

Physics flourishes in Hong Kong

In just two decades, scientific research in Hong Kong has been transformed from an underfunded pastime into a world-class enterprise.

On 14 April, Hong Kong's condensed-matter theorists gathered at Hong Kong Baptist University (HKBU) to discuss a new family of iron-based superconductors. The discovery, published barely two months earlier, had touched off an explosion of research activity (see *PHYSICS TODAY*, May 2008, page 11).

Visitors from the US and mainland China joined the locals. Three of the participants, the University of Hong Kong's Fuchun Zhang and Zidan Wang and Stanford University's Shoucheng Zhang, had already posted their respective proposals for the pairing symmetry on the arXiv e-print server. Jianxin Li of Nanjing University brought news of the latest results from mainland China, where experimenters were leading the race to make, characterize, and understand the superconductors.

The meeting at HKBU epitomized the current state of physics in Hong Kong. Condensed matter is one of the territory's strengths, as is cooperation and coordination among its physics departments. And, from its establishment

as a British colony in 1842 through its return to China in 1997 to today, Hong Kong serves as a place where China and the West exchange not only goods and services but also ideas.

Thanks to those qualities, physics in Hong Kong is flourishing. Last year, authors from Hong Kong published more papers in *Applied Physics Letters* than authors from Switzerland, whose population is about the same. But as recently as the early 1990s, despite the territory's rich economy and competitive ethos, Hong Kong's research enterprise was puny. Universities focused on training lawyers, doctors, and other professionals.

Upgrading universities

Nai-Ho Cheung had just \$1000 a year to fund his research in laser-based analysis when he joined HKBU's physics department in 1981. The contrast between now and then is stark: "Like heaven and hell," he says.

The transformation began largely at the behest of two men: Sze-Yuen Chung, an industrialist and politician,

and Edward Youde, the 26th governor of Hong Kong. By the early 1980s, Hong Kong had grown rich thanks to booms in manufacturing and construction. In 1979 China's paramount leader Deng Xiaoping created a capitalist enclave in Shenzhen, a city that abuts Hong Kong's border with the mainland. China's economic rise began. Investment flowed from Hong Kong to Shenzhen; factories and manufacturing jobs followed.

To secure its continued prosperity, Hong Kong had to compete with its new, rich-country peers in a knowledge-based economy. More and better-educated graduates were needed. Hong Kong, as Chung, Youde, and others realized, needed to upgrade its university system.

The upgrade took several forms. In 1991 a new university, Hong Kong University of Science and Technology (HKUST), opened on a tree-lined campus overlooking Clear Water Bay. In 1994 two former technical colleges were raised to university status: the Hong Kong Polytechnic University (PolyU) and City Uni-



Looking North from Victoria Peak on Hong Kong Island you can see the skyscrapers of the central business district and, across Victoria Harbour, Kowloon. (Photo courtesy of Samuel Louie, Diocesan Boys' School, Kowloon.)

versity of Hong Kong (CityU).

To fund research at the new and old universities, Hong Kong created the Research Grants Council. Modeled on the UK's Science and Engineering Research Council, the RGC awards grants by competitive peer review. It routinely sends proposals to reviewers in the US, the UK, Japan, and other countries. Outside reviewers help to ensure that Hong Kong's research aspires to and meets world standards.

In beefing up university research, Hong Kong's goal was not so much to foster ties with industry, although that has happened. Rather, as Kenneth Young of the Chinese University of Hong Kong (CUHK) recalls, "We needed credible universities." Hong Kong also saw a marketing opportunity: to become a higher-education hub for southern China.

As if to reflect Hong Kong's free-market spirit, the RGC did not stipulate what science it would fund. The size of a typical grant, now about \$35 000 per year, does, however, limit what equipment a researcher can buy. On the other hand, the modest level of RGC research grants means that more—about half—can be awarded.

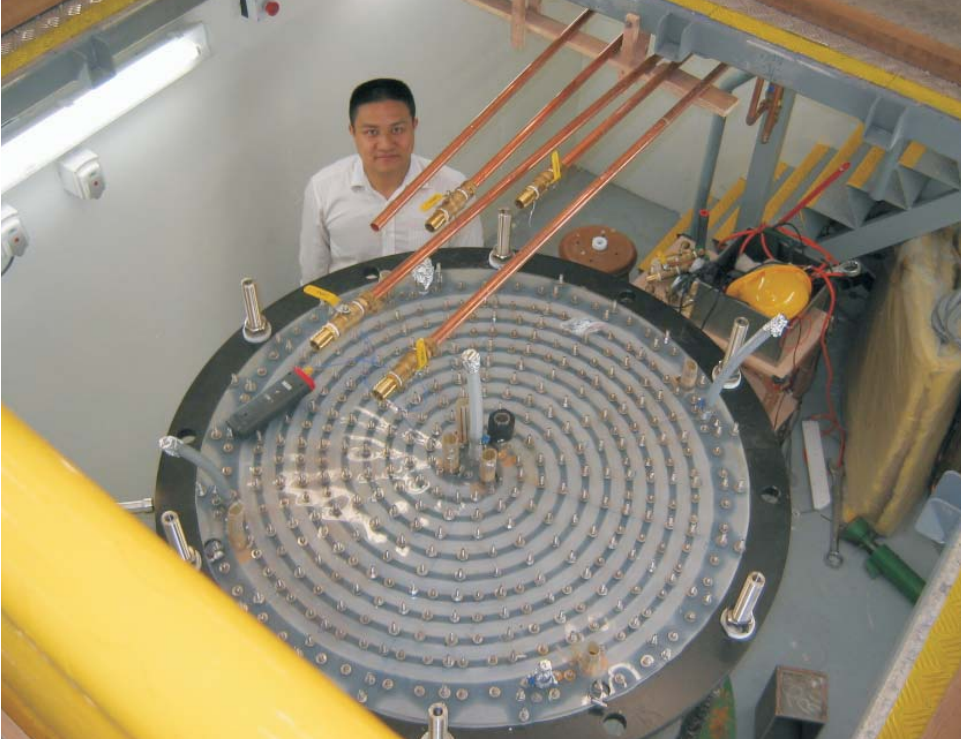
Without any guidance from above, what sort of physics has developed? Condensed matter, optics, and materials science, are all represented in one form or another in Hong Kong's six physics departments. Fluid dynamics, device physics, and astrophysics also feature.

Particle accelerators, fusion reactors, space telescopes, and other big-science projects are beyond Hong Kong's means. Moreover, Hong Kong is one of China's Special Administrative Regions, not a sovereign nation. It can't join and help fund international consortia such as the International Thermonuclear Experimental Reactor. Nevertheless, Hong Kong physicists do participate in international projects, as members of their universities.

For example, the University of Hong Kong (HKU) and CUHK are among the 33 institutions from five countries working on the Daya Bay Reactor Neutrino Experiment (see *PHYSICS TODAY*, December 2007, page 28). The \$32 billion project is in essence a bilateral collaboration between China and the US.

The relationship between the physics communities of Hong Kong and the rest of China reflects Hong Kong's special status. Since the 1997 handover to China, the former colony has operated under Deng's doctrine of one country, two systems.

CHARLES DAY



Experimental fluid dynamics is one of the strengths of the Chinese University of Hong Kong and Hong Kong University of Science and Technology. Here, Li-Yuan Ren, a graduate student in Ke-Qing Xia's group at CUHK, stands beside a tank he built to investigate Rayleigh-Bénard convection.

Hong Kong has retained its legal system and civil service, and it doesn't contribute tax revenue to mainland China. As a consequence of Deng's doctrine, Hong Kong receives no research funding from China, the world's third biggest economy.

Personal ties

Scientific ties between Hong Kong and the rest of China are more evident at the personal level. Just over half of HKUST's physics faculty, for example, come from the mainland. Ping Sheng, who recently stepped down as chair of HKUST's physics department, sits on advisory committees at several mainland universities. Until 1998, Nobelist C. N. Yang directed CUHK's Institute of Mathematical Sciences. Now he's a professor at Tsinghua University in Beijing and a distinguished professor-at-large at CUHK.

China's relationship with Hong Kong also affects another area in which physicists play a role: industry. Beginning in the 1950s, Hong Kong's manufacturing industry grew rapidly. Because local entrepreneurs found it difficult to borrow large amounts of capital, light, low-tech industry developed. Without government support, high-tech industry on the scale that developed in Taiwan and South Korea never took off, even after Hong Kong's manufacturing industry moved to China. Now Hong Kong's economy is

one of the least industrialized in the developed world. Manufacturing contributes 4% of GDP; services employ 83% of the workforce.

Still, ties between physics and local manufacturers do exist. HKBU's Kok-Wai Cheah, for example, develops LEDs in collaboration with Clover Display Ltd, Varitronix, and other companies. At PolyU and CityU, faculty members act as paid consultants for manufacturers in Hong Kong and the mainland.

Some universities are also forging ties with the financial sector. In June, CityU announced the establishment of a climate impact center. Funding for the center comes from Guy Carpenter & Co, a reinsurance broker based in New York City.

Even without extra income from consultancy, physicists in Hong Kong earn salaries comparable to those in the US and higher than in most European countries. Wang Yao is the newest member of HKU's physics faculty. When he was a postdoc at the University of Texas at Austin, he applied for tenure-track positions in Singapore, Hong Kong, and the US. HKU prevailed, in part because of the salary, but also because Yao's wife, a corporate lawyer, could easily find work. And, says Yao, "Hong Kong is not isolated. You can feel connected to exciting discoveries all around the world."

Hong Kong is also attractive to

physicists visiting from abroad. Itamar Procaccia of the Weizmann Institute of Science in Rehovot, Israel, is a frequent visitor to CUHK. Besides the science, he cites as attractions Hong Kong's convenient location for exploring South-east Asia, the efficiency of its infrastructure, the use of English, and the food. "Cantonese food is the best in the world," he says.

To improve its competitive position further, Hong Kong is pushing ahead with more changes. The economy has boomed in recent years, allowing the

RGC to establish a \$2.3 billion endowment fund for research. And in 2012, the entire university system will switch from offering English-style, three-year degrees to more internationally attractive US-style, four-year degrees.

As a result of the switch, the number of undergraduate students at Hong Kong's universities will increase by 33%. Building programs are under way to accommodate the impending influx.

The switch to US-style degrees will bring another challenge to physics departments: teaching large service

courses. Helen Chan, who chairs PolyU's applied physics department, sees service courses as an opportunity to expose nonmajors to physics. She and her colleagues also promote physics to high-school students through lectures and workshops. "We need to tell them what a career in physics is like," she says.

Chan herself decided to become a physicist when she was in high school. Her inspiration was a public lecture that C. N. Yang gave at Hong Kong's city hall.

Charles Day

G8 nations commit to building a score of CO₂ sequestration demonstration projects

But Congress could block the Bush administration's plan to finance 10 commercial-scale CO₂ capture and storage projects at coal-fired power plants.

The US government plans to sponsor half of the 20 commercial-scale demonstrations of carbon capture and storage (CCS) technology that the world's biggest industrialized nations have collectively pledged to get under way in the next decade. Heads of the G8 nations announced their commitment to deploy CCS as part of their goal to slash their nations' carbon emissions in half from current levels by 2050.

According to a joint communiqué issued at their 6–9 July summit in Japan, the G8 leaders said they "strongly support the launching of 20 large-scale CCS demonstration projects globally by 2010 ... with a view to beginning broad deployment of CCS by 2020." Both the number of and the timetable for the demonstrations are taken from a report by the International Energy Agency, prepared at the request of the G8 leaders. It is just 1 of 17 "technology roadmaps" that the IEA said will need to be followed in order to achieve the 50% reduction in carbon dioxide emissions.

At a Senate hearing in June, Neil Hirst, director of energy technology and R&D for the Paris-based IEA, warned that the size of that challenge should not be underestimated. On average, 35 coal-fired power plants with CCS must be installed each year from now through 2050, on top of new investments in wind, solar, and nuclear energy, if the world is to cut carbon emissions in half. "Given the challenges of establishing a single CCS project today, this is really an energy technology revolution," Hirst said. The UN's Intergovernmental Panel on Climate Change (IPCC) estimated last year that broad deployment of CCS could reduce CO₂ emissions by as much as 55% over

the coming century.

At the federal level, a number of actions have taken place during recent months that could accelerate CCS commercialization, but setbacks have occurred as well. In June the Department of Energy announced a plan to fund several commercial-scale CCS demonstration projects that will sequester at least 1 million tons of CO₂ a year. Although DOE's request for proposals didn't specify the number of projects it plans to support with about \$1.2 billion over several years, a top department official indicated that there are likely to be at least three.

A troubled future

The June solicitation resulted from a restructuring of FutureGen, a 2003 initiative by which DOE would share the cost of building an entire integrated gasification combined cycle (IGCC) electric-generating station and the associated CCS system. Energy Secretary Samuel Bodman pulled the plug on the project in January, citing cost estimates that had doubled from the original \$1 billion

projection and the unwillingness of a 13-member industry consortium to pick up a greater share of the overruns. DOE had agreed to pay 74% of the project's cost at the outset, far more than the traditional 50–50 cost sharing it offers in most of its cooperative agreements with industry. Moreover, Bodman reasoned that with commercial-scale IGCC plants already in operation, the FutureGen resources could be spent more productively on developing CCS technologies alone.

But the cancellation created an uproar in Congress. Senate appropriators zeroed out DOE's \$290 million fiscal year 2009 request for the restructured program, and Senator Richard Durbin (D-IL) has blocked Senate consideration of President Bush's nominee for deputy energy secretary, calling for the fate of FutureGen to be left to the next administration. The House Committee on Science and Technology meanwhile continues its probe into the project. In a 28 July letter to Bodman, committee chairman Bart Gordon (D-TN) and two other panel Democrats demanded that

Dave Luebke, an engineer in the office of research and development at the Department of Energy's National Energy Technology Laboratory, examines membranes used in NETL research on CO₂ separation. The membranes are among the technologies being explored to capture CO₂ generated from coal combustion for underground sequestration.



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