way of sorting photons according to their orbital angular momentum. In the 24 June *Physical Review Letters*, the team members describe how they first prepared a laser beam containing photons with different amounts of orbital angular momentum. They then split the beam, giving the two branches a further twist of 180° relative to one another, and finally recombined them.

When they come together, because of that extra twist and the symmetry properties of orbital angular momentum, photons having an odd number value of orbital angular momentum exit one way from the recombination point, and those with even values exit at right angles to it. These two sorted beams are then individually fed into a second similar splitting, twisting, and recombining setup and so on, in a cascade. Successive levels sort photons according to different multiples of 2 in their orbital angular momentum. Padgett's team made a trial two-stage cascade, enabling them to sort photons having orbital angular momentum values of 0, 1, 2, and 3. "This is equivalent to reading two bits of data from each photon," says Courtial.

"We will be able with this new method to process information in new ways and perhaps make more secure communications," says Oxford's Burnett. For example, blending several quantum states onto a single photon might offer a new route to quantum computation. Although the system is unlikely to work in optical fibers, Padgett sees numerous commercial prospects in loading data onto a single photon, and he is already talking to communications companies. **–ANDREW WATSON**

Andrew Watson is a writer in Norwich, U.K.

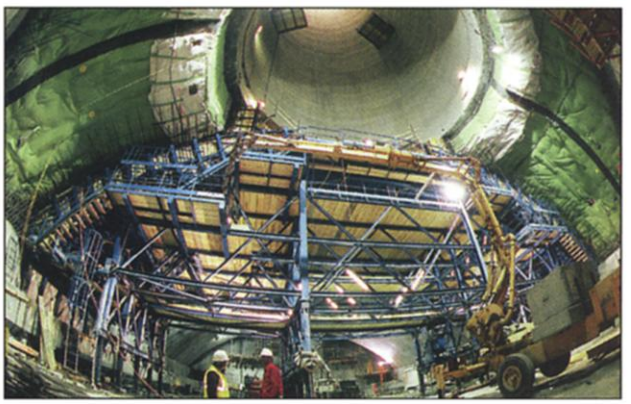
HIGH-ENERGY PHYSICS

CERN Panel Calls for Cuts and Shake-Ups

GENEVA—It's official: CERN must slash other research projects in order to finish the Large Hadron Collider (LHC). That's the conclusion of a group tasked with reviewing the $2 billion megaproject, under construction here at the European laboratory for particle physics, in the wake of cost overruns disclosed last fall (*Science*, 5 October 2001, p. 29). And non-LHC projects might not be the only sacrificial lambs: CERN is coming under pressure to shake up its senior management.

In December, CERN's governing council, outraged by LHC's increasing price tag, appointed a nine-member external review committee (ERC) to assess how best to complete the massive proton collider. In its report, presented last week at the council's biannual meeting in Geneva, ERC praised the design of LHC and the technical competence of CERN staff. But it blasted the lab for "serious weaknesses" in cost control, contract management, and financial reporting, and it called for steps to set things right. CERN council president Maurice Bourquin says the council has accepted ERC's recommendations.

The proposed remedies generally follow those in a medium-term plan that CERN proposed in March (*Science*, 29 March, p. 2341). The committee called on the lab to shift some $300 million from other operations into LHC and stretch out payments for the facility until 2010. Among numerous cost-cutting measures, ERC recommended that CERN shut down both of its existing proton colliders—the Proton Synchrotron and Super Proton Synchrotron—for all of 2005 and reshuffle staff from other accelerator projects to LHC. Finally, ERC's report laid out two models for a new organizational structure aimed at making CERN's management more efficient and accountable.



CREDIT: CERN-GENEVA

Depth charge. Underground construction of the Large Hadron Collider gave CERN's governors a case of sticker shock.

Such changes would be "a big step in the right direction," says Ian Halliday, a council member from the United Kingdom, adding that given the rift between CERN and its council, the negotiations that led to agreement on the report's conclusions "could have gone very badly wrong."

The council has given CERN's management until September to develop a short-term plan for putting most of ERC's recommendations into effect and until December to overhaul LHC's finances. The revision will include cost-to-completion estimates for LHC and a long-term budget and staffing plan for the entire lab. One key ERC recommendation—the call for a "new organizational structure"—although welcomed by council, "will take a bit longer" to implement, says Halliday. CERN director Luciano Maiani's term ends in December 2003, and particulars of the new organizational structure must be worked out in collaboration with his successor, whose name will be known in December 2002.

With a plan in place, the council agreed to release $22 million it had held back from the laboratory's 2002 budget when it launched the ERC investigation. It also approved the lab's proposed $805 million budget for 2003.

CERN's LHC push will hurt smaller projects such as the lab's Antiproton Decelerator, which will also be suspended for 2005. And although CERN will still provide a beamline to send neutrinos to Gran Sasso, Italy, it has withdrawn from the planned experimental portion of the project, which means a halt to neutrino physics for the lab. "Nobody likes it, that's for sure," says Dieter Schlatter, leader of CERN's experimental physics division. Yet most researchers agree that such cutbacks are the price to pay for LHC.

Indeed, all the good news was saved for LHC. Maiani announced that CERN is in the final stages of negotiating a bank loan for an additional $198 million toward the project's construction. He also reported happily that excavation of LHC's two new detector caverns, a major villain in the cost overruns, is now essentially complete. That puts the collider on track to begin operations in mid-2007—2 years late. That schedule is based on staffing levels that are not yet guaranteed, and it assumes that nothing else will go wrong, ERC notes.

Although it would be "dangerous" to think that CERN's problems are solved, Maiani says, the LHC picture is in sharper view than it was a year ago. "We know pretty well how much [LHC] will cost; we know pretty well who will make it; and we are even starting to know who is going to pay for it," he says. **–GISELLE WEISS**

Giselle Weiss is a writer in Allschwil, Switzerland.

ASTRONOMY

Cosmic Lenses May Be Magnifying Quasars

Some objects in deep space are not quite as they appear. As their light zips across billions of light-years to Earth, the gravity of matter along the way stretches, splits, and contorts their images. Now, a new study predicts that these mirages, called gravitational lenses, are unexpectedly common for the most distant bodies that astronomers see: quasars near the fringes of the visible cosmos. Up to one-third of these remote beacons might be dramatically brightened by what Harvard University astronomer Abraham Loeb calls "natural telescopes" in the sky. The finding might help resolve a puzzle about these enigmatic

Not so bright? This quasar, one of the four most distant known, might be magnified by an intervening galaxy.

denizens of the early universe.

The farthest quasars have popped up during the Sloan Digital Sky Survey (SDSS), a multiyear effort to map the sky in exhaustive detail (*Science*, 25 May 2001, p. 1472). To date, SDSS astronomers have found four quasars that shone brilliantly when the universe was less than a billion years old. Cosmologists presume that black holes with billions of times the mass of our sun powered those early blazes by devouring gas at the cores of the first big galaxies. However, theories of galaxy evolution struggle to explain how such massive objects arose so soon after the big bang. Gravitational lensing might ease the problem: If some quasars are actually dimmer than they appear, then their host galaxies must be correspondingly smaller.

To calculate how lensing affects our view of that epoch, Loeb and Harvard postdoctoral researcher J. Stuart B. Wyithe worked backward from the statistics of quasars and lenses closer to Earth. As they explain in the 27 June issue of *Nature*, they considered two key factors. First, it's more likely that a random galaxy will align with and magnify a distant quasar, because its light travels a much longer path. Second, lenses might allow telescopes to detect many faint quasars that they otherwise wouldn't find. This "magnification bias" could be extreme in the early cosmos, says Loeb, where modest quasars might greatly outnumber the truly bright ones.

When Wyithe and Loeb combined both factors, they found that gravitational lensing might boost the apparent light output of 10% to 30% of the most distant quasars by a factor of 10 or more. "That's a surprisingly big fraction, and observers need to correct for it," Loeb says. Indeed, the proportion is far higher than astronomers are used to seeing. Of the quasars that existed when the universe was 3 billion to 4 billion years old, just one in every 750 are magnified, according to a recent survey by astronomer Joshua Winn of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, and his colleagues.

"If Wyithe and Loeb are right, the early universe will be all that much harder for us to understand because of the distorted view," comments Princeton University astrophysicist Edwin Turner. A test will come soon: Starting this fall, Princeton astronomer Michael Strauss and his SDSS partners will use the Hubble Space Telescope to examine dozens of quasars, including their four most distant ones, for multiple images—the signpost of a lensed quasar. Moreover, SDSS should find 10 to 20 more quasars at similar distances in the next several years. **–ROBERT IRION**

CANADA

Few Women Win New Academic Chairs

OTTAWA—Statistics can often be subtle and hard to interpret. But sometimes, says Wendy Robbins, co-founder of the women's studies program at the University of New Brunswick in Fredericton, they can slap you right in the face. That's what she hopes will happen to Canadian university administrators reading a new report showing that women are seriously underrepresented in a fledgling program to help the country retain its best academic talent.

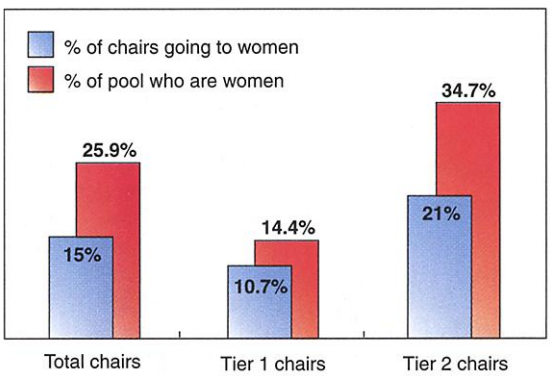
In October 1999 the government committed $585 million to create 2000 new posts under the Canada Research Chairs (CRC) program. The program provides $910,000 over 7 years to free up established researchers (Tier 1) from teaching duties and $325,000 over 5 years to help universities hire rising stars (Tier 2) to replace aging faculty. The fifth round of winners was due to be announced this week.

A report looking at the first four classes shows that women, who represent 25% of the total academic pool, have received just under 15% of the 532 chairs (see graphic). The gender gap is especially wide for the Tier 2 posts, 21% of which have gone to women despite the fact that they make up 35% of the assistant and associate professors eligible for the award. CRC officials commissioned the study, done by Nicole Bégin-Heick, professor emeritus of biochemistry at the University of Ottawa, after receiving numerous complaints from female faculty members across the country.

Bégin-Heick says one possible reason for the imbalance is that women "are perhaps less ambitious than men, and they are less likely to seek these honors, if you want to call it that." But Robbins, an English professor who's vice president of the women's issues network at the Humanities and Social Sciences Federation of Canada, points the finger at "the old boy's network of deans and academic vice presidents" that shuts out women. "Several universities have not appointed a single woman," she notes. "One would have thought, by now, that enlightenment would have prevailed." Robbins says that affirmative action plans and more aggressive recruitment are needed to make a real difference in the short run.

Imposing quotas would be difficult because universities are autonomous institutions, says René Durocher, CRC secretariat executive director. "You can't give orders to these people." But he says that CRC could seek legislative approval for such a "last resort" measure if the gender imbalance doesn't significantly improve over the coming year.

The heads of the councils that fund social science and medical research have sent letters to all university presidents, beseeching them to redress the imbalance in future competitions for the roughly 1400 chairs still to be awarded. "I trust you will take advantage of this opportunity to reflect upon the significance of these numbers and, more importantly, what your university plans to do to address the situation," wrote Marc Renaud, president of the social sciences granting council and chair of the CRC steering committee, who attached a table showing the gender distribution of all nominations for each participating university.



Seats at the table. Women are underrepresented in both categories of the Canadian Research Chairs program.

Meeting last week in Toronto, Durocher and 100 senior university administrators proposed that institutions provide a written rationale for the gender distribution of all future nominations. They also want the federal government to create 400 additional chairs in the social sciences and humanities, in which women constitute a larger proportion of the professoriate. Those fields now get only 20% of the chairs, despite representing a majority of the professoriate, with the rest split equally between the biomedical and natural sciences.

–WAYNE KONDRO

Wayne Kondro writes from Ottawa.

CREDITS: (TOP TO BOTTOM) STEPHEN KENT/SDSS COLLABORATION; SOURCE: CANADIAN RESEARCH CHAIRS