Academia Sinica is currently offering Ph.D. programs in cooperation with local universities, but it wants to take full responsibility for the programs. Adding a graduate program won't trigger a hiring boom, however, because the courses will be taught by existing Academia Sinica staff members. That staff is still dominated by ethnic Chinese, although it is recruited internationally.

SIT's distinguishing characteristic will be "very strong interaction with the IT industry," says Chung KunMo, president of Hoseo University in Seoul and chair of SIT's advisory committee. Located in the heart of Teheran Valley, South Korea's answer to Silicon Valley and the home of the country's booming IT sector, SIT is offering internships and work-study programs and hopes to link future entrepreneurs with venture capitalists to better prepare students for the real world. For the first semester, only one member of the faculty is a foreigner, and he's a part-timer borrowed from an international management consulting firm. But the school anticipates hiring several top-level U.S. academics as it expands.

One challenge facing all the new schools is attracting sufficient numbers of foreign faculty members and students to provide an international flavor. "The success of this project really depends on recruiting qualified non-Korean researchers," says SNU's Yim. Academia Sinica, sensitive to charges that it is out to steal the best students from local universities, hopes that three-fourths of its Ph.D. candidates will be non-Taiwanese.

One existing institute suggests that it is at least possible to attract good foreign faculty members to Asia: Singapore's Institute of Molecular and Cellular Biology (IMCB), at which 13 of 35 principal investigators hail from North America or Europe. "When we were starting, no one believed we could attract qualified researchers from the advanced countries, but we did," says Chris Tan, who became IMCB's founding director in 1987 after working overseas for many years. Tan stepped down as director last year and serves on the board of advisers to the Okinawa graduate university. But even IMCB has yet to attract more than a handful of graduate students from the West.

Adequate funding is critical, says Tan. Yim says that South Korea's Ministries of Education and Trade and Industry have jointly promised at least $200 million over 5 years to get Bio MAX up and running. But government support is still a dream for the private SIT, bankrolled by Kang Chul-Koo, an entrepreneur with interests in architecture, construction, and real estate. George Strawn, executive officer for the computing sciences directorate at the U.S. National Science Foundation and an adviser to the program, says that SIT really needs "a broader financial base." Organizers hope South Korean IT companies will lead the way.

Japan's new school also faces formidable financial hurdles. As Japan's poorest region, Okinawa receives approximately $3 billion a year in economic subsidies from the central government, mostly for public-works projects. The university's supporters hope to tap into those road-building funds to cover the operating costs of the school. But that idea may not sit well with local and national construction officials, contractors, and site workers. The outcome of that tug of war may become clear this fall when the budget for the next fiscal year takes shape.

Backers of all these schemes admit that their ventures are hardly risk free. But they believe that the consequences of standing pat—and failing to train their students to world-class standards—leave them no choice but to try.

–DENNIS NORMILE

Astrophysics

Robotic Telescopes Catch Up With Gamma Ray Bursts

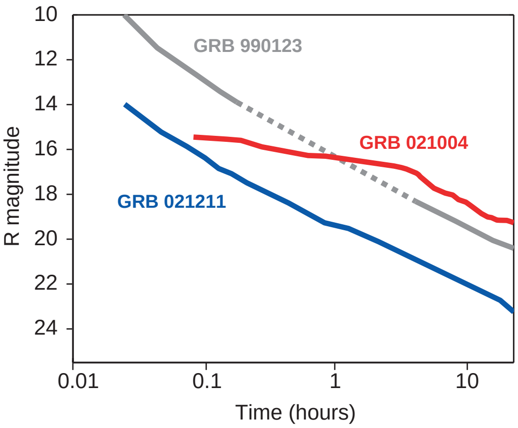
Optical flashes spotted just minutes after two bursts portend a bright future for understanding the universe's most violent explosions

Robots still can't master the mundane—like mowing the lawn or washing your socks—but they can pull off some spectacular feats. Astronomers have trained robotic telescopes to sweep the skies in one of the field's most glamorous pursuits: the hunt for gamma ray bursts (GRBs), brief but enormously powerful blasts of high-energy radiation from deep space. Now, after years of unrealized hopes, the automatons have come through—with surprising results.

Reports this week describe two GRBs spotted late last year by an x-ray satellite, which beamed the locations of the bursts to an Internet-based alert network on the ground. Within minutes, rapidly pivoting optical telescopes photographed fiery "afterglows" of lower energy visible light, created as shock waves from the bursts reverberated through space. The events—just the second and third ever seen so quickly—have thrilled experts by revealing one unusually persistent fireball and illuminating the brief life of another that otherwise would have passed unnoticed.

"These are about as different as you could possibly imagine two bursts being," says astrophysicist George Ricker of the Massachusetts Institute of Technology (MIT) in Cambridge. "People now realize how much can be done in the first few minutes" to explore those differences, he says.

Theorists believe that so-called long GRBs—those lasting a few seconds to a few minutes—arise within ferocious beams of particles and energy spawned when a massive spinning star collapses to form a new black hole, which swallows most of the star. Models predict that such a "collapsar" spits out narrow jets that explode into space along the star's axis. Gamma rays stream from turbulence within the jet itself, the theory holds. "These should be the fastest bulk motions in the universe," says astrophysicist Bing Zhang of Pennsylvania State University (PSU), University Park. Only the small fraction of explosions with jets aimed directly at Earth would appear as GRBs; the rest might look like ordinary supernovas.



Not fadeaway. An October burst (red curve) dimmed far more gradually than two other rapidly detected afterglows.

According to the currently reigning model, GRB afterglows arise when a jet hits gas or dust in space near the burst. A violent "reverse shock" cascades back into the jet itself and sparks a flash of optical light that quickly expires, says astrophysicist Peter Meszaros of PSU. The leading edge of the jet then keeps plowing forward, spewing x-rays and optical light as it gradually slows down during the next hours and days.

"This fireball model is a nice description,

CREDIT: DEREK FOX/CALTECH

but we have needed more detail about its initial evolution," says astrophysicist Andrew MacFadyen of the California Institute of Technology (Caltech) in Pasadena, a creator of the collapsar scenario. That's because the jet moves fastest during the earliest phases of the afterglow, opening the clearest window onto the central engine that powers it.

Not long ago, such early detections seemed set to become routine. Several groups of astronomers built small robotic telescopes to monitor wide swaths of the sky, often several times a night, in a quest for rapidly varying or moving objects. Programmers designed the systems to interrupt their scans if they received an Internet alert from NASA's Compton Gamma-Ray Observatory (CGRO) or the Dutch-Italian BeppoSAX satellite. Most systems weren't cheap—typically $250,000 in hardware costs and perhaps four times that for the complex software needed to control them. Still, astronomers knew there was no other way to ensure a rapid GRB follow-up on the ground, because big telescopes can't whip to a random spot on the sky that quickly.

The first sighting was spectacular. On 23 January 1999, the Robotic Optical Transient Search Experiment (ROTSE), telephoto lenses on a swiveling platform near Los Alamos National Laboratory in New Mexico, caught the fantastically bright optical emission from the most powerful burst yet seen, GRB 990123 (*Science*, 26 March 1999, p. 2003). That image, snapped just 22 seconds after the explosion began, remains the only optical record of a burst in progress.

But the robots wouldn't strike again for nearly 4 years. Burst alerts dwindled as CGRO and BeppoSAX expired in 2000 and early 2002, respectively. Meanwhile, on Earth, astronomers realized that their robot scopes needed bigger lenses or mirrors to catch typical GRB optical glows, which are less than 1% as bright as GRB 990123's flash. Consequently, most GRB images on the ground were taken hours or days later by astronomers at larger telescopes, long after the crucial initial flash was gone.

The current GRB sentinel in orbit is the High-Energy Transient Explorer-2 (HETE-2), launched in October 2000. HETE-2 spent its first year beset by a degraded optical filter and funding woes (*Science*, 30 November 2001, p. 1817). But now, says mission leader Ricker of MIT, it's all systems go as HETE-2 beams down sky positions for about 20 bursts per year. Even so, it takes a chain of good fortune—quick and accurate positions, accessible spots on the sky, clear observing conditions—for robots to spot the glows within a minute or two.

Two of HETE-2's latest detections have set the field abuzz. On 4 October 2002, the satellite spotted a bright GRB about 10.7 billion light-years away. Although it was too low in the sky for U.S.-based robotic telescopes to see, an automated system in Wako, Japan, captured an image just 193 seconds after the explosion. The burst alert also jangled the cell phone of Caltech astronomer Derek Fox, who leapt out of bed to send a command to the upgraded 1.2-meter Oschin Telescope at Caltech's Palomar Observatory, which ordinarily scans for near-Earth asteroids. That telescope took several images starting 9 minutes after the burst.

As Fox and his colleagues report this week in *Nature*, these and myriad other observations of GRB 021004 paint a fascinating portrait of a stubbornly bright afterglow. Its light subsided at a leisurely rate, in stark contrast to that of GRB 990123 and the other recent burst spotted by HETE-2 (see figure, p. 1833). "Our story is that something continuously refreshes the reverse shock," says Caltech astrophysicist Shrinivas Kulkarni, who was scheduled to appear with Fox this week at a NASA press briefing in Washington, D.C. "The only way to do that is to keep adding energy."

In a flash. The 0.76-meter KAIT, a robotic telescope at Lick Observatory in California, nabbed the glow of a December gamma ray burst less than 2 minutes after a satellite spotted it.

CREDIT: WEIDONG LI/UC BERKELEY

Fox and Kulkarni see two plausible explanations. First, the central explosive engine powering the jets could remain active for much longer than expected. If so, the collapsar would be a sort of inferno rather than a single detonation, perhaps driven by material falling back onto a raging accretion disk around the newborn black hole. Second, the jets themselves might drag slower material along their edges, forming an extended spray of matter to feed the reverse shock.

No such behavior was evident in a much shorter burst seen by HETE-2 on 11 December 2002, for which robots played the critical role. First on the scene in 65 seconds was RAPTOR, an advanced telephotolens system based at Los Alamos. At that early phase, the afterglow was the second-brightest yet seen, says astronomer W. Thomas Vestrand, leader of the RAPTOR team. Vestrand's group has fixed a software bug that prevented an even faster image, so he expects RAPTOR to take data as early as 10 seconds after future explosions.

The best records of GRB 021211 came from the Katzman Automatic Imaging Telescope (KAIT) at Lick Observatory near San Jose, California. KAIT, a 0.76-meter telescope designed to discover scores of supernovas per year, swung to the GRB less than 2 minutes after the blast. In the next 10 minutes, KAIT took 18 exposures, producing by far the most detailed tracing of a GRB's early output.

GRB 021211 dimmed so fast that its afterglow might have escaped notice without the robots, says KAIT director Alex Filippenko of the University of California (UC), Berkeley. In earlier years, astronomers might have classified the event as a mysterious "dark" GRB with no visible afterglow. "Now, it seems that dark bursts may just fade very quickly and be faint to begin with," says astronomer Weidong Li of UC Berkeley, lead author of a report on GRB 021211 in the 20 March *Astrophysical Journal Letters*.

It's too soon to draw conclusions about early GRB behaviors with just three good samples in hand, Filippenko notes. That will soon change. A NASA satellite called Swift, set for launch in December, should spot and study about 100 bursts per year. A growing fleet of perhaps two dozen telescopic robots worldwide will respond obediently to Swift's notices. Leading systems include Super-LOTIS at Kitt Peak National Observatory in Arizona and a Spanish collaboration called BOOTES. ROTSE, now an international program led by the University of Michigan, Ann Arbor, is installing four identical telescopes in Australia, Namibia, Texas, and Turkey. An Italian team has erected a new 0.6-meter Rapid Eye Mount automated telescope for GRB studies in Chile, and an older 1.5-meter telescope at Palomar Observatory will be fully roboticized later this year.

Even veterans of cosmic mayhem are bracing themselves for more surprises about GRBs from Swift and this robot army. "Ten years ago, I would have said that we understand how massive stars die," says Kulkarni. "Now, I think there is a huge variety of ways, and gamma ray bursts are the tip of the iceberg."

–ROBERT IRION