss with Landau, he would just give a short explanation, and that was it. Like Wolfgang Pauli. Once he said, "The only person in the world of whom I was afraid was Pauli." Because Pauli is known to have said once to Landau, "You should be ashamed, you should think for yourself," when Landau asked him why something was so.

PoS

"You yourself can generate the proper and correct answer."

IED

Yes, sure.

PoS

Now, of course Landau is famous for having been very sceptical about Hamiltonian formulations of quantum field theory in this period.

IED

No, but at that time he became convinced (it was about 1955, 1956) that this theory does not work, in the sense that it simply does not exist, because renormalized charges are zero, and that was the theory.

PoS

So what did your circle think about S-matrix theory? Did you do work with that? Did you feel like that was a useful technique perhaps? Or did that seem "without prospects"?

IED

No, but at the time who was able to do anything with it? There was simply not a single result besides all these infinite series of [Arthur] Wightman's articles on axiomatics, and that sort of thing.

PoS

But I mean, for instance, the work of Geoffrey Chew and Stanley Mandelstam.

IED

Yes, that was when Landau first got excited, that was basically with Mandelstam's work. And then there was the second work -- complex angular momenta (there was a second part), which eventually -- they were developed by Feynman: partons, and that sort of thing. But that was already after Landau's accident. But then we started to apply, we understood that in condensed matter theory everything is finite anywhere, so... But still we were educated in diagram summation and fundamentally we certainly knew Gell-Mann-Low renormalization, and we understand that the theory is renormalizable only when divergences are logarithmic. If you look at what we did, all our lives we were summing logarithms. Until my most recent work I never used the renormalization group (RG). I always wrote the same RG for slightly different charges, actually for [voltages?] and not for charges. That was what we were doing, and then we sum up in higher orders of bare charge times logarithm. Of course it was a first approximation to RG.

PoS

Before we move to issues in condensed matter physics, do you have any recollection of the international conference on high-energy physics in Moscow in 1956?

IED

Sure, I was young at the time, and I certainly did not talk to anybody, but I remember I saw [Freeman] Dyson. Dyson for us was the most exciting personage. I remember he came to Moscow directly from Finland, and there he somehow damaged his nose bathing in a pool, and he wore a bandage on his nose.

PoS

A very distinctive demeanor at a conference, I'm sure.

IED

So he was the most interesting person for me and for us, even though there were some older people there. But we were young and excited. "Summation" was our motto. We summed diagrams, we did not write RGs. And I never did. I always sum, and then you call it RG if you like. Because we were always summing logarithms -- it was RG anyway. So that's OK.

PoS

So at this stage you didn't pay much attention to, say, the 1955 articles of N. N. Bogoliubov and D. S. Shirkov.

IED

No.

PoS

Had you studied them carefully?

IED

Well, but I did not see anything specific. You write Lie group equations, OK, but... I understand that maybe for some particle physicists it was more exciting, but for us -- I certainly read it -- but it was never a working tool. RG became a working tool when it indicated it could not be derived from any field theory.

PoS

Could you expand on that?

IED

Well, I mean in statistics or whatever, like [Kenneth G.] Wilson started to do. But actually if you read his paper, the last one was, he derived equations for exponents using Feynman diagrams and stuff. He used the fact that [for] d=4 you have mean field theory, and then he interpolated. But it was OK if you do not go too far off. The main troubles are first, your fixed points could become unstable, and second, a new one could arrive from infinity of some step. But if you keep to this point, it's OK. His formula for exponents are good.

And then this math was extended to the utmost, I believe, by Zinn-Justin, this thick book. It's impossible to read.

PoS

It's a compendium, an encyclopedia.

IED

Yes. The main thing is, as soon as you know that there are exponents, who cares about what they are? That's what Wilson did. And he showed an outrageously simple way to calculate the first term in d-4, but the rest is... [*dismissive gesture*]. Obviously there are some exponents. It is still hard to measure them, because the closer you are to the transition, the more the uncertainties grow experimentally. I was never excited with calculations of exponents. In fact, what I did, my only real work in phase transitions, was when I found cases when there is not a single stable fixed point.

PoS

Are you referring to your work with A. I. Larkin?

IED

No. That's my only work on phase transitions, actually I would say. No, I did this, but that's OK. Actually there are two cases where fluctuations make the transitions first-order. There's liquid-solid, where fluctuations are, well, it's like field theory with an infinite number of components. And this one, the system has complicated enough long-range order. All of them, I was not able to prove all of them unstable. But I made a conjecture, and the late Louis Michel (Institute des Hautes Etudes)... He died, I think, last year. In fact, he started as a physicist, but then he turned more toward mathematics under the influence of the place where he worked. This institute is an analogue of the Institute for Advanced Study at Princeton. In fact it was modelled on that. And more and more it was heavily mathematized. But he proved the conjecture, in fact. My guess was that it is a topological fact, and indeed it was. So you look the complicated topology -- I wasn't able to, he did it, and he found a flaw: it's always unstable in this many-dimensional space. Well, you know already from the paper of [Lev Petrovich] Gor'kov, we started to apply this summation concept to 1D, and then we did it with Larkin, and with Gor'kov again.

{The papers referred to by Dzyaloshinskii are:

S. A. Brazovskii, I. E. Dzyaloshinskii, and B. G. Kukharenko, "First-order magnetic phase transitions and fluctuations," Sov. Phys. JETP 43 (1976): 1178-1183.

I. E. Dzyaloshinskii, "Character of phase transitions to a helical or sinusoidal state in magnetic materials," Sov. Phys. JETP 45 (1977): 1014-1022.

S. A. Brazovskii, I. E. Dzyaloshinskii, and A. R. Muratov, "Theory of weak crystallization," Sov. Phys. JETP 66 (1987): 625-633.

I. E. Dzyaloshinskii and A. I. Larkin, "Possible state of quasi-unidimensional systems," Sov. Phys. JETP 34 (1972): 422-427.

L. P. Gor'kov and I. E. Dzyaloshinskii, "Possible phase transitions in systems of interacting metallic filaments (quasiunidimensional metals)," Sov. Phys. JETP 40 (1975): 198-207.}