



Issue 8
November 2007

Swift Year in Review - PI Neil Gehrels



The year 2007 has been a roller coaster ride for the Swift mission. We have been to the top of the top and the bottom of the bottom and everywhere in between at dizzying speed. The top was the wonderful news in January that the Swift team was

awarded the Bruno Rossi Prize of the American Astronomical Society. The bottom occurred in August and September when Swift was largely off-line due to hardware/software problems on the spacecraft. And everywhere in between has been a string of new scientific findings and a workshop in May where the Swift team peered into the looking glass to plan for the future.

I would love to wax eloquent on the Rossi Prize, but I already did that in the last newsletter. So, I guess we should start with the recent hardware/software problems. Mission Director John Nousek gives a detailed discussion of Swift status in his article. The short summary is that one of the 3 dual-gyro modules on the spacecraft exhibited anomalous behavior (occasional glitches in its readings) starting August 10. We only need two for normal operations and so switched to the back-up unit. In the effort to calibrate that unit, we discovered that it had a misalignment which could not be corrected for in the onboard software due to a subtle flaw in the attitude control algorithms. Two months of hard work later, we finally have things patched up, using a clever technique devised by Craig Markwardt on the BAT team, and are returning to normal operations and burst chasing. Luckily, the faulty gyro is still functional and, with suitable care to avoid the glitches, could be used to control the spacecraft if one of the other two failed.

The planning meeting in May was held at Penn State and was a thrilling event. The purpose of this workshop was to gather input from the astronomical community about how best to use Swift's capabilities over the coming years to advance our understanding of the universe. We invited world experts in a wide range of topics and asked them to think about, and then speak to us on, future opportunities for Swift observations relevant to their areas. We also invited several prominent researchers with broad interests to advise us on how best to balance the observing time between promising science areas.

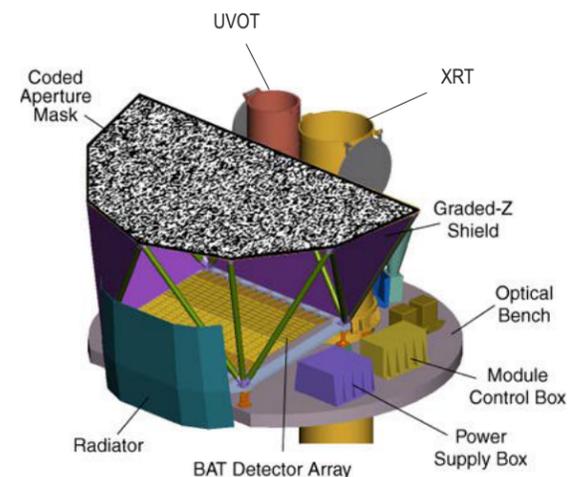
I was delighted to hear how much Swift has become a key tool in studies of Gamma-Ray Bursts (GRBs), of course, but also in studying galaxies, quasars, supernova, novae, black holes and neutron stars in our Galaxy, along with active stars, and even comets. We debated how much observing time should be spent on observing GRBs and non-burst targets. The conclusion was that Swift should keep its primary focus on GRB research, but spend about half the time spread among the other science areas.

As a result of the input we received at the workshop, the Swift Executive Committee has decided on several new initiatives for the mission. First, to improve the GRB data, we are now taking greater care to choose targets to observe each day that are as far away from the sun as possible, that way Swift detects new GRBs in regions of space that are most accessible in the night sky for ground-based telescopes that gives better follow-up data from big telescopes to find the host galaxies of the bursts and their distances.

continued on p.2

Swift Newsletter





Another new initiative is to tune the BAT instrument for weaker GRBs. This will not be easy since the BAT is already set to be sensitive. We will lower the thresholds for detecting faint signals to the point where false "noise" events start to creep in. We won't know at first if the weak blip is a real GRB or a false event, so the spacecraft will slew immediately for each BAT detection and observe with XRT and UVOT. The idea is that an afterglow detection by XRT and/or UVOT will tell that the event was really a GRB and that Swift should keep observing it. If nothing is seen with XRT or UVOT, we will quickly terminate the observation and go back to the original schedule observing non-GRB targets and waiting for the next event. It is difficult to predict how successful this method will be in picking up interesting new types of GRBs. We will lower thresholds first as an experiment for a month toward the end of 2007. I can't wait to see what develops and will let you know the outcome!

In the next newsletter, I will discuss some of the non-GRB science opportunities identified at the workshop.

Swift in the News

By Chip McAuley, SSU E/PO

5/22/07 - Gamma-ray Bursts Active Longer Than Thought

Observations indicate the afterglows of GRBs to be part of the continuous GRB explosion and not separate phenomena. For more information on this developing discovery visit the GSFC press release at:

<http://swift.gsfc.nasa.gov/docs/swift/news/2007/07-22.html>

6/26/07 - Double Supernova in Galaxy Seen

Two supernovae flared up in the Hercules constellation, galaxy MCG + 05-43-16, 380 million light years away from earth. Such rare events, never observed together until this year, likely took place thousands of years from one another in the distant past. Go in-depth by reading the GSFC press release at:

http://www.nasa.gov/centers/goddard/news/topstory/2007/double_supernova.html

7/30/07 - Japanese and NASA Satellites Unveil New Type of Active Galaxy

A new class of active galactic nuclei (AGN) was discovered by an international team of scientists using the NASA Swift satellite and Japanese/U.S. Suzaku X-ray observatory. The findings will assist researchers in understanding why some supermassive black holes shine while others do not emit radiation. Learn more about this joint discovery by reading the GSFC press release at:

http://www.nasa.gov/centers/goddard/news/topstory/2007/active_galaxy.html

9/12/07 - NASA Astronomers Find Bizarre Planet-Mass Object Orbiting Neutron Star

A planet-mass body approximately 10 times the size of Jupiter was discovered orbiting a pulsar every 54.7 minutes. The relatively short distance between the two celestial bodies is 230,000, less than the distance between the earth and the moon. The discovery was made by Swift and the Rossi X-ray Timing Explorer (RXTE). Get more facts on this celestial oddity from the GSFC press release at:

http://www.nasa.gov/centers/goddard/news/topstory/2007/millisecond_pulsar.html

For links to all of these press releases and images, see: <http://swift.gsfc.nasa.gov/docs/swift/news/>

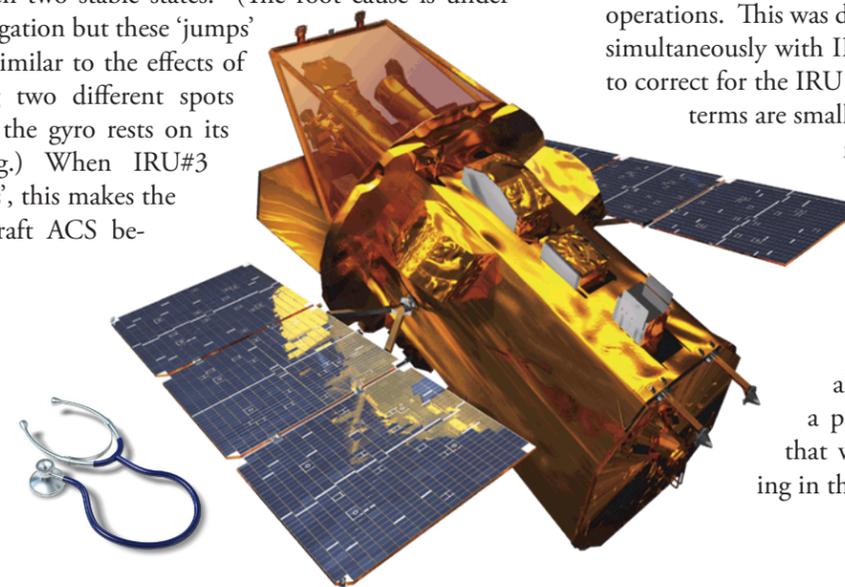
Mission Director Report

By John Nousek, Penn State, Swift Mission Director

On August 11, after 991 days of near flawless operations, the Swift satellite had its first significant hardware problem. The immediate problem was an inability to accurately conduct pointings at the desired targets. This Attitude Control System (ACS) issue forced Swift into a safehold mode where control of the pointing direction was based on the Coarse Sun Sensors (CSS) and magnetometer. In safehold the safety of the observatory and its instruments were protected, but the usual ACS system (based on gyros and a star tracker) was not engaged, so Swift neither observed planned targets nor automatically slewed to new GRBs.

Very quickly it was determined that the ACS problem resulted from a change in behavior in one of the gyro units (IRU#3, to be precise). The three gyro units (IRU#1, IRU#2 and IRU#3) sense inertial motions (i.e. rotations) of the Swift spacecraft. Each IRU returns values for two perpendicular axes, so normal Swift operation requires two IRUs, resulting in four measurement values which determine the three dimensions of Swift orientation.

The problem with IRU#3 is that it started to 'jump' between two stable states. (The root cause is under investigation but these 'jumps' seem similar to the effects of having two different spots where the gyro rests on its bearing.) When IRU#3 'jumps', this makes the spacecraft ACS be-



lieve that Swift has experienced a rapid motion, which causes the ACS to respond, losing the correct understanding of the spacecraft attitude, and hence, triggering a safehold.

The Swift operations team switched the spacecraft from operating with IRU#1 and #3 to IRU#1 and #2 within two days of the problem's appearance. The switch allowed Swift to exit the safehold conditions, but in order to get scientific operations we had to recalibrate the gyros, in the same way we did during the initial month of Swift's orbital life. These recalibrations uncovered a problem with the orientation of IRU#2 (it is misaligned with the IRU#1 and #3 pair by about 1000 arc seconds). Unfortunately, the Swift on-board flight software does not allow for such a misalignment, and so the gyro parameters are only able to use the gyro data to get Swift to approximately point in the direction of the desired targets after slews.

It has taken two months of hard work to correct this problem. We now have implemented a fix that has the spacecraft pointing to within specifications again and allows GRB chasing and full operations. This was done by using all three IRUs simultaneously with IRU #3 weighing in slightly to correct for the IRU #2 alignment. The IRU #3 terms are small enough that its 'jumps' do not cause problems. Craig Markwardt on the BAT team was key to identifying and working out this solution. The spacecraft development team at General Dynamics has also coded a patch to the flight software that we are considering uploading in the November time frame.



Japanese and NASA Satellites Unveil New Type of Active Galaxy

By Robert Naeye, Goddard Space Flight Center

An international team of astronomers using NASA's Swift satellite and the Japanese/U.S. Suzaku X-ray observatory has discovered a new class of active galactic nuclei (AGN).

By now, you'd think that astronomers would have found all the different classes of AGN — extraordinarily energetic cores of galaxies powered by accreting supermassive black holes. AGN such as quasars, blazars, and Seyfert galaxies are among the most luminous objects in our Universe, often pouring out the energy of billions of stars from a region no larger than our solar system.

But by using Swift and Suzaku, the team has discovered that a relatively common class of AGN has escaped detection...until now. These objects are so heavily shrouded in gas and dust that virtually no light gets out.

"This is an important discovery because it will help us better understand why some supermassive black holes shine and others don't," says astronomer and team member Jack Tueller of NASA's Goddard Space Flight Center in Greenbelt, Md.

Evidence for this new type of AGN began surfacing over the past two years. Using Swift's Burst Alert Telescope (BAT), a team led by Tueller has found several hundred relatively nearby AGNs. Many were previously missed because their visible and ultraviolet light was smothered by gas and dust. The BAT was able to detect high-energy X-rays from these heavily blanketed AGNs because,

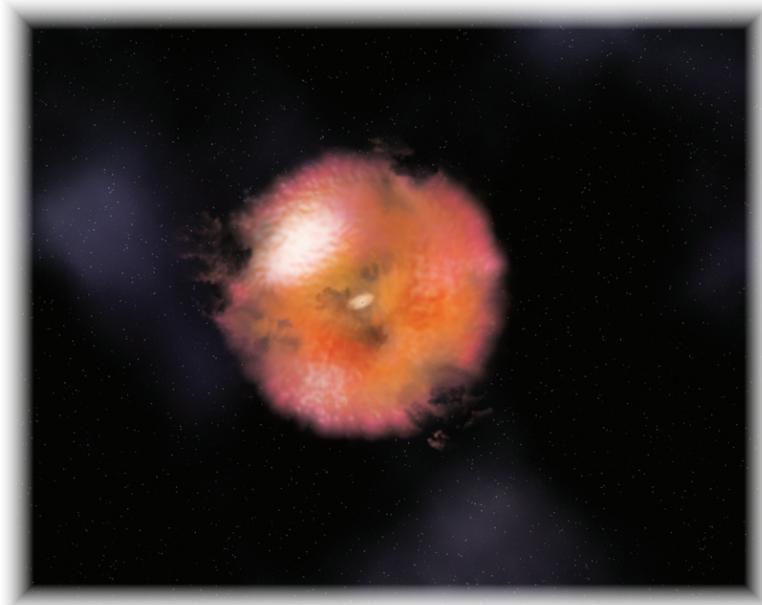


Image credits: Aurore Simonnet, SSU NASA E/PO

unlike visible light, high-energy X-rays can punch through thick gas and dust.

To follow up on this discovery, Yoshihiro Ueda of Kyoto University, Japan, Tueller, and a team of Japanese and American astronomers targeted two of these AGNs with Suzaku. They were hoping to determine whether these heavily obscured AGNs are basically the same type of objects as other AGN, or whether they are fundamentally different. The AGNs reside in the galaxies ESO 005-G004 and ESO 297-G018, which are about 80 million and 350 million light-years from Earth, respectively.



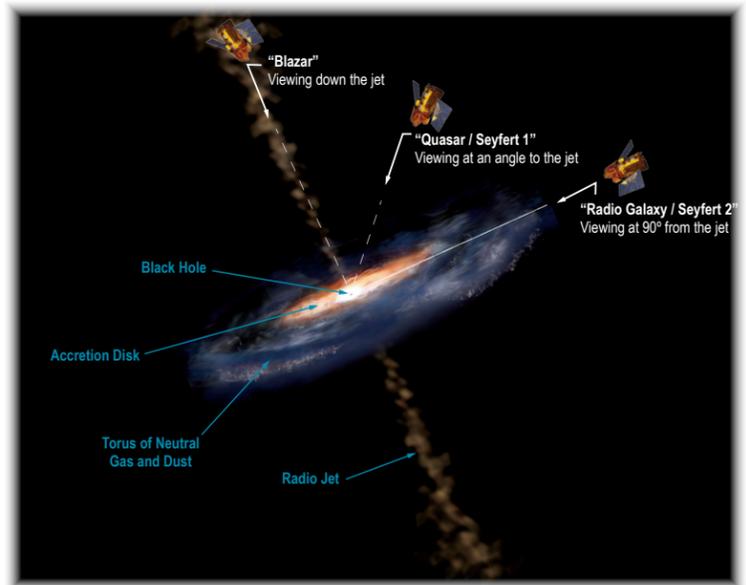
Suzaku covers a broader range of X-ray energies than BAT, so astronomers expected Suzaku to see X-rays across a wide swath of the X-ray spectrum. But despite Suzaku's high sensitivity, it detected very few low- or medium-energy X-rays from these two AGN, which explains why previous X-ray AGN surveys missed them.

According to popular models, AGNs are surrounded by a donut-shaped ring of material, which partially obscures our view of the black hole. Our viewing angle with respect to the donut determines what type of object we see. But team member Richard Mushotzky, also at NASA Goddard, thinks these newly discovered AGN are completely surrounded by a shell of obscuring material. "We can see visible light from other types of AGN because there is scattered light," says Mushotzky. "But in these two galaxies, all the light coming from the nucleus is totally blocked."

Another possibility is that these AGN have little gas in their vicinity. In other AGN, the gas scatters light at other wavelengths, which makes the AGN visible even if they are shrouded in obscuring material.

"Our results imply that there must be a large number of yet unrecognized obscured AGNs in the local universe," says Ueda.

In fact, these objects might comprise about 20 percent of point sources comprising the X-ray background, a glow of X-ray radiation that pervades our Universe. NASA's Chandra X-ray Observatory has found that this background is actually produced by huge numbers of AGNs, but Chandra was unable to identify the nature of all the sources.



This illustration shows features of an active galactic nucleus (AGN).

By missing this new class, previous AGN surveys were heavily biased, and thus gave an incomplete picture of how supermassive black holes and their host galaxies have evolved over cosmic history. "We think these black holes have played a crucial role in controlling the formation of galaxies, and they control the flow of matter into clusters," says Tueller. "You can't understand the universe without understanding giant black holes and what they're doing. To complete our understanding we must have an unbiased sample."

The discovery paper appeared in the August 1st issue of the Astrophysical Journal Letters.





BBC-2 Television Show Features Swift

By Kim Page and Julian Osborne (University of Leicester, UK)



Kim Page (far right), Julian Osborne and other members of the Leicester Swift Group.

In November 2006, the Leicester Swift group had the opportunity to be filmed for a new popular science TV show, trying to capture the excitement of the detection of a new Gamma-ray Burst. We were entrusted with a couple of camcorders, which were carefully pointed towards my desk. Each evening when I left I had to take one of them with me in case we detected a burst during the night, at which point I would have had to film as I got out of bed and jogged into work. Needless to say, I didn't sleep very well that week.

Duty weeks run from Wednesday to Wednesday so by Tuesday afternoon, without any kind of trigger, we were getting a little downhearted. Then, at 15:22UT - a perfect time of day, since everyone was around - BAT triggered on GRB 061121. We immediately switched on the cameras and then tried our best to ignore them as we went about our usual burst-related duties.

GRB 061121 turned out to be a fantastic burst (see Page et al., 2007, ApJ, 663, 1125), detected across the electromagnetic spectrum from Gamma-rays to

radio waves, with extensive ground-based follow-up, including a redshift of $z=1.314$ measured by Keck (Perley & Bloom 2006, GCN Circ. 5825; Bloom, Perley & Chen, 2006, GCN Circ. 5826). The burst peaked at the highest flux of any long burst yet detected by Swift and reached a count-rate of ~ 2500 count s^{-1} in the X-ray band - perfect TV material!

After the initial flurry of on-the-spot filming, we waited for the presenter, Adam Hart-Davis, and the Screenhouse production team, to come to Leicester the following week to record interviews and more footage (including pretending to receive the initial alert when away from my desk, and then running back to the office).

In August 2007, more than 8 months later, the series "The Cosmos: A Beginner's Guide" was finally broadcast on BBC 2 in the UK, with the Swift-related program expected to air in early September.

"Then, at 15:22UT - a perfect time of day, since everyone was around - BAT triggered on GRB 061121."



The Leicester Swift group appears on BBC-2.

<http://www.open2.net/cosmos/index.html>

NASA Astronomers Discover Strange Binary Pair

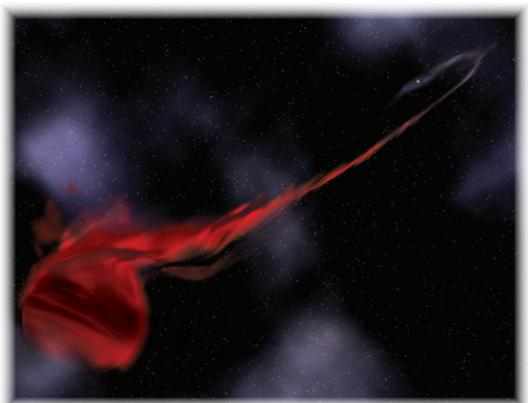
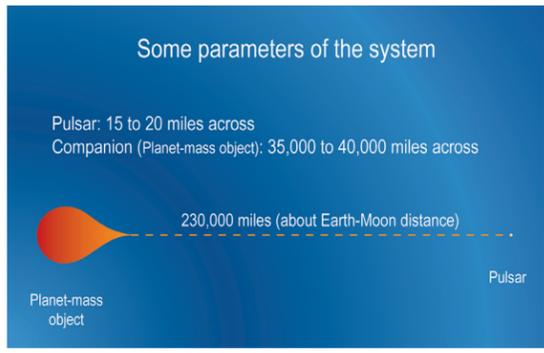
By Hans Krimm

Using Swift and the Rossi X-ray Timing Explorer (RXTE) satellite, Swift scientists and their collaborators have discovered the eighth known accretion-powered millisecond pulsar, named SWIFT J1756.9-2508, or "J1756" for short. This unusual object is actually a binary pair consisting of a rapidly spinning neutron star, or pulsar, and a very low mass companion star, which is believed to be a white dwarf star which has been whittled down to near planetary mass through billions of years of accretion onto the neutron star.

This pair of strange stars, which orbit each other once every 54.7 minutes with a separation of slightly less than the Earth-Moon distance, is normally invisible even to sensitive instruments like Swift. However, every few years billions of tons of material from the white dwarf fall onto the neutron star, causing a bright, but short-lived burst of X rays, like the one which was detected by the Burst Alert Telescope (BAT) on Swift in June 2007. The BAT transient monitor is designed to track X-ray activity from known objects, but occasionally finds something like J1756 which has never been seen before.

When Dr. Hans Krimm of NASA's Goddard Space Flight Center and Universities Space Research Association first discovered J1756, he requested observations with the Swift X-Ray Telescope (XRT) and RXTE. XRT was able to pinpoint its position in the sky, and Craig Markwardt of NASA/Goddard and the University of Maryland used the timing data from RXTE to determine that J1756 was indeed a millisecond pulsar, spinning at a period of 5.5 msec, and from small variations in orbital frequency, he deduced that the pulsar was part of a binary system.

Then the research team set to work trying to figure out what the companion to the pulsar was. Using their understanding of orbital dynamics and detailed numerical models provided by Chris Deloye of Northwestern University, the team deduced that the companion is likely a white dwarf star of around ten times the mass of Jupiter, very small for a star, and that its composition is mostly helium. They also believe that the star was once the size of the Sun, but has lost nearly all of its mass to its hungry companion. After two weeks the outburst was over and the system faded back to its normal invisibility, leaving scientists to wait years, perhaps decades, for its next outburst.



The pulsar (upper right) is tidally distorting its planet-mass companion in this artist depiction.

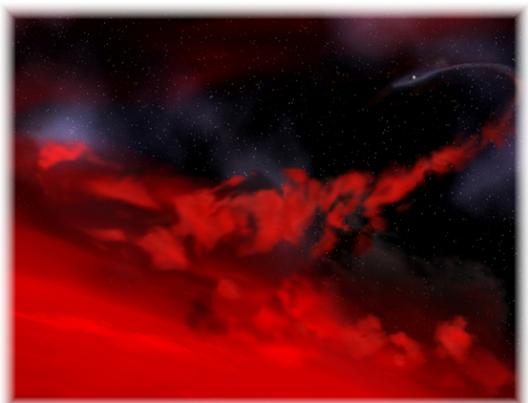


Image credits: Aurore Simonnet, SSU NASA E/PO





Becoming a Swift Educator Ambassador

By Janet Moore

In 2002, I began teaching high school mathematics in a small, rural school in central Illinois. Although mine was technically a math classroom, that didn't stop me from teaching as much science as I possibly could. Whether my pre-Algebra students were flying paper airplanes or flinging rubber bands across the classroom or my Algebra II/Trigonometry students were using ripple tanks and satellite dishes, we were learning science while we learned math.

One of the biggest challenges I faced in my endeavor to teach the intersection of math and science was that many math textbooks reduced science to very contrived situations that just happened to be convenient for the math involved, and many science textbooks reduced math to a conversion table or a formula or finding a mean. And the lower the grade level, the farther the gap between math and science.

In 2003, after making two career changes, I found myself in a place where I could make a difference – not just for my own students, but for students in hundreds of classrooms all across the country. First, I took a job at a Challenger Learning Center (CLC) in Bloomington, Illinois. At the



Janet Moore speaks to students at Challenger Learning Center.

CLC, I conduct simulated space missions for students in classrooms throughout central Illinois, and I provide professional development for elementary and middle school teachers around the state.



A student learns about Black Holes.

My second career change was to join the NASA Education and Public Outreach group at Sonoma State University as a Swift Educator Ambassador.

For the past four years, these two positions have allowed me to bring real science and real mathematics to teachers around the country by training them at our CLC as well as at state, regional, and national conferences. And what I have found throughout this time is that NASA space science is just as fascinating and intriguing for adults as it is for children.

Almost always, my NASA sessions at conferences are overflowing with excited, engaged participants who are eager to learn and teach. In Spring 2006, I taught a 3-hour mini-course about the mathematics of black holes at the National Council of Teachers of Mathematics conference in St. Louis. For three solid hours, our group of about 45 people looked at, learned about, and interacted with black holes, Gamma-ray Bursts, and active galaxies from a mathematical perspective. The science was good. The mathematics was meaningful. And the teachers loved it.

After that session, several participants stayed behind just to tell me how much they enjoyed the presentation. One gentleman, who later identified himself as the President of the Association of Mathematics Teachers of New York State (AMTNYS), told me that the teaching strategies I used and the activities I facilitated composed an exemplary model of how mathematics should be taught. As a result of that mini-course, he invited me to be a keynote speaker at the 2007 AMTNYS conference, which will be held at the end of October.

We hope you enjoyed this publication. The Swift Newsletter was produced by the Swift Education and Public Outreach group at Sonoma State University. You can find all the Swift newsletters at: <http://swift.sonoma.edu/resources/multimedia/newsletter/index.html>

You can subscribe to this newsletter! Please visit our signup page at: <http://swift.sonoma.edu/resources/multimedia/newsletter/signup.html>

For more information, please visit these Swift websites:

- ☞ *Swift Mission:* <http://swift.gsfc.nasa.gov>
- ☞ *Swift Education and Public Outreach:* <http://swift.sonoma.edu>
- ☞ *Gamma-Ray Burst Real-time Update:* <http://grb.sonoma.edu>
- ☞ *Global Telescope Network:* <http://gtm.sonoma.edu>

<http://www.nasa.gov/swift>

