Within a few hours, a team led by Derek Fox (Pennsylvania State University) had established with photometric data from the 8-m Gemini North telescope that the new GRB's redshift was about 8, clearly a record!

By then dawn was breaking over Hawaii, so IR spectroscopy had to wait for nightfall at large telescopes in Chile and the Canaries.[3] Together with the earlier photometry, the IR spectra yielded $z = 8.26 \pm 0.08$ (see figure 2). But because a GRB's afterglow fades rapidly after a few hours, the spectra were too noisy to reveal absorption features that could address two cosmologically important issues: the abundance of "metals" (astronomers' jargon for anything heavier than helium) in this very early star and its galaxy, and the abundance of neutral atomic hydrogen in the intergalactic medium (IGM) nearby.

Swift's burst-alert telescope monitors more than 10% of the entire sky at once. So it discovers GRBs almost daily. For about a third of them, however, no optical afterglow is found and therefore no redshift is measured. It's likely that among those discards, most of them local, are a few high-z GRBs for which no one troubled to look for the IR afterglow. "So there was some serendipity in the recognition of GRB090423's record redshift," says Edo Berger (Harvard) of the Gemini North team. "And a handful of comparably distant GRBs recorded by *Swift* have almost certainly evaded such recognition."

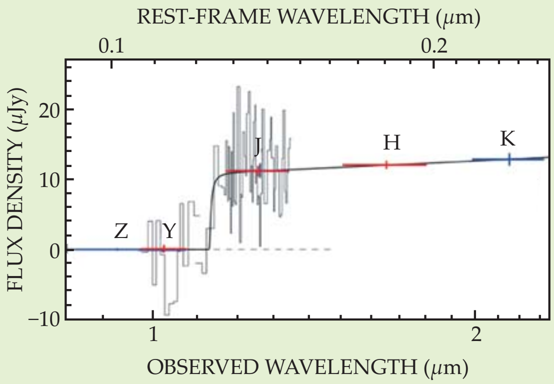

Figure 2. IR spectrum (the noisy gray curve) recorded 17 hours after the onset of GRB090423 with the 16-m Very Large Telescope in Chile. The GRB's redshift is determined primarily from the fitted wavelength of the Lyman-α absorption break near 1.1 μm. (In the laboratory, the Lyman-α line is at 122 nm in the UV.) The fitted break position is strengthened by photometric observations (the colored data points labeled by IR wavelength band) recorded much earlier by various ground telescopes. The absence of any photometric signal blueward of 1.1 μm was the first evidence that the GRB had a record redshift. (Adapted from ref. 1.)

Population III stars and reionization

Because Big Bang nucleosynthesis produced almost nothing but hydrogen and helium, it's assumed that the first generation of stars—perversely called "population III"—began life with no metals. Astronomers have yet to find a population III star. The population III epoch had probably begun by $z = 20$. "But we don't know how long it lasted or how much of a role it played in cosmic reionization," says Loeb. "Nor do we know if population III stars could have produced GRBs." They were probably massive enough. But to generate an observable GRB, a collapsar must previously have shed its hydrogen envelope, and the stellar wind that strips off the envelope may require some threshold metallicity to get the job done.

There's no spectral information about GRB090423's metallicity. But its progenitor was probably not a population III star. Population III GRBs, if they exist at all, are expected to have atypically long durations.

Why is the ionization of intergalactic hydrogen by UV radiation from early stars called *re*ionization? The cosmic

physics update

These items, with supplementary material, first appeared at http://www.physicstoday.org.

Glacier-related seismicity. Iceland, located on top of the Mid-Atlantic Ridge, is one of the most geologically active places on Earth. Its Katla volcano—buried deep under a huge glacier—is particularly large and active: It tends to explosively erupt every 50 or 60 years, although its most recent eruption was back in 1918. One type of nearby seismic activity is so-called long-period (lp) earthquakes, which have shallow origins and magnitudes of less than 3.3. Swarms of those quakes are sometimes thought to indicate an imminent eruption; after more than 900 lp events took place in October 2002, local authorities developed evacuation plans.

But Kristín Jónsdóttir (shown here making field measurements) and her colleagues at Uppsala University in Sweden conclude that the glacier, not the volcano, is the culprit. As the glacier gradually flows down a long valley, part of it reaches a cliff where gargantuan 80-meter-thick ice sheets break off and drop 100 meters, carrying more than enough energy to account for the seismicity. The researchers analyzed data from more than 14 000 lp events in 1991–2007. The events' locations, waveforms, seasonal variations, and other variables all pointed to the calving outlet glacier as the seismic source. The authors note that continued global warming could increase such seismicity. For more on glaciers and earthquakes, see PHYSICS TODAY, September 2008, page 17. (K. Jónsdóttir et al., *Geophys. Res. Lett.* **36**, L11402, 2009.)

—SGB

Measuring a quark–antiquark mass difference. In any Lorentz-invariant local field theory, particle and antiparticle masses must be identical. That equality has been verified to high precision for leptons and hadrons, but not for quarks. With one exception, it's impossible to measure quark masses directly because a newly created quark "dresses itself" in other quarks and gluons to form a hadron within 10^{-22} seconds. And hadron masses yield, at best, only rough estimates of the quark masses. The exception is the top quark. Almost 200 times heavier than the proton, the top is by far the most massive quark. Its lifetime of 10^{-24} seconds is much too brief to form a hadron. Thus by measuring its decay products, experiments at Fermilab's Tevatron collider have determined the top mass (173 GeV) with a precision of better than 1%. Those experiments were based on the production of top–antitop pairs, and the analyses assumed that the masses were equal. Now the DZero collaboration at the Tevatron has reanalyzed its data to