Jan Hendrik Schön scandal

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Main Source:

1. Report of Bell Lab Inquiry: REPORT OF THE INVESTIGATION COMMITTEE ON THE POSSIBILITY OF SCIENTIFIC MISCONDUCT IN THE WORK OF HENDRIK SCHÖN AND COAUTHORS http://www.alcatel-lucent.com/wps/DocumentStreamerServlet?LMSG_CABINET=Docs_and_Resource_Ctr&LMSG_CONTENT_FILE=Corp_Governance_Docs/researchreview.pdf

2. Wikipedia: http://en.wikipedia.org/wiki/Jan_Hendrik_Sch%C3%B6n

3. Physics today, eg: http://www.aip.org/pt/vol-55/iss-11/p15.html

4. Big trouble in the world of "Big Physics“ by Leonard Cassuto:

http://dir.salon.com/story/tech/feature/2002/09/16/physics/index.html?pn=1

Outline

- Before the scandal
- Allegation and investigation
- Aftermath and sanctions
- How to avoid scientific misconduct?

Biography

- Born in 1970.
- Ph.D. from the University of Konstanz in 1997.
- In late 1997, hired by Bell Labs.
- Field of research: condensed matter physics and nanotechnology.
- Briefly rose to prominence after a series of apparent breakthroughs that were later discovered to be fraudulent.
- In 2000 he had 5 papers in Science and 3 in Nature. (all first author)
- In 2001 he has published 4 papers in Science and 4 papers in Nature. (all as first author) Interestingly enough, he avoided PRL for some reason - only one first-author PRL.
- In 2001, he was listed as an author on an average of one research paper every eight days.
- He was a recipient of Otto-Klung-Weberbank Prize for Physics in 2001, Braunschweig Prize in 2001 and Outstanding Young Investigator Award of the Materials Research Society in 2002.

Before the scandal

- For more than two years, condensed matter physicists were enthralled by results coming out of Bell Labs, Lucent Technologies, where researchers had developed a technique to make organic materials behave in amazing new ways: as superconductors, as lasers, as Josephson junctions, and as single-molecule transistors. (Physics Today ran news stories on some of these topics in May 2000, page 23; September 2000, page 17; January 2001, page 15; and October 2001, page 19.) Increasingly, however, enthusiasm gave way to frustration, as research groups were unable to reproduce the results. Was the technique exceedingly difficult to master, or was something else amiss?
- In 2001 Schön announced in Nature that he had produced a transistor on the molecular scale. Schön claimed to have used a thin layer of organic dye molecules to assemble an electric circuit that, when acted on by an electric current, behaved as a transistor. The implications of his work were significant. It would have been the beginning of a move away from silicon-based electronics and towards organic electronics. It would have allowed chips to continue shrinking past the point at which silicon breaks down, and therefore continue Moore's Law for much longer than is currently predicted. It also would have drastically reduced the cost of electronics.

Allegation and investigation (I)

- Physicists from inside and outside Bell Labs called management's attention to several sets of figures, published in different papers, that bore suspiciously strong similarities to one another (see Physics Today, July 2002, page 15). Much of the suspicion focused on Jan Hendrik Schön, a key participant in the research and the one author common to all the papers in question. With a few exceptions, Schön had applied crucial aluminum oxide insulating layers to the devices, had made the physical measurements, and had written the papers. Moreover, the sputtering machine that Schön used to apply the Al2O3 films was located, not at Bell Labs, but in his former PhD lab at the University of Konstanz in Germany.

- In particular, scientists found the data seemed overly precise, and that some of it contradicted the prevailing understanding of physics. Professor Lydia Sohn, of the University of California, Berkeley, noticed that two experiments carried out at very different temperatures had identical noise. When the editors of Nature pointed this out to Schön, he claimed to have accidentally submitted the same graph twice. Professor Paul McEuen of Cornell University then found the same noise in a paper describing a third experiment. More research by McEuen, Sohn, and other physicists uncovered a number of examples of duplicate data in Schön's work. In total, 25 papers by Schön and 20 coauthors were considered suspect.

Allegation and investigation (II)

- According to Cherry Ann Murray, director of physical science research at Bell Labs, management had been made aware of some problems with Schön's work in the autumn of 2001, but at the time attributed the problems to sloppiness and poor record-keeping, not fraud. After learning this past spring about the similar-looking figures, Bell Labs management convened a committee to investigate the matter.

- In May, 2002, Bell Labs appointed Professor Malcolm Beasley of Stanford University to chair a committee to investigate possible scientific fraud. Malcolm Beasley of Stanford University headed the committee; serving with him were Supriyo Datta of Purdue University, Herwig Kogelnik of Bell Labs, Herbert Kroemer of the University of California, Santa Barbara, and Donald Monroe of Agere Systems, a spinoff of Lucent.

- Bell Labs released the committee's 127-page report in late September, 2002. The committee had examined 24 allegations (involving 25 papers) and concluded that Schön had committed scientific misconduct in 16 of those cases. "The evidence that manipulation and misrepresentation of data occurred is compelling," the report concluded. The committee also found that six of the remaining eight allegations were "troubling" but "did not provide compelling evidence" of wrongdoing. Bell Labs immediately fired Schön.

Detective work

- The committee sent questionnaires to all of Schön's coauthors, and interviewed his three principal coauthors (Zhenan Bao, Bertram Batlogg, and Christian Kloc). They examined electronic drafts of the disputed papers, which included processed numeric data. They requested copies of raw data but found that Schön had kept no laboratory notebooks. His raw data files had been erased from his computer. According to Schön, the files were erased because his computer had limited hard drive space. In addition, all of his experimental samples had been discarded or damaged beyond repair. Even the sputtering machine at Konstanz was no longer producing films with the required high breakdown strengths. Nevertheless, Bell Labs provided the committee with some data files that had been embedded in early electronic drafts of papers or in presentation files.

- The committee classified each allegation as one of three types:

  substitution of data: substitution of whole figures, single curves and partial curves in different or the same paper to represent different materials, devices or conditions;

  unrealistic precision: precision beyond that expected in a real experiment or requiring unreasonable statistical probability;

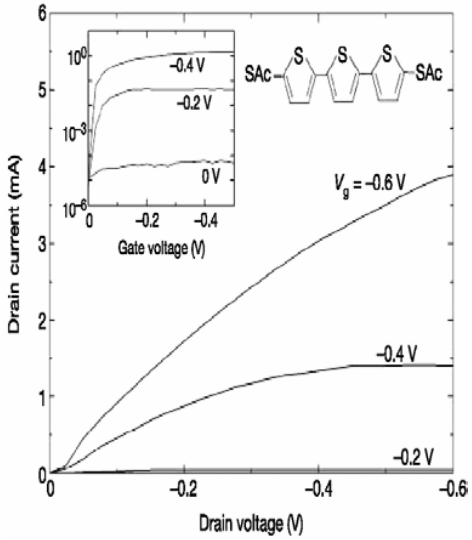
  contradictory physics: behavior inconsistent with stated device parameters and prevailing physical understanding, so as to suggest possible misrepresentation of data;

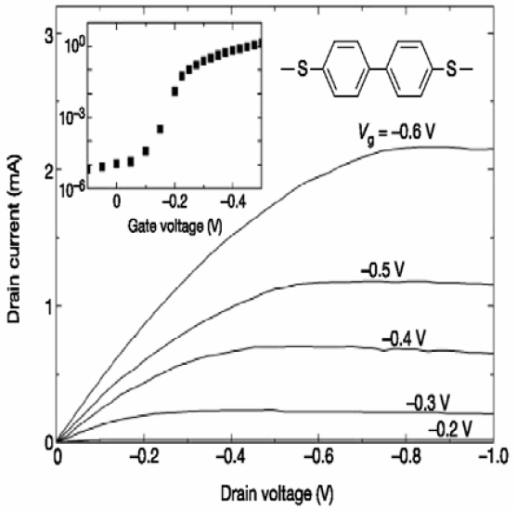
Final list of Allegation

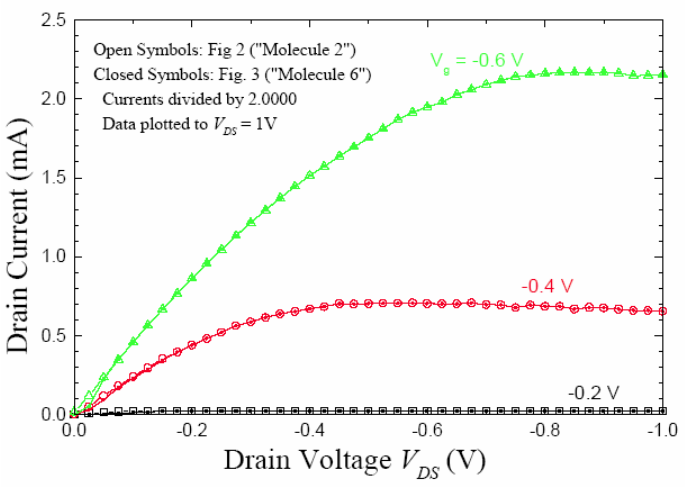
• I. Data Substitution: Triode characteristics	data falsification
• II. Data Substitution: Ambipolar triode characteristics	data falsification
• III. Data Substitution: Inverter characteristics	data falsification
• IV. Data Substitution: Ring oscillator time dependence	data fabrication and falsification
• V. Data Substitution: Normal-state resistivity of polythiophene	data falsification
• VI. Data Substitution: Space-charge limited I-V	data were duplicated, more evidence needed
• VII. Data Substitution: Laser emission spectrum	data falsification
• VIII. Data Substitution: Superconducting Tc versus charge	extremely troubling (data fabrication)
• IX. Data Substitution: Magnetotransport	troubling
• X. Unrealistic Precision: Normal-state resistance of gated C60	data fabrication
• XI. Unrealistic Precision: Normal-state resistance of gated C70	data fabrication
• XII. Unrealistic Precision: Resistance of CaCuO2	data fabrication
• XIII. Unrealistic Precision: Pentacene mobility	data fabrication and falsification
• XIV. Unrealistic Precision: Ballistic transport	data fabrication
• XV. Unrealistic Precision: Conductance quantization statistics	data fabrication
• XVI. Unrealistic Precision: SAMFET Dilution series	data falsification
• XVII. Unrealistic Precision: SAMFET width series	data fabrication
• XVIII. Unrealistic Precision: Characterization of sputtering process	data fabrication
• XIX. Contradictory Physics: Unipolar inverter characteristics	data falsification
• XX. Contradictory Physics: SAMFET subthreshold swing	data falsification
• XXI. Contradictory Physics: Hysteretic planar Josephson junctions	extremely troubling
• XXII. Contradictory Physics: Low sub-gap conductance	troubling
• XXIII. Contradictory Physics: Squid results	troubling
• XXIV. Contradictory Physics: Sharp 2-D superconducting transitions	misconduct

Examples of Misconduct (I)

- Data substitution: Triode characteristics--data falsification







Left: Triode data from “SAMFET” Paper (XII), Fig. 3: “molecule 6”. The figure has been compressed laterally for comparison.

Middle:Triode data from “SAMFET” Paper (XII), Fig. 2: “molecule 2”

Right: Original plotting data from middle and left figure ,replotted to illustrate that the data present in both are exactly the same, after dividing the latter by 2. All but a few of the solid symbols are within the open symbols, and agree with each other to five significant figures, although they represent distinct data sets.

Very similar data (transistor triode curves), including detailed “noise,” appear in two different figures in the same paper, represented as two different molecules making up the Self-Assembled Monolayer Field Effect Transistor (SAMFET). The vertical scale differs by a factor of two, and some curves are present in only one figure.

Examples of Misconduct (II)

- Unrealistic Precision: Resistance of CaCuO2

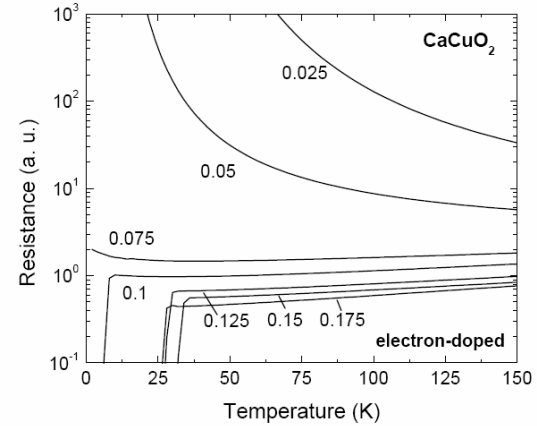


Figure 37. Resistivity data for electron-doped $CaCuO_2$ for various "electron doping levels," from Figure 3 of Paper XXI ("FETCaCuO2").

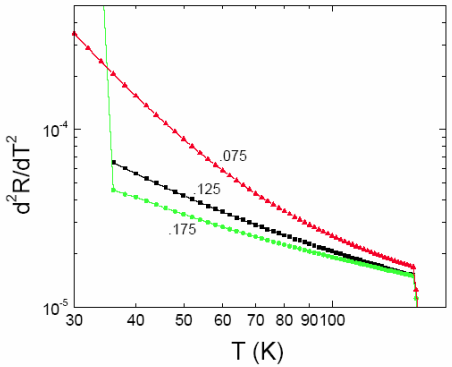


Figure 38. Second derivative of resistance for original plotting data from Figure 37, (extracted from electronic draft) for three metallic doping levels.

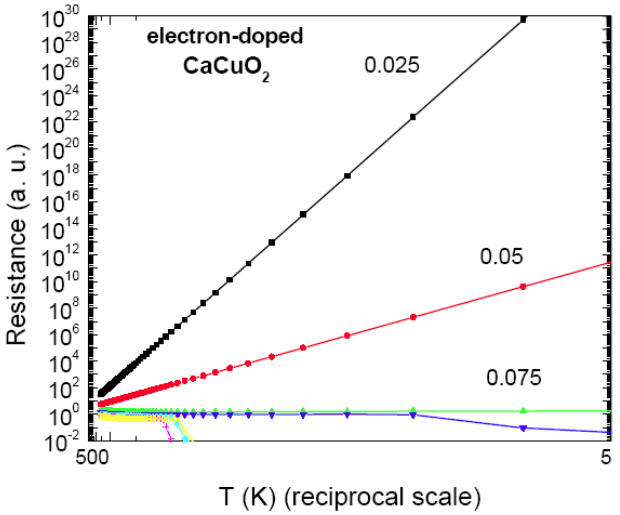


Figure 39. Resistivity data from Figure 37 (extracted from electronic draft), replotted on an Arrhenius plot to emphasize the insulating regime of gate voltage The reported resistivity follows an activated behavior over more than 25 decades.

For CaCuO2, the samples are tuned between insulating and metallic states with applied field in Paper XXI ("FETCaCuO2") (see Figure 37). As shown in Figure 38, for the electron-doped case, the normal-state resistivity on the metallic side shows the same smoothness in second derivative that the C60 data did, indicating a non-experimental source.

On the insulating side, the original plotting data embedded in a draft of the paper indicate an activated resistivity covering more than 70 orders of magnitude. ("Only" 30 orders are shown in Figure 39). There is no way these very high resistance values could represent real data; measurement apparatus covering more than 10-12 orders of magnitude is very unusual. This data clearly comes from an analytical expression (Arrhenius' law), not experiment. Of course, the very high resistance points did not fit within the range of the plot in the original paper, but they were contained in the original plotting data.

Conclusion of the investigation

- On September 25, 2002, the committee publicly released its report. The report contained details of 24 allegations of misconduct. They found evidence of Schön's scientific misconduct in at least 16 of them. They found that whole data sets were reused in a number of different experiments. They also found that some of his graphs, which purportedly had been plotted from experimental data, had instead been produced using mathematical functions.

- The report found that all of the misdeeds had been performed by Schön alone. All coauthors were completely exonerated of scientific misconduct. However, it was unclear whether all of them had exercised sufficient professional responsibility in trusting the integrity of his data.

- Bell Labs fired Schön on the day they received the report. It was the first known case of fraud in the lab's history.

Withdrawn journal papers

On October 31, 2002, Science withdrew eight papers written by Schön:

http://www.sciencemag.org/cgi/content/full/sci;298/5595/961b

- * J. H. Schön, S. Berg, Ch. Kloc, B. Batlogg, Ambipolar pentacene field-effect transistors and inverters, Science 287, 1022 (2000)
- * J. H. Schön, Ch. Kloc, R. C. Haddon, B. Batlogg, A superconducting field-effect switch, Science 288, 656 (2000)
- * J. H. Schön, Ch. Kloc, B. Batlogg, Fractional quantum Hall effect in organic molecular semiconductors, Science 288, 2338 (2000)
- * J. H. Schön, Ch. Kloc, A. Dodabala-pur, B. Batlogg, An organic solid state injection laser, Science 289, 599 (2000)
- * J. H. Schön, A. Dodabalapur, Ch. Kloc, B. Batlogg, A light-emitting field-effect transistor, Science 290, 963 (2000)
- * J. H. Schön, Ch. Kloc, H. Y. Hwang, B. Batlogg, Josephson junctions with tunable weak links, Science 292, 252 (2001)
- * J. H. Schön, Ch. Kloc, B. Batlogg, High-temperature superconductivity in lattice-expanded C60, Science 293, 2432 (2001)
- * J. H. Schön, H. Meng, Z. Bao, Field-effect modulation of the conductance of single molecules, Science 294, 2138 (2001)

On December 20, 2002, the Physical Review journals withdrew six papers written by Schön:

http://www.aps.org/media/pressreleases/122002.cfm (no longer available)

- * J. H. Schön, Ch. Kloc, R. A. Laudise, and B. Batlogg, Electrical properties of single crystals of rigid rodlike conjugated molecules, Phys. Rev. B 58, 12952-12957 (1998)
- * J. H. Schön, Ch. Kloc, and B. Batlogg, Hole transport in pentacene single crystals, Phys. Rev. B 63, 245201 (2001)
- * J. H. Schön, Ch. Kloc, D. Fichou, and B. Batlogg, Conjugation length dependence of the charge transport in oligothiophene single crystals, Phys. Rev. B 64, 035209 (2001)
- * J. H. Schön, Ch. Kloc, and B. Batlogg, Mobile iodine dopants in organic semiconductors, Phys. Rev. B 61, 10803-10806
- * J. H. Schön, Ch. Kloc, and B. Batlogg, Low-temperature transport in high-mobility polycrystalline pentacene field-effect transistors, Phys. Rev. B 63, 125304 (2001)
- * J. H. Schön, Ch. Kloc, and B. Batlogg, Universal Crossover from Band to Hopping Conduction in Molecular Organic, Phys. Rev. Lett. 86, 3843-3846 (2001)

On March 5, 2003, Nature withdrew seven papers written by Schön:

http://www.nature.com/nature/journal/v422/n6927/index.html

- * Schön, J. H., Kloc, Ch. & Batlogg, B. Superconductivity at 52K in hole-doped C60. Nature 408, 549-552 (2000).
- * Schön, J. H. et al. Gate-induced superconductivity in a solution-processed organic polymer film. Nature 410, 189- 192 (2001).
- * Schön, J. H., Meng, H. & Bao, Z. Self-assembled monolayer organic field-effect transistors. Nature 413, 713-716 (2001).
- * Schön, J. H. et al. Superconductivity in single crystals of the fullerene C70. Nature 413, 831-833 (2001).
- * Schön, J. H. et al. Superconductivity in CaCuO2 as a result of field-effect doping. Nature 414, 434-436 (2001).

Aftermath and sanctions

- Schön acknowledged that the data was incorrect in many of these papers. He claims that the substitutions could have occurred by honest mistake. He admits to falsifying some data and states he did so to show more convincing evidence for behaviour that he observed. He continues to maintain that his experiments worked, and that molecular-sized transistors are possible using the techniques he demonstrated.

- Experimenters at Delft University of Technology and the Thomas J. Watson Research Center have since performed experiments similar to Schön's. They did not obtain similar results. Also before the allegations became public, several research groups tried - without success - to reproduce most of the groundbreaking results in the field of the physics of organic molecular materials.

- In June 2004 the University of Konstanz revoked Schön's doctoral degree due to "dishonorable conduct". Department of Physics spokesman Wolfgang Dieterich called the affair the "biggest fraud in physics in the last 50 years" and said that the "credibility of science had been brought into disrepute". [4]

- In October 2004, the Deutsche Forschungsgemeinschaft (DFG) (trans.: German Research Foundation) Joint Committee announced sanctions against him. The former DFG post-doctorate fellow was deprived of his active right to vote in DFG elections or serve on DFG committees for an eight-year period. During this time, Schön will also be unable to serve as a peer reviewer or apply for DFG funds

What's more…

- Waste numerous money and time of others. Some people still believe that some of Schön's work may have value! Physicists around the country and the world have spent tens of millions of dollars trying to reproduce Schön's key results. There are an estimated 100 laboratory groups working on Schön's results in the United States and around the world. For graduate students basing their Ph.D. research on Schön's experiments, their education is at stake. Postdoctoral fellows worry about their prospects for future employment. Some junior professors have tied their bids for tenure to experiments based on Schön's findings. Their professional livelihoods are literally at risk.
- Abuse trust in science community. Cause serious credibility problem.
- Bell Labs website, now the new Alcatel-Lucent site, doesn't keep good records on this matter (the scandal).
- Schön's retracted papers are still being cited! Should one cite retracted papers?

  For example, Schon's 2001 Nature paper :

  Self-assembled monolayer organic field-effect transistors (Retracted article. See vol 422 pg 92 2003) SCHON JH, MENG H, BAO Z NATURE 413: 713-716 2001

  However, it was cited at least 24 times since retraction was issued by Nature and Science in Spring of 2003. Including 5 citations in 2006 and 5 citations in 2005. (http://nanoscale.blogspot.com/)
- Schön claimed in the process of investigation and after the report that "all the scientific publications that I prepared were based on experimental observations. I have observed experimentally the various physical effects reported in these publications, such as the Quantum Hall effect, superconductivity in various materials, lasing, or gate-modulation in self-assembled monolayers, and I am convinced that they are real, although I could not prove this to the investigation committee. Furthermore, I believe that these results will be reproduced in the future and, if possible for me, I am willing to work hard on this task, since reproduction will be the only prove of these scientific effects,…, nevertheless, I truly believe that the reported scientific effects are real, exciting, and worth working for." (in the response to the committee)

  What made him so insisted? Why would Schön rush to publish dubious results if he knew others would attempt to repeat his experiments? A writing machine? Has psychological problem? Are other coauthors truly innocent? Perhaps nobody knows more except themselves. But there are many many more questions one can ask…

How to avoid scientific misconduct? (I)

How to catch misdeed at an early stage? What should be done?

1. Coauthors:

   exercised appropriate professional responsibility in ensuring the validity of data and physical claims. By virtue of their coauthorship, coauthors implicitly endorse the validity of the work. It is a matter of how to validate. There should be some trust between coauthors.

2. Senior coauthor/mentor/advisor/supervisor:

- "Part of the reason the work was accepted," says Greene, was because Schön's coauthor and one-time supervisor Bertram Batlogg put his imprimatur (and that of Bell Labs) on it. Batlogg has been a respected superconductivity physicist for more than two decades. (http://dir.salon.com/story/tech/feature/2002/09/16/physics/index.html)
- Batlogg recruited Schön while Schön was still a graduate student. He brought Schön into his lab. He sponsored Schön's experiments. And rather than formally withdraw any papers he might have considered suspicious, he gave many well-received talks at elite international conferences on the results. However, he simply made excess.
- Batlogg: "If I'm a passenger in a car that drives through a red light, then it's not my fault.“
- Princeton's Sohn: "He's a collaborator, not a casual passenger. He's been benefitting all along, riding the public wave. If a young driver has a learner's permit, then who's responsible for him? Batlogg was the licensed driver, and Schön was the student driver."
- Rice University's Douglas Natelson: “If my student came to me with earth-shattering data, you wouldn't be able to pry me out of the lab. I'd be in there turning the knobs myself ” Heath echoes this sentiment: "I'd sit down there to see how this is being done. I'd demand to see it several times.“
- Sohn: "I am responsible for what my students publish. If my name is going to be on a paper, I want to make sure it's right.“
- Nobel laureate Horst Stormer: "My goal may be to win a prize, but my duty is to report what I have observed in the most objective way that I can. I say this in the strongest terms. This is what I expect from my colleagues, from my graduate students, at all levels of the field."

How to avoid scientific misconduct? (II)

3. Peer referees:

- The peer review system is designed to weed out substandard work, and to improve promising submissions and make them publishable. It's supposed to keep things honest. There's a certain amount of trust in the physicists. The peer review system is the means by which that trust is maintained. The Schön affair has besmirched the peer review process in physics as never before. Why didn't the peer review system catch the discrepancies in his work? A referee in a new field doesn't want to "be the bad guy on the block," says Dutch physicist Teun Klapwijk, so he generally gives the author the benefit of the doubt.
- The editors of Science and Nature defended their review process: "There is little journals can do about detecting scientific misconduct.“
- Nobel prize-winning physicist Philip Anderson of Princeton: These two industry-leading publications "decide for themselves what is good science -- or good-selling science, encourages people to push into print with shoddy results." Such urgency would presumably lead to hasty review practices.
- Klapwijk, a superconductivity specialist, said that he had raised objections to a Schön paper sent to him for review, but that it was published anyway.
- Klapwijk points out that the duplicated figures were in separate papers that weren't necessarily sent to the same people for vetting. But as one physicist admits, "It's hard to criticize someone else's productivity without sounding like you're full of sour grapes."
- Another reason for the breakdown is the hypnotizing effect of reputation. When the names of eminent people and places appear on the top of submitted papers, says Florida physicist Hebard, "reviewers react almost unconsciously" to their prestige. "People discount reports from groups that aren't well known," adds University of Maryland physicist Richard Greene.

4. Institutions and more …