

REPORT OF THE INVESTIGATION COMMITTEE ON THE POSSIBILITY OF SCIENTIFIC MISCONDUCT IN THE WORK OF HENDRIK SCHÖN AND COAUTHORS

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Executive Summary

In late May 2002, the management of Bell Labs formed a committee to investigate “the possibility of scientific misconduct, the validity of the data and whether or not proper scientific methodology was used in papers by Hendrik Schön, et al., that are being challenged in the scientific community”. The members of the Committee were M.R. Beasley (Chair), S. Datta, H. Kogelnik, H. Kroemer and D. Monroe.

The first task of the Committee was to establish the specific allegations. This task was complicated by the public nature of some of the allegations and by additional allegations that came to the attention of the Committee as the investigation progressed. By the time this initial process was ended on June 20, 2002, allegations had been made about 25 papers, involving 20 coauthors. Of these allegations, the Committee selected 24 Final Allegations for detailed examination.

These Final Allegations can be grouped into 3 classes:

- *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 of data* (precision beyond that expected in a real experiment or requiring unreasonable statistical probability)
- *Results that contradict known physics* (behavior inconsistent with stated device parameters and prevailing physical understanding, so as to suggest possible misrepresentation of data)

In examining the allegations, the Committee sent questionnaires to all coauthors and interviewed Hendrik Schön and his three principal coauthors (Zhenan Bao, Bertram Batlogg and Christian Kloc). The Committee also examined drafts of many of the papers in question, which were available in electronic form, including the embedded, processed data files used to plot the figures. These data files permitted detailed, quantitative examination of the data in the figures. The

Committee requested primary (raw) data files for some of the papers but was unable to examine them because they no longer exist, as discussed below.

The Committee's main findings and conclusions can be summarized as follows.

By all accounts, Hendrik Schön is a hard working and productive scientist. If valid, the work he and his coauthors report would represent a remarkable number of major breakthroughs in condensed-matter physics and solid-state devices.

Except for the provision of starting materials by others, all device fabrication, physical measurement and data processing in the work in question were carried out (with minor exceptions) by Hendrik Schön alone, with no participation by any coauthor or other colleague. None of the most significant physical results was witnessed by any coauthor or other colleague.

Proper laboratory records were not systematically maintained by Hendrik Schön in the course of the work in question. In addition, virtually all primary (raw) electronic data files were deleted by Hendrik Schön, reportedly because the old computer available to him lacked sufficient memory. No working devices with which one might confirm claimed results are presently available, having been damaged in measurement, damaged in transit or simply discarded. Finally, key processing equipment no longer produces the unparalleled results that enabled many of the key experiments. Hence, it is not possible to confirm or refute directly the validity of the claims in the work in question.

The most serious allegations regarding the work in question relate to possible manipulation and misrepresentation of data. These allegations speak directly to the question of scientific misconduct. The Committee carefully investigated each of these allegations and came to a specific conclusion in each case.

The evidence that manipulation and misrepresentation of data occurred is compelling. In its mildest form, whole data sets were substituted to represent different materials or devices. Hendrik Schön acknowledges that the data are incorrect in many of these instances. He states that these substitutions could have occurred by honest mistake. The recurrent nature of such mistakes suggests a deeper problem. At a minimum, Hendrik Schön showed reckless disregard for the sanctity of data in the value system of science. His failure to retain primary data files compounds the problem.

More troublesome are the substitutions of single curves or even parts of single curves, in multiple figures representing different materials or devices, and the use of mathematical functions to represent real data. Hendrik Schön acknowledges these practices in many instances, but states that they were done to achieve a more convincing representation of behavior that was nonetheless observed. Such practices are completely unacceptable and represent scientific misconduct.

One of the most troublesome cases is that of superconductivity in polythiophene. Here, identical curves appear multiple times in whole or in part in a single figure. Hendrik Schön acknowledges that these data are not valid but cannot explain how they arose. In the view of the Committee, it is not possible that this set of curves represent real data and therefore this is a clear, unambiguous case of scientific misconduct.

In the end, the Committee concluded that, of the 24 Final Allegations examined, Hendrik Schön committed scientific misconduct in 16, some of which were interrelated. Of the remaining 8, 2 were judged to have no clear relationship to publications, while 6 were troubling but did not provide compelling evidence of scientific misconduct.

The Committee finds all coauthors of Hendrik Schön in the work in question completely cleared of scientific misconduct. The Committee also finds no evidence that the laboratory practices of any coauthor of Hendrik Schön in the work in question are outside the accepted practices of their fields.

In addition to addressing the question of scientific misconduct, the Committee also addressed the question whether the coauthors of Hendrik Schön exercised appropriate professional responsibility in ensuring the validity of data and physical claims in the papers in question. By virtue of their coauthorship, they implicitly endorse the validity of the work. There is no implication here of scientific misconduct; the issue is one of professional responsibility.

The Committee found this to be an extremely difficult issue, which the scientific community has not considered carefully. Therefore, no clear, widely accepted standards of behavior exist. In order to proceed, the Committee adopted, for working purposes, a minimal set of principles that it feels should be honored in collaborative research. At its core, the question of professional responsibility involves the balance between the trust necessary in any collaborative research and the responsibility all researchers bear for the veracity of the results with which they are associated. The Committee does not endorse the view that each coauthor is responsible for the *entirety* of a collaborative endeavor: the relative responsibility of researchers with very different expertise, seniority and levels of participation must be considered.

The Committee examined this question for each coauthor, considering the nature of their participation and their differing degrees of responsibility. The Committee concluded that the coauthors of Hendrik Schön in the work in question have, in the main, met their responsibilities, but that in one case questions remain that the Committee felt unqualified to resolve, given the absence of a broader consensus on the nature of the responsibilities of participants in collaborative research endeavors.