

BOOKSHELF

Superconducting Materials for High Energy Colliders

edited by L Cifarelli and L Maritato, World Scientific Science and Culture Series – Physics, ISBN 080243197.

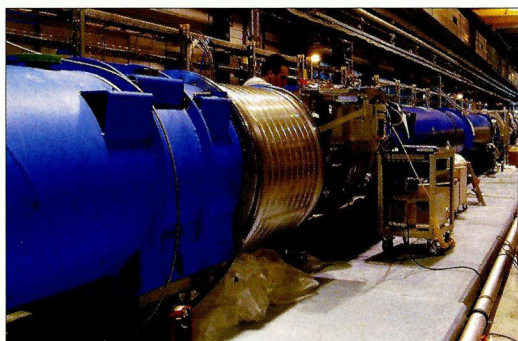
Imagine the ultimate high-energy physics project – 10 times as powerful as CERN's mighty LHC collider. This ambitious goal, which is aiming for a hadron collider with a collision energy of 200–1000 TeV and with a luminosity as high as 10^{36} , is the theme of Antonino Zichichi's foreword to this book. The vision of the multihundred TeV "ultimate collider", the Eloisatron, is supported by the conviction that no energy threshold well beyond the Standard Model seems near.

The book is dedicated to the memory of Tom Ypsilantis (*CERN Courier* October 2000 p48) and gives a full description of a workshop held in Erice, Sicily, at the end of 1999 on superconducting materials for future high-energy colliders. This marked the return of a full European perspective of the Eloisatron workshops, after a period during which the European community had been busy designing the LHC, while our US colleagues emerged from the trauma of the cancelled SSC and set up a new programme that is now focused on the VLHC.

With the LHC on track to produce physics by 2006, European scientists began to look beyond the present horizon. The workshop provided an excellent forum where materials scientists met with accelerator specialists to exchange information and to focus R&D towards common goals.

Superconductivity is the key accelerator technology, and the communities striving for high field (magnets) and for high gradient (radiofrequency cavities) exploit the absence of electrical resistance at low temperatures. In the reverse direction, high-energy physics has provided the right environment (and resources) to achieve real progress in applied superconductivity, by developing high-critical current density cables with fine filaments and achieving mass-production. A good example is magnetic resonance imaging (MRI), which could not have progressed from a laboratory-scale experiment to a general medical technique without the impetus of high-energy physics cryogenics.

At the Erice workshop, Philippe Lebrun, head of CERN's LHC division, addressed the problem of technical management of mega-



Test string for superconducting magnets for CERN's LHC collider. Particle physics is a major focus for research and development work in applied superconductivity.

science projects and described what we are learning with the LHC, the first global accelerator project, and reviewed the main machine subsystems, including the powerful cryogenics needed to keep some 50 000 tons of superconducting magnets at 1.9 K – the coldest point of the universe and twice as cold as the relic cosmic microwave radiation. Also for the LHC, Tom Taylor covered the vigorous technical effort that is under way to design and build the LHC's superconducting components to conform to stringent energy and luminosity requirements, and the room for improvements.

Kjell Johnsen, the designer of CERN's ISR, the first hadron collider, reviewed the tentative feasibility study of the Eloisatron, just 10 years after it was issued, showing that the machine, although very ambitious, is technically feasibly with a 300 km ring where some 16 000 dipoles reaching 10 tesla can provide 100 TeV proton beams (200 TeV collisions).

On basic superconductivity, C Grimaldi (Lausanne) introduced the present understanding of high-temperature superconductors (HTS), stressing that much work still needs to be done, but the reward would be the cheap and easy cryogenics of liquid nitrogen.

J Halbrittner (Karlsruhe) described the detailed analysis of radiofrequency losses in superconducting cavities, showing the present superiority of bulk niobium cavities over sputtered ones for very high power.

Superconducting cavities for frontier colliders were the topic of an extensive review by H Padamsee (Cornell) on the impressive progress with bulk niobium and niobium-sputtered copper cavities. With proper selection and treatment of the material, the

road is open to 40 MV/m and a TeV electron-positron superconducting linear collider. A Cassinese (INFN-Naples) described microwave measurements of superconducting films of niobium and niobium-tin, stressing the need to understand surface resistance.

L Rossi (Milan) turned to the design and characteristics of accelerator magnets, highlighting the demands on superconductor performance to build 5–15 T dipole and quadrupole magnets. He included an overview of worldwide R&D for magnets beyond the LHC-phase1, emphasizing the necessity of a vigorous effort to improve niobium-tin

characteristics to reach a critical current of 1000 A/mm² at 18 T (LHC-phase1 material reaches this level at 8 T and 4.2 K) and showed the novel magnet designs being explored in the US for VLHC studies.

The Japanese effort on doped niobium-tin reinforced with a copper-niobium matrix was covered by K Watanabe (IMR, Tohoku) who showed the potential of this technique to overcome the problems posed by the brittleness of niobium-tin. Japan is also leading the effort on the less brittle niobium-aluminium superconductor, and K Inoue (NRIM, Tsukuba) described the potential of the recently developed, rapid-quenching and transforming process. Although very difficult, this process could achieve interesting current densities.

For HTS, K Salama (Houston) reviewed the fabrication technique for bismuth- and yttrium-based, silver-stabilized superconducting tapes, reporting an improvement in critical current of almost an order of magnitude using suitable heat treatment. His former assistant, L Martini (ENEL-Ricerca, Milan), reported on his unique "accordion-folding method" to produce short (0.1–1 m) Bi-2223 samples with a very low silver content, useful for low-consumption multi-kA current leads (needed in large quantities for the LHC).

J Scudiere (American Superconductor Corporation) reviewed the results obtained by the leading company in HTS development and production. The impressive results on short samples have yet to be reproduced in long samples. However, for fields above 18 T, HTS could become a viable alternative to niobium within a few years. He highlighted the necessity of reasonable homogeneity and reliability of such a delicate (ceramic)

material under "industrial" conditions and indicated that a production rate of at least 2000 km/year of tapes is needed to reduce prices to a reasonable level. Considering that such a quantity is approximately equivalent to about 50 LHC dipoles, major projects are needed to drive this promising material to market (as for MRI). Finally, C M Friends (BICC General Superconductors) reported on 13 kA HTS current leads for the LHC and the development of Bi-2223 tapes and of round wires (radial filaments) for low losses in AC conditions.

The book gives the impression that accelerator technology is far from saturation and there is plenty of room yet for exciting developments and significant breakthroughs. On an optimistic note, in the two years since the workshop was held, the increase in conductor performance from LHC values to final goals is already half-achieved. A field of 14.5 T at 4.2 K was attained earlier this year at Berkeley in a short model with a new niobium-tin coil configuration.

Lucio Rossi, Milan.

The Golden Age of Theoretical Physics by Jagdish Mehra, World Scientific, ISBN 9810243421, two-volume set £56.

Jagdish Mehra has spent much of his long career carefully documenting the development of quantum mechanics and the people involved. One of the results is his monumental work (with Helmut Rechenberg) *The Historical Development of Quantum Theory*. The six-volume/nine-book series, completed last year, is imposing. His other contributions include the collected works of Eugene Wigner; books on Einstein, Hilbert and general relativity; and the more popular *The Beat of a Different Drum*, a biography of Richard Feynman.

His new collection brings together 37 essays, based on his invited lectures, mostly covering modern physics – relativity, quantum theory and quantum mechanics, spin and statistics, quantum electrodynamics, elementary particles – and physicists – Einstein, Planck, Gibbs, Bohr, Sommerfeld, Bose, de Broglie, Pauli, Heisenberg, Dirac, Schrödinger, Wigner and Landau.

Mehra is a scientists' historian who understands concepts and traces their evolution, as well as the personalities involved.

In the introduction to the book, he explains his own fascination with literature, philosophy

and history and his quest to reconcile these with his solid grounding in physical science.

Gordon Fraser, CERN

Heavy Quark Physics by Aneesh V Manohar and Mark B Wise, Cambridge University Press, ISBN 0521642418 (hbk) £40/\$64.95.

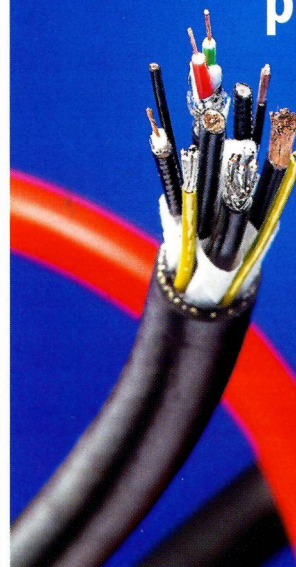
Most of the achievements in the understanding of the physics of particles containing heavy quarks date from the past decade, both on the experimental and on the theoretical side. More and more precise measurements of b hadron properties carried out at CESR, LEP and the Tevatron colliders have gone in parallel with the development of the Heavy Quark Effective Theory (HQET), which has become the key tool for a quantitative description of the interactions of heavy particles. Such important theoretical developments were up to now documented in a fairly large number of papers, published over the years by the pioneers of the field. Manohar and Wise now provide us with a valuable textbook on heavy quark physics. The presentation of the material is clear and concise, covering the majority of the fundamental theoretical results currently available in the field.

The book starts with a review of the Standard Model. A discussion of spin-flavour symmetry follows, including the implications for the heavy hadron spectroscopy and for the hadron production rates in the heavy quark hadronization. Then HQET is developed, first at one loop in the infinite mass limit, then including radiative corrections and $1/m_Q$ corrections. Many important results are derived, such as the heavy meson decay constants, the form factors in the semileptonic decay of B mesons to D and D* mesons, and the semileptonic decays of Λ_b to Λ_c baryons (heavy-to-heavy currents) and Λ_c to Λ (heavy-to-light).

Chiral perturbation theory is also discussed, deriving the matrix elements for the semileptonic decay of heavy-to-light mesons, as well as corrections to heavy-to-heavy transitions ($B \rightarrow D^{(*)} \ell \bar{\nu}$). The powerful operator product expansion formalism is finally developed and used to calculate inclusive weak decays of b hadrons.

Some of the calculations are reported step by step, especially when they involve techniques and subtleties developed for the purpose that have become key tools in HQET. Each chapter is complemented with problems that are non-trivial applications of the

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theory discussed, and a collection of bibliographical references.

The book is aimed at readers with a solid background in quantum field theory who are aiming to get acquainted with the techniques of HQET. The illuminating discussions of the approximations and assumptions made at each step, and of their implications on the validity of the results derived, make it valuable reading for all physicists who want to get a better insight into heavy quark physics, even without going through all of the calculations.

Heavy quark physics is now entering an exciting new era in which high-luminosity machines will significantly improve our experimental knowledge, demanding corresponding progress in the precision of theoretical predictions. This text provides a concise and systematic summary of today's knowledge, and will stay as a bibliographical milestone while new developments take place.

Duccio Abbaneo, CERN

At the Frontier of Particle Physics: Handbook of QCD – Boris Ioffe Festschrift
edited by M Shifman, three volumes, World Scientific, ISBN 9810244452, set £112.

As would be expected from such a meticulous editor (see *The Supersymmetric World – The Beginnings of the Theory* edited by G Kane and M Shifman, World Scientific, ISBN 981024522X reviewed in *CERN Courier* September p50), these three volumes contain a wealth of well-prepared and highly valuable information. They bring together 33 reviews covering all aspects of the analytical aspects of the theory of quantum chromodynamics (QCD), assembled to mark the 75th birthday of Boris Ioffe. The majority of the work provides an encyclopedia of QCD that is useful for students and for research workers.

The first part of the work is more historical, and it includes contributions from Ludwig Faddeev on quantizing Yang-Mills fields, and from David Gross on the discovery of asymptotic freedom and the emergence of QCD. These are followed by an amusing aside by Shifman: "How the asymptotic freedom of the Yang-Mills Field could have been discovered three times before Gross, Wilczek and Politzer, but was not".

Introducing all of this is the material specifically on Ioffe and on events in Russia at the end of the 20th century, with very useful editorial explanations. After the introductory festschrifts, Boris Ioffe's *Top Secret*

Assignment (which won the 1999 Novy Mir prize after being published in that magazine) and Yuri Orlov's *Snapshots from the 1950s* (based on excerpts from Orlov's book *Dangerous Thoughts – William Morrow* 1991, New York) are full of fascinating insights.

Gordon Fraser, CERN

Oeuvre et engagement de Frédéric Joliot-Curie eds Monique Bordry and Pierre Radvanyi, EDP Science, ISBN 2868835252.

Frédéric Joliot-Curie, a major French scientific figure, was born in 1900 and the 100th anniversary of his birth called for a special celebration. This took place on 9–10 October 2000 at the Collège de France, where he was a professor until his death in 1958 and where he long communicated his insight and enthusiasm to the many members of his laboratory.

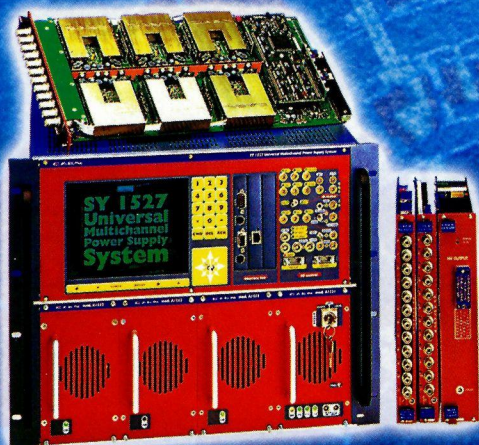
The symposium consisted of three series of formal talks, each followed either by numerous testimonies from many of those who had the privilege to work with Joliot-Curie, or know him well, or by round-table discussions with invited participants. These three main themes covered artificial radioactivity (the discovery for which he, together with his wife Irène, received the 1935 Nobel Prize for Chemistry), nuclear energy, and social and political commitments.

Joliot-Curie was not only a great scientist but he also played a key role in the early development of nuclear energy in France, and was for more than two decades a very important figure in French political and social circles.

The symposium was opened by Hubert Curien, former president of the CERN council, and closed by an address from Minister of Research Roger-Gérard Schwartzberg. A plaque commemorating the discovery of artificial radioactivity was unveiled at the Institut du Radium (*CERN Courier* December 2000 p40).

This beautifully edited book brings together the texts of all of the invited talks, testimonies and round-table presentations during the symposium. It is in French except for two historical texts in English. The book pays ample tribute to Joliot-Curie but also provides much topical matter. It not only brings the past alive, but also shows in a brilliant and well documented way how many questions on which Joliot-Curie strongly made his mark are still very important today. There are many historical photographs and a good biographical summary. The cover is graced by a Picasso portrait. *Maurice Jacob, CERN*

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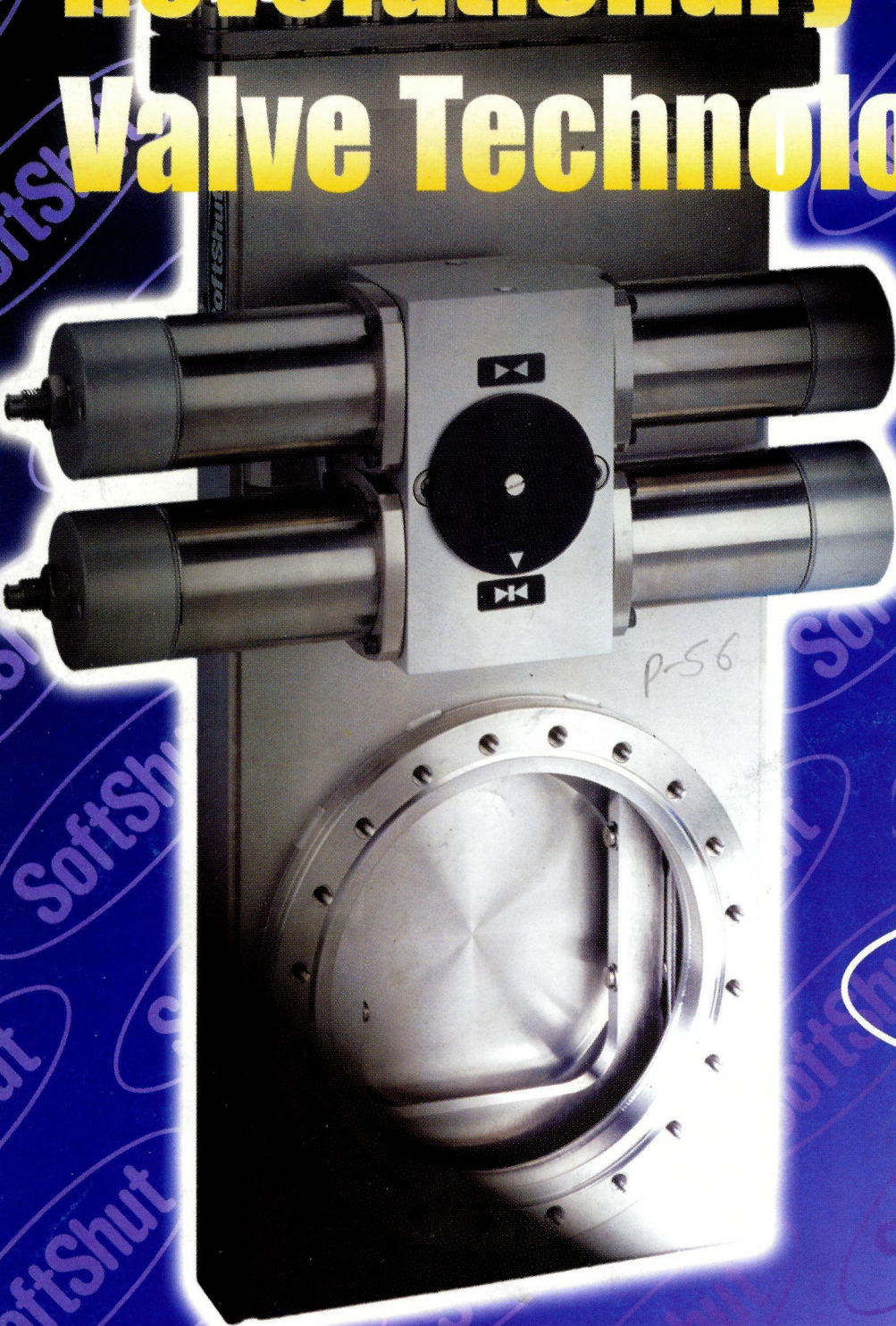


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