felt by the carriers has a different shape than that experienced by electrons in atoms. It is interesting to note that the contribution of the hole to the polarizability dominates over the electron owing to the larger effective mass and hence smaller energy spacing of hole energy levels. The quantitative values for the exciton polarizabilities in CdSe colloidal quantum dots are of the order of 10,000 Å^3, that is, three orders of magnitude larger than typical atomic or molecular polarizabilities. This is in agreement with earlier measurements based on the shift of the energy levels with electric field due to the Stark effect[6].

This high polarizability, which can be even higher in elongated CdSe crystals, or nanorods[7], makes quantum dots particularly attractive not only for efficient photon-emission devices but also for fundamental quantum-optics experiments. The first steps in this direction have already been taken. For example, the strong coupling of an exciton in a single nanorod to photons in an optical cavity has been demonstrated[8]. A colloidal quantum dot can also be coupled to a metal nanosystem with plasmonic resonances by moving a metal nano-antenna placed on the tip of an atomic force microscope (AFM) in the close vicinity of the dot[9] or by nano-assembling an antenna–nanocrystal structure on a surface with an AFM (M. Kahl *et al.* manuscript in preparation). Owing to the high degree of flexibility in moving colloidal particles, complex arrangements with completely new physical effects and properties may arise in the future. Many of the experiments that may be envisioned rely on the possibility of manipulating excitons in quantum dots by external electric fields. The demonstration by Wang *et al.* of a high, atom-like, polarizability is therefore a fundamental piece of information for the development of semiconductor-based quantum optics.

REFERENCES

1. Scholes, G. D. & Rumbles, G. *Nature Mater.* **5,** 683–696 (2006).
2. Wang, F. *et al. Nature Mater.* **5**, 861–864 (2006).
3. Huber, R. *et al. Nature* **414,** 286–289 (2001).
4. Bratschitsch, R. & Unterrainer, K. in *Encyclopedia of Modern Optics* (eds Guenther, R. D., Steel, D. G. & Bayvel, L.) 168–175 (Elsevier, Oxford, 2004).
5. Hendry, E. *et al. Phys. Rev. Lett.* **96,** 057408 (2006).
6. Empedocles, S. A. *et al. Science* **278,** 2114–2117 (1997).
7. Li, L. & Alivisatos, A. P. *Phys. Rev. Lett.* **90,** 097402 (2003).
8. Le Thomas, N. *et al. Nano Lett.* **6,** 557–561 (2006).
9. Farahani, J. N. *et al. Phys. Rev. Lett.* **95,** 017402 (2005).

MATERIAL WITNESS

Dirty physics

My copy of *The New Physics*, published in 1989 by Cambridge University Press, is much thumbed. Now regarded as a classic, it provides a peerless overview of key areas of modern physics, written by leading experts who achieve the rare combination of depth and clarity.

It is reasonable, then, to regard the revised edition, just published as *The New Physics for the Twenty-First Century*, as an authoritative statement on what's in and what's out in physics. So it is striking to see materials, almost entirely absent from the 1989 book, prominent on the new agenda.

Most noticeably, Robert Cahn of Cambridge University has contributed a chapter called "Physics and Materials", which covers topics such as dopant distributions in semiconductors, liquid-crystal displays, photovoltaics and magnetic storage. In addition, the chapter by Yoseph Imry of the Weizmann Institute in Israel, "Small-scale Structure and Nanoscience", is a snapshot of one of the hottest areas of materials science.

All very well, but it begs the question of why materials science was, according to this measure, more or less absent from twentieth-century physics but central to that of the twenty-first. One may have thought that the traditional image of materials science as an empirical engineering discipline with a theoretical framework based in classical mechanics looks far from cutting-edge, and would hardly rival the appeal of quantum field theory or cosmology.

Topics such as inflationary theory and quantum gravity are still on the menu. But the new book drops topics that might be deemed the epitome of physicists' reputed delight in abstraction: gone are chapters on grand unified theories, gauge theories, and the conceptual foundations of quantum theory. Even Stephen Hawking's chapter on "The Edge of Spacetime" has been axed (a brave move by the publishers) in favour of down-to-earth biophysics and medical physics.

So what took physicists so long to acknowledge its materials aspects? "Straight physicists alternate between the deep conviction that they could do materials science much better than trained materials scientists (they are apt to regard the latter as fictional) and a somewhat standoffish refusal to take an interest," claims Cahn.

One could say that physicists have sometimes tried to transcend materials particularities. "There has been the thought that condensed matter and material physics is second-rate dirty, applied stuff," Imry says. Even though condensed matter is fairly well served in the first edition, it tended to be rather dematerialized, couched in terms of critical points, dimensionality and theories of quantum phase transitions. But it is now clear that universality has its limits — high-temperature superconductors need their own theory, graphene is not like a copper monolayer nor poly(phenylene vinylene) like silicon.

"Nanoscience has both universal aspects, which has been much of the focus of modern physics, and variety due to the wealth of real materials," says Imry. "That's a part of the beauty of this field!"

Philip Ball