Ian Affleck and me

Masaki Oshikawa
(ISSP, University of Tokyo; former Killam Post-Doctoral Fellow at UBC with Ian Affleck for 1995-1998)

Very sadly, Ian Affleck passed away on October 4th, 2024.
UBC announcement: In Memoriam: Ian Affleck (1952-2024)

As many people know, he was very fit (he was a much better hiker than me, although I am significantly younger). So I did not expect that he would leave us so early when he was only 72 years old, but he was unfortunately losing his health in the last year.

He had substantial impacts on physics and the physics community, and perhaps I am the most benefited. Ian has been an inspiration in many ways and I miss him greatly.

I couldn't help but write down some of my memories. This note is incomplete and I will add more contents later. The last part is currently a random collection of photos.

My first encounter with Ian

I first saw Ian in April 1990, when I just started my graduate study. There was a workshop at the Institute for Solid State Physics (ISSP), University of Tokyo. I currently work at ISSP located in Kashiwa (suburb of Tokyo), but it was located in Roppongi in Central Tokyo back then. I was not affiliated with ISSP at that time, and I just went there for the workshop. It was mostly a domestic meeting but several overseas speakers, such as Maurice Rice and Yong-Shi Wu, were present. I remember well that there was a tall blonde, and bearded guy who spoke VERY FAST. He was talking about "A Current algebra approach to Kondo effect" which I didn't understand at all. But he left a strong impression on me. In fact he was Ian, but at that time I didn't know that I would become his postdoc 5 years later in 1995. The ISSP workshop was organized by Mahito Kohmoto and Hal Tasaki among others -- I also did not know that I would start working on spin chains thanks to Hal's lectures at Summer School later in the same year, and that I would join Mahito's group as a Ph. D. student in 1992. (My first advisor, Professor Takeo Izuyama, retired in 1992 when I got the M. Sc. degree.)

A Current Algebra Approach to the Kondo Effect

Univ. of British Columbia Ian Affleck

The kondo effect is studied using current algebra techniques which allow a separation of charge and spin degrees of freedom. An algebraic interpretation of the low temperature fi xed point is obtained. The Wilson ratio is shown to be the ratio of the specific heat for the total system to that of the spin sector which is expressed in terms of the conformal anomaly parameter of a Kac-Moody theory.

Abstract for Ian's talk at ISSP on 19 April 1990

taken from 物性研だより (ISSP Bulletin) July 1990 issue↓
https://www.issp.u-tokyo.ac.jp/maincontents/docs/tayori/tayori30-2.pdf

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目　　次

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It was perhaps not just me who did not understand Ian's talk. As far as I could see, the reception of his talk was not great. In retrospect, it was before the now famous Affleck-Ludwig theory of overscreened Kondo effect which demonstrated non-Fermi liquid behavior beautifully. In that workshop perhaps he was giving an alternative formulation of the well-understood Fermi liquid case reproducing the known results, as a start. Maybe the audience was not quite impressed because of this. (I might be wrong on this -- please let me know if you know better.) In any case, he was on the right track towards one of his famous achievements. But I didn't understand anything at that point, and did not talk with that fast-speaking tall blonde guy.

ISSP again in 1993

Ian came to Japan again in 1993, and also visited ISSP. I don't remember the dates, but I found the record of Ian's seminar at Yukawa Institute, Kyoto University on 2 November 1993, so perhaps around that time.
https://www.yukawa.kyoto-u.ac.jp/seminar/s16128

At ISSP Mahito Kohmoto was his host. I joined Mahito's group as a Ph.D. student in 1992, so this time I could talk to Ian. I think I gave a short presentation on my first paper (generalization of Kennedy-Tasaki transformation) for him, but perhaps he wasn't too interested. That paper would later become an important starting point of my work with Ian (see below), but I guess I didn't have time to discuss the magnetization process. I remember we went to a Chinese restaurant in Roppongi (around ISSP) with a (not so fantastic) view of Roppongi street and Tokyo Metropolitan Expressway Route 3 above the street.

One interesting thing I remember is the following. Ian was a renowned physicist, so many people wanted to talk to him, also at ISSP. There was a physicist visiting ISSP, and he caught Ian for a long time (I think I remember his identity but don't show it here) and didn't leave him. Ian looked rather annoyed, as he himself wanted to talk to Minoru Takahashi (Professor at ISSP until 2007) very much during his visit to ISSP. It was rare for Ian to look annoyed, but this was one of such occasions.

I didn't join his discussion with Takahashi, and I had no idea what it was about. However, I think I understood it later. In the following year (1994) Eggert-Affeck-Takahashi paper appeared in arXiv and was published in PRL. The paper was about the magnetic susceptibility of the S=½ Heisenberg antiferromagnetic chain – a very fundamental physical property of the perhaps the most fundamental system in quantum magnetism which is very relevant for experiments. For this problem, “Bonner-Fisher curve” was the standard for a long time. Bonner-Fisher studied the problem with a numerical exact diagonalization up to 11 sites which is rather small by today’s standard. But it was done in 1964(!) and perhaps one of the first successful applications of computational physics to quantum many-body problems. Anyway, “Bonner-Fisher curve” did capture several important features of the magnetic susceptibility as a function of the temperature, such as the broad peak at T∼J.

However, for the isotropic Heisenberg antiferromagnetic chain (which has numerous experimental realizations), while the low-energy physics is well described by Tomonaga-Luttinger Liquid (free boson field theory), there is a marginally irrelevant perturbation which affects the physics down to very low temperatures. Presumably Ian worked with Sebastian Eggert on the effects of the marginally irrelevant perturbation, and found the logarithmic corrections to the magnetic susceptibility which leads to its infinite slope near the zero temperature. Such a feature was (unsurprisingly) missed by Bonner-Fisher. So perhaps Ian wanted to discuss his findings with Minoru Takahashi, who is an expert on integrable systems. In fact, in the Eggert-Affleck-Takahashi paper, the field theory prediction is verified by the thermal Bethe Ansatz method developed by Takahashi.

How it started – Boundary CFT and Ising defect problem

While I was a student, I learned conformal field theory (CFT) with great interest. In particular, Yoichi Kazama (string theorist) gave a nice course on CFT over a semester. I also read Ginsparg's Les Houches lecture notes "Applied Conformal Field Theory" rather seriously. In fact I wrote a review on CFT and its applications to 1D quantum systems as my Master’s Thesis. At UTokyo all the students have to obtain Master’s degree before proceeding to Ph. D.; most students in condensed matter write the thesis based on original research, but it could be a review (to my knowledge most of Master’s theses in high-energy theory are reviews). Somehow I chose to write a review. But I did not know what problem in CFT I could work on as a research project.

While in Japan (shortly before going to UBC) I also figured out an alternative derivation of the universal scaling of the correlation length of 1D near-critical quantum Ising chain at finite temperatures, which was studied by Subir Sachdev.
https://arxiv.org/abs/cond-mat/9509147

My result at that time was just an alternative derivation of the result obtained by Subir, so I didn't bother writing it up as a paper. However, after coming to UBC I explained my argument to Ian. He was interested -- and immediately suggested that we could study a generalized problem of a defect line in the critical Ising model, which can be studied by a "folding trick" and boundary conformal field theory. I still remember vividly that all the

concepts and techniques I learned about CFT in Japan turned out to be useful for this project. This resulted in my first PRL (and Nucl. Phys. B) which are still often cited these days as among the first papers on "conformal defects".
https://arxiv.org/abs/hep-th/9606177 and https://arxiv.org/abs/cond-mat/9612187

VOLUME 77, NUMBER 13 PHYSICAL REVIEW LETTERS 23 SEPTEMBER 1996

Defect Lines in the Ising Model and Boundary States on Orbifolds

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(Received 24 June 1996)

Critical phenomena in the two-dimensional Ising model with a defect line are studied using boundary conformal field theory on the $c = 1$ orbifold. Novel features of the boundary states arising from the orbifold structure, including continuously varying boundary critical exponents, are elucidated. New features of the Ising defect problem are obtained including a novel universality class of defect lines and the universal boundary to bulk crossover of the spin correlation function. [S0031-9007(96)01226-4]

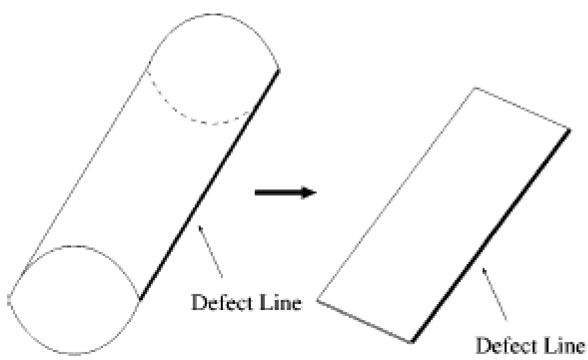

FIG. 1. The folding of the Ising model on a cylinder to a $c = 1$ theory on a strip. We fold at the defect line and also at the line on the opposite side. These lines correspond to the boundary in the folded system.

By the way, it was much later in 2019 that I finally wrote up the paper generalizing Subir's result to the defect problem. https://arxiv.org/abs/1910.06353

Magnetization plateau, Lieb-Schultz-Mattis theorem, and filling-enforced constraints

Also when I was a student in Japan, I got a very vague idea that intermediate phases might appear in the magnetization process of 1D quantum spin systems, based on my generalization of the AKLT states.
https://iopscience.iop.org/article/10.1088/0953-8984/4/36/019/meta

However I was quite confused about physics at that time and did not know how to make use of the picture.

Figure 6. Ferromagnetic Ising-VBS state.

I guessed this kind of state would appear in the magnetization process, but how? and what would it mean??

When I came to UBC, I explained my idea to Ian, and he immediately suggested that it should be related to Lieb-Schultz-Mattis (LSM) theorem. Our discussion resulted in a generalization of the LSM theorem as a filling-enforced constraint, which has become a central concept in contemporary quantum many-body physics.
https://arxiv.org/abs/cond-mat/9610168 and https://arxiv.org/abs/cond-mat/9701141

VOLUME 78, NUMBER 10 PHYSICAL REVIEW LETTERS 10 MARCH 1997

Magnetization Plateaus in Spin Chains: "Haldane Gap" for Half-Integer Spins

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(Received 16 October 1996)

We discuss zero-temperature quantum spin chains in a uniform magnetic field, with axial symmetry. For integer or half-integer spin, S, the magnetization curve can have plateaus and we argue that the magnetization per site m is topologically quantized as $n(S - m) =$ integer at the plateaus, where n is the period of the ground state. We also discuss conditions for the presence of the plateau at those quantized values. For $S = 3/2$ and $m = 1/2$, we study several models and find two distinct types of massive phases at the plateau. One of them is argued to be a "Haldane gap phase" for half-integer S. [S0031-9007(97)02624-0]

PACS numbers: 75.10.Jm

In retrospect, my confusion before talking to Ian was indeed very much related to fundamental issues in statistical physics, as I discussed for example at:

https://www.youtube.com/watch?v=eWdTXd1Aa_g

So I was extremely lucky that I brought a few very vague ideas which were not even half-cooked, and my "boss" gave the right clues on how to develop them (while paying me a salary🙂). I wonder if any other has had a similar experience.

Working with Experiments

Ian was always interested in understanding experimental results and making predictions testable by experiments. This was one of the reasons why he switched to condensed matter theory from high-energy theory. When I was in high school I loved to do some primitive experiments but my interest had shifted to theoretical physics. I had not analyzed any experimental results seriously before coming to UBC. Thinking about experiments was another thing I learned from Ian.

The most memorable experience related to experiments for me was the following. When I was at UBC, Ian invited Collin Broholm for a seminar. Before the seminar, he had sent us the title and abstract, which described very strange results. That is, they applied a magnetic field on a S=1/2 Heisenberg antiferromagnetic chain material (Cu benzoate), and found that not only a finite magnetization but also an excitation gap was induced by the applied field. https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.79.1750

VOLUME 79, NUMBER 9 PHYSICAL REVIEW LETTERS 1 SEPTEMBER 1997

Direct Observation of Field-Induced Incommensurate Fluctuations in a One-Dimensional $S = 1/2$ Antiferromagnet

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(Received 31 March 1997)

Neutron scattering from copper benzoate, $Cu(C_6D_5COO)_2 \cdot 3D_2O$, provides the first direct experimental evidence for field-dependent incommensurate low energy modes in a one-dimensional spin $S = 1/2$ antiferromagnet. Soft modes occur for wave vectors $\tilde{q} = \pi \pm \delta\tilde{q}(H)$, where $\delta\tilde{q}(H) \approx 2\pi M(H)/g\mu_B$ as predicted by Bethe ansatz and spinon descriptions of the $S = 1/2$ chain. Unexpected was a field-induced energy gap $\Delta(H) \propto H^\alpha$, where $\alpha = 0.65(3)$ as determined from specific heat measurements. At $H = 7$ T ($g\mu_B H/J = 0.52$), the magnitude of the gap varies from $0.06J$ to $0.3J$ depending on the orientation of the applied field. [S0031-9007(97)03950-1]

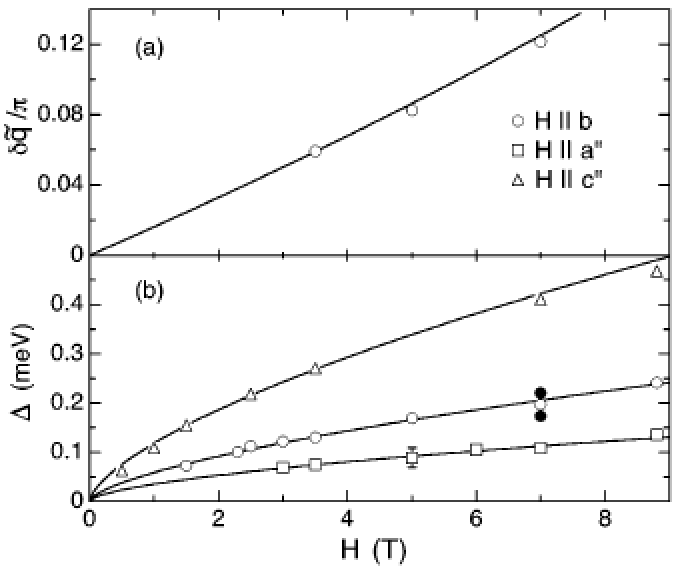

FIG. 5. (a) Field dependence of the displacement $\delta\tilde{q}$ of the incommensurate side peaks from $\tilde{q} = \pi$ in copper benzoate, as derived from fits to the data shown in Fig. 2. The solid line is the theoretical curve from Ref. [3]. (b) Field dependence of the energy gap derived from fits to specific heat data such as those shown in Fig. 4. Data for fields along the three principal magnetic directions are shown. Filled symbols are the gaps measured at $\tilde{q} = \pi$ and $\tilde{q} = 1.12\pi$ by neutron scattering. The solid lines are from fits to power laws described in the text.

This seemed to contradict with the well-established exact solution of the Heisenberg chain under the field (the system should remain gapless until the saturation at high field). By that time, I was familiar with the field-theory treatment of such systems, thanks to the study of the magnetization curve (or filling-enforced constraints) with Ian as I mentioned above. By analyzing the possible relevant perturbations, I came to a strange conclusion that the system must have a (transverse) staggered magnetic field, which breaks the U(1) symmetry so that the LSM theorem does not apply. But there can't be such a strange field in the real material! How can you possibly switch the direction of the magnetic field at an atomic scale?

I talked this to Ian but we were rather perplexed. Anyway, after the seminar talk, we mentioned this to Collin. Then we got quite an unexpected response --- he could indeed expect such a field, because the crystal structure is alternating along the chain. Namely, thanks to a staggered g-factor (and also a staggered Dzyaloshinskii-Moriya interaction as we found out later), the system acquires an effective staggered field which is proportional to the applied field. (At zero field, the system is basically like an ideal

Heisenberg chain but it is quite different under a finite applied magnetic field thanks to the highly relevant staggered field.)

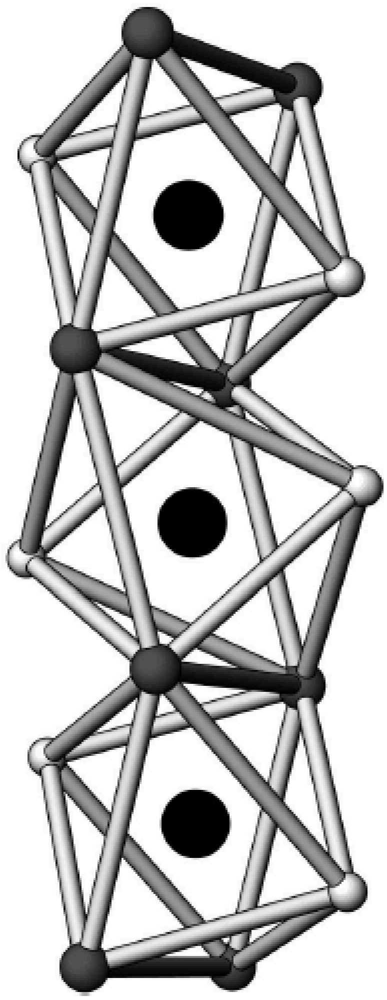

FIG. 2. Enlargement of crystal structure near a Cu (black spheres) chain with O atoms of H_2O (dark spheres) and those of benzoate groups (light spheres). Note that the oxygen octahedra have two different orientations on staggered Cu atoms.

Then the strange experimental results became rather natural. Ian derived the scaling of the gap on the blackboard during our discussion with Collin -- the gap should be proportional to the applied field to the power of 2/3 (with logarithmic corrections), and it agreed with the experiments quite well! (They estimated 0.65 from experiments, before knowing our ⅔ – not bad, eh?) Collin looked quite impressed -- it was also when I really felt the power of theoretical physics with respect to experiments.
https://arxiv.org/abs/cond-mat/9706085 and https://arxiv.org/abs/cond-mat/9905002

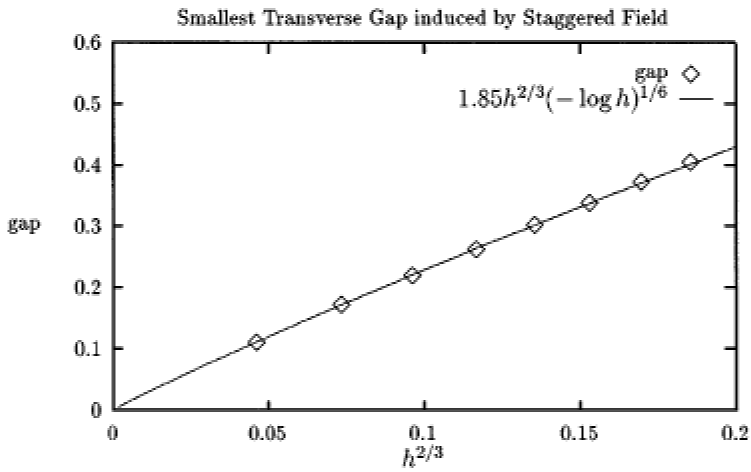

FIG. 1. The lowest excitation gap to $\sum S^z = 1$ sector in the Heisenberg antiferromagnetic chain, induced by the staggered field h. The gap is obtained by an extrapolation of finite-size gap by Lanczos method up to 22 sites. Both gap and h are measured in unit of the coupling constant J. The data are well fit by the field-theory prediction $h^{2/3}|\ln h|^{1/6}$, with a coefficient 1.85.

So, to some extent our theory of "field-induced gap" evolved from the magnetization curve/LSM project. The story did not end there. While we were working out details of the "field-induced gap" problem discussed above, we saw strange crystal axes in the experimental papers. Usually we see a, b, and c axes for a crystal, but there were also a' and c', and even a'' and c'' axes in the experimental papers on Cu benzoate. We again asked Collin about this, and were told that they were defined in old papers from Japan --- published in 1970s by the group of Professor Date, such as https://journals.jps.jp/doi/10.1143/JPSJ.33.1574

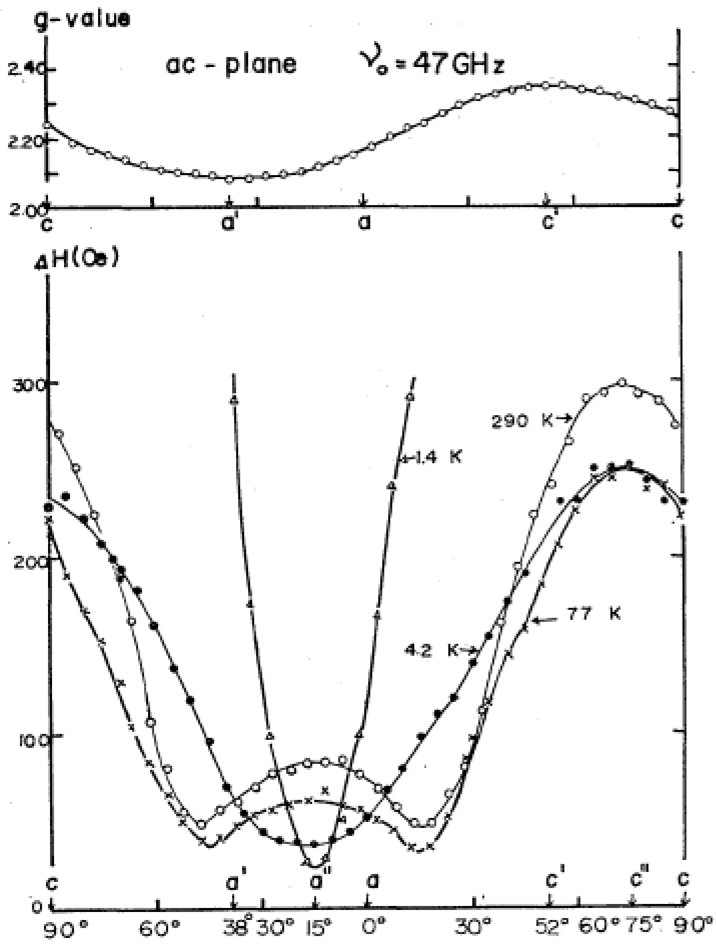

Fig. 2. Angular dependences of line width and *g*-value in the *ac*-plane at 47 GHz.

So I started to read those papers. Back in those days, I had to go to the library and take photocopies of printed journals. Fortunately for me, the UBC library had back numbers of Journal of Physical Society of Japan, in which most of those papers were published. Those mysterious axes were defined by Electron Spin Resonance (ESR) measurements -- the linewidth showed mysterious divergences at low temperatures, and it took the maximum for magnetic field applied in c'' direction whereas the minimum (absence of the divergence) was observed for the magnetic field applied in a'' direction. I did not know anything about ESR, but it was clear that there was no theoretical explanation for those experiments. We tried to develop a theory of ESR for 1D magnets based on field theory (bosonization). Actually there were many subtleties and we had to develop the theory carefully, but we managed to do that. It works beautifully both in the perturbative and nonperturbative regimes; the latter can be handled by the sine-Gordon effective field theory which is integrable. By the time we published the paper I had left

UBC to take a faculty position in Tokyo Institute of Technology (recently merged into "Institute of Science Tokyo"). But the project did start at UBC. Maybe our ESR theory is not known as much as other works outside the ESR community, but for me this is still among the most favorite works of mine.
https://arxiv.org/abs/cond-mat/9904199 and https://arxiv.org/abs/cond-mat/0108424

VOLUME 82, NUMBER 25 PHYSICAL REVIEW LETTERS 21 JUNE 1999

Low-Temperature Electron Spin Resonance Theory for Half-Integer Spin Antiferromagnetic Chains

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(Received 26 March 1999)

A theory of low-temperature (T) electron spin resonance (ESR) in half-integer spin antiferromagnetic chains is developed using field theory methods and avoiding previous approximations. It is compared to experiments on Cu benzoate. Power laws are predicted for the linewidth broadening due to various types of anisotropy. At $T \to 0$, zero width absorption peaks occur in some cases. The second ESR peak in Cu benzoate, observed at $T < 0.76$ K, is argued not to indicate Néel order as previously claimed, but to correspond to a sine-Gordon "breather" excitation. [S0031-9007(99)09424-7]

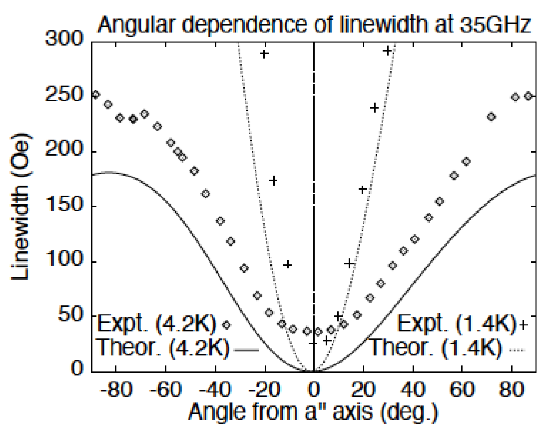

FIG. 1. The field-direction dependence of the ESR linewidth in the *ac* plane at frequency 35 Hz [6] compared to Eq. (9).

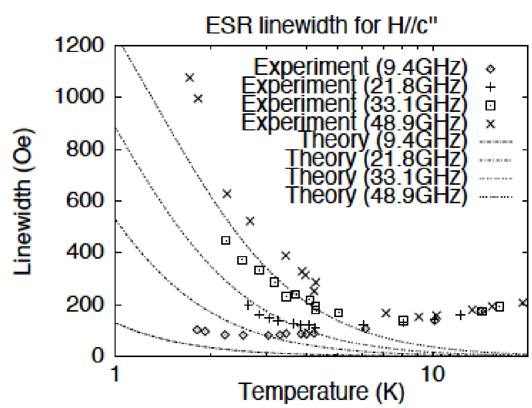

FIG. 2. The temperature and frequency dependence of the ESR linewidth for $H \parallel c''$ [6], compared to Eq. (9).

Santa Barbara

Logarithmic Corrections

Ian and computational physics

Ian's 2 years in Boston and Y-junction

Ian moved to Boston University in 2001. I remember one of his motivations was that, until around that time, the condensed matter theory group in UBC was rather small and he didn't have many people outside his group to discuss with. When I was a postdoc, basically Ian and Philip Stamp were the only faculties in (quantum) condensed matter theory. (There were also Gordon Semenoff who was in high-energy physics but also had some papers well-known in condensed matter, and Birger Bergersen in stat mech.) Not only BU had a larger condensed matter theory group, it is of course also close to so many good universities. As is perhaps common in North America, he took a leave of absence from UBC for 2 years. (Maybe it was initially one year and later extended to two, but I don't remember well). So within two years he had an option to go back to UBC. I remember asking him maybe a few weeks before the final deadline for the decision whether he would stay at BU or go back to UBC, and he was still undecided. Anyway, eventually he went back to UBC. The deciding factor perhaps was that Glenda (and perhaps Ian) liked Vancouver better — which is of course totally understandable even though Boston is also a great city. The condensed matter theory group at UBC has grown significantly since then, so I guess he was happy about the development after he returned to UBC.

I visited Ian at BU a few times. That was when I started the collaboration with Claudio Chamon and Ian on "Y-junction".

https://arxiv.org/abs/cond-mat/0305121

https://arxiv.org/abs/cond-mat/0509675

So anyone who is familiar with my scientific works to some extent can see that Ian was essential for my scientific career. Without him, I am not even sure if I would be still doing physics professionally, and even if I were, I would have done much much less. While I kept my collaboration with him even after I left UBC, I have been working less with him directly over years. However, much of my work originated from my discussions with Ian.

Of course the above are just what I did with Ian --- Ian did many more important things including baryogenesis, dynamical supersymmetry breaking, AKLT model, flux phase, boundary CFT solution of multi-channel Kondo problem, and "g-theorem" (conjecture) in boundary CFT to name a few. So needless to say, I benefited much more from him than the other way around, but I would be very happy if you can count some of our works as his achievements as well.

Hunting mattress

Ian was also a very kind person. I remember very well that, when I first came to Vancouver as a postdoc, he had kindly arranged a faculty/staff apartment for me. However, it was unfurnished, so he let me stay at his home for a few days. He drove me around and asked me to watch for garage sales. Initially I did not understand what he meant (I was less fluent in English, and perhaps I was not familiar with the concept of "Garage Sales" yet.) so he had to watch for garage sales while driving. Eventually I bought a bed (mattress) from a private seller --- maybe we found the ad in "Buy and Sell" (there used to be a printed newspaper specialized for private sales, before the era of "eBay"). Anyway, Ian carried the huge mattress to my apartment with his car.

Ian and Glenda were also so kind as to invite us to their home many times, and often we enjoyed barbecues.

Tattered Guidebook

He also loved hiking -- I remember he had a copy of the book "103 Hikes in Southern British Columbia" and it was very much tattered because he was using it so often! He took us hiking numerous times, and he was climbing hills so comfortably while I was struggling (so I still cannot believe that he left us so early.) I think he particularly loved Stawamus Chief (near Squamish, north of Vancouver) as he took me a few times over the years.

The photo of us taken at the top of Stawamus Chief in August 2015.

Skiing and Windsurfing on the same day

Maybe windsurfing was his most favorite hobby. Actually he once took me (and a few others) to try windsurfing. It was quite challenging for me --- it was rather difficult just to keep standing on the board. After that, he never suggested going for windsurfing again to me -- maybe he found my skill too poor for the sport 🙂 He told me that once he tried to ski in mountains north of Vancouver (perhaps Grouse Mountain?) in the morning, and do windsurfing in the afternoon of the same day in April. He was proud that he made it, but said he would never do it again as it was quite tiring.

Besides physics, I certainly learned from Ian how to enjoy the outdoors. Maybe my recent acquaintances regard me as an “outdoor person”, but I definitely was not, before coming to Vancouver. It was to some extent thanks to the environment (one of the most beautiful cities in the world, where you can ski and windsurf on the same day!) and also to the local culture in Vancouver at large. However I think Ian had the biggest influence on me, also in this regard.

I also learned that you can love and care for your family so much while doing great work; he always left his office to have dinner with his family at 6pm. Coming from Japan it was a fresh experience for me, although the culture in Japan has also been changing in recent years. (Sometimes I received e-mails from him in late evenings however, perhaps after spending some time with family after dinner.)

Ian's visits to Japan

2004: Sendai / Tokyo Tech / Hiroshima / Kyoto / Ama-no-hashidate / Fukui
2007: ESR workshop / Physics and Mathematics of Interacting Quantum Systems / Kyoto?
2016 (and more): Yukawa Institute

At the party honoring the retirement of Minoru Takahashi (with his wife to the right)
Kashiwa, Japan, May 2007

Ian had an impactful Eggert-Affleck-Takahashi paper on the magnetic susceptibility of the S=½ Heisenberg antiferromagnetic chain published in 1994. (See my note on Ian's visit to ISSP in 1993).

Vancouver, May 2009

After a bike ride to Steveston (Fisherman's village about 20km south of Vancouver)

Vancouver, Aug 2015

“30 years of AKLT: Interacting Systems in Low Dimensions” at UBC (April 2018)

Celebrating Ian’s lifetime achievements and his 65th birthday
https://aklt2018.qmi.ubc.ca/

My slides
https://oshikawa.issp.u-tokyo.ac.jp/Slides/AKLT30-Oshikawa.pdf

At the dinner for AKLT30 Symposium, receiving a gift and words from Marcel Franz

My Last Meeting with Ian (September 2022)

I visited UBC in September 2022 and met Ian.


GIRO