European Astronomical Society
NEWSLETTER

Issue 33. June 2007

Contents

Editorial

In the current newsletter we continue the review of space astrophysics facilities by describing space missions that sample higher energies. These are XMM-Newton, Chandra, and Swift. Three articles on the mission description, operations, and a few of the science highlights are available for the readers in this issue. These facilities have been proven extremely useful, as they provide unique insights on the physical mechanisms behind many of the violent phenomena in the Universe. At the same time though, they also give the opportunity to observational astronomers to develop a personal relation with the photons they collect, as these are often counted in the fingers of one hand.

We also include a very interesting article by V. Trimble and J. Ceja who have analyzed more than 7500 papers published in 20 astronomy and astrophysics journals. The authors use these data to comment on the productivity and science impact of astronomical facilities, both on the ground and in space.

Finally, I would also like to remind to all our members that 2009 is the International Year of Astronomy. This is a unique opportunity to increase the popularity of astronomy among the general public. A number of activities both scientific and public outreach are being organized in Europe and throughout the word. Information on some of those is presented in a dedicated website at http://www.astronomy2009.org It is clear that the assistance of many of us will be needed to make this a successful endeavour so all of us should consider of finding ways to contribute to it.

Vassilis Charmandaris
University of Crete, Greece

Message from the President

In its meeting in January the EAS Council unanimously decided to admit the Turkish Astronomical Society as Affiliated Society. We cordially welcome our Turkish colleagues and hope that the Turkish Society will play an active role in Europe. EAS has now 24 Affiliated Societies spread across Europe, from the Eurasian and Armenian Societies in the East to the Royal Astronomical and the Portuguese Societies in the West. Europe is in a special situation because of the co-existence of both European and National societies. However, the situation in Europe requires such a co-existence: while Europe is growing closer and while we have more and more collaborative European projects (like ESO, ESA, the various ERA-nets, etc.) each country still has its own specific circumstances. In general, EAS is meant to handle the affairs on a supranational level for issues of importance for astronomers across Europe. EAS should provide support for European astronomers like job markets, the planned inventory of national recruitment processes or a directory of European astronomers; it should promote communication across the continent and it should complement the national societies by providing an independent forum for communication and discussion. On the other hand, the national societies handle all those affairs which are specific for a given country. In order to improve the relations between the EAS and its Affiliated Societies, the EAS Council plans to invite the Affiliated Societies to a face-to-face meeting with multiple aims: to exchange information of what rôle the Affiliated Societies currently play on national and European level, discuss the role of the EAS now and in future, discuss common problems, promote collaboration between Affiliated Societies on a regional as well on a European basis, and design a model of cooperation between the EAS and Affiliated Societies which optimizes the interaction and information flow between astronomers in the member states and pan-European institutes. This meeting is foreseen for early 2008 and we are presently in the final stage of the preparations. An invitation will be sent out in the near future.

On a European level one of the most important events has been the Astronet symposium which took place in January in Poitiers, France. The ambitious goal of Astronet which was initiated by European national funding agencies is to decide upon a joint roadmap for astronomical research in Europe through 2025. In Poitiers more than 200 European astronomers discussed the report of the 'Science Vision' working group, which will be the basis for the 'Infrastructure Roadmap' working group. Although Astronet is a group of funding agencies, it has set up a mechanism to involve the astronomical community by setting up working groups and by inviting the community as a whole to discuss the 'Science Vision' and later on the 'Infrastructure Roadmap' drafts. However, I think it is regrettable that the EAS which represents such a broad cross section of European astronomers and astrophysicists, has not been invited by ASTRONET to get involved in the process (unlike in many other of the ERA-nets where the EAS has observer status). I have to repeat what I said half a year ago: one of the prime goals of EAS Council has to be to increase the visibility of EAS among the European associations in order to play a major role in the shaping of European astronomy and thus serve its membership.

Let me finish with an outlook to our next JENAMs. This year's JENAM will take place in Yerevan, Armenia, from August 20-25. I would like to encourage everyone to register for this meeting since the program with 7 EAS symposia, a number of special sessions, and distinguished invited speakers is very attractive. Next year's JENAM will take place in Vienna and will be organized together with the Astronomische Gesellschaft. In 2009 we shall meet together with the Royal Astronomical Society in Hertfordshire in Great Britain.

Joachim Krautter
President of EAS

EURO-VO News

The European Virtual Observatory (EURO-VO) Project aims at deploying an operational Virtual Observatory (VO) in Europe. It promotes new science by providing easy access, retrieval, and analysis of data from archives worldwide.

The new EURO-VO web pages (http://www.euro-vo.org) contain information about the structure of the project, provide access to available VO tools and manuals, as well as news and announcements. A way of staying tuned to the latest news with a minimum number of mouse clicks is the newly established EURO-VO mailing list, via which information on technical and capacity building workshops, news on VO tools and applications, and highlights on VO-based scientific results are circulated. To subscribe, go to http://help.euro-vo.org/esupport/index.php?_m=news&_a=view and insert your e-mail address in the "Subscribe" widget.

The next EURO-VO workshop will be held at ESAC, on 25-29 June 2007, and will be focused on instructing data centres and large projects on how to publish their data in the VO (http://esavo.esac.esa.int/EuroVOWorkshopJune2007). The last workshop, held on March 21-23, was dedicated to spectroscopy in the VO and brought EURO-VO and the community scientists together in an effort to establish the the way the VO will address the needs of modern spectroscopy. The presentations given during the workshop are available via the workshop's web pages (http://esavo.esac.esa.int/SpectroscopyAndVOWorkshopMarch2007/program.html).

In the framework of the Joint European and National Astronomy Meeting (JENAM) 2007, a dedicated symposium will take place (EAS Symposium 8, «Science with the Virtual Observatory»). It will discuss the achievements in the area and plan further developments and future projects. For more details see the JENAM 2007 web pages (http://www.aras.am/JENAM-2007).

Evanthia Hatziminaoglou
on behalf of the EURO-VO Facility Centre

IAU Symposia in 2008

The following meetings, sponsored by the International Astronomical Union, will take place in 2008.

IAU Symposium No. 251
Organic Matter in Space
18-22 February 2008, Hong Kong, China
contact: Sun Kwok < sunkwok@hku.hk >
webpage: www.hku.hk/science/iau251

IAU Symposium No. 252
The Art of Modelling Stars in the 21st Century
10-14 March 2008, Sanya, Hainan Island, China
contact: LiCai Deng < licai@boa.ac.cn >

IAU Symposium No. 253
Transiting Planets
19-23 May 2008, Boston, MA, USA
contact: Didier Queloz < didier.queloz@obs.unige.ch >

IAU Symposium No. 254
The Galaxy Disk in Cosmological Context
9-13 June 2008, Copenhagen, Denmark
contact: Birgitta Nordstrom < birgitta@astro.ku.dk >
webpage: www.nbi.dk/IAU254

IAU Symposium No. 255
Low-metallicity Star Formation: from the First Stars to Dwarf Galaxies
16-20 June 2008, Villasimius, Sardinia, Italy
contact: Leslie Hunt < hunt@arcetri.astro.it >
webpage: www.arcetri.astro.it/iaus255

IAU Symposium No. 256

The Magellanic System: Stars, Gas, and Galaxies
28 July - 1 August 2008, Keele University, Stafffordshire, UK
contact: Jacobus Th. van Loon < jacco@astro.keele.ac.uk >
webpage: www.astro.keele.ac.uk/iaus256

IAU Symposium No. 257

Universal Heliophysical Processes
5-9 September 2008, Ionnina, Greece
contact:
Natchimuthuk Gopalswamy < gopal@ssedmal.gsfs.nasa.gov >

IAU Symposium No. 258

The Ages of Stars
13-17 October 2008, Baltimore, MD, USA
contact: David R. Soderblom < drs@stsci.edu >
webpage: www.scsci.edu/institute/conference/iau258

IAU Symposium No. 259

Cosmic Magnetic Fields: from Planets, to Stars and Galaxies
3-7 November 2008, Puert Santiago, Tenerife, Spain
contact: Klaus G. Strassmeier < kstrassmeier@aip.de >

Two IAU Regional Meetings will also take place in 2008.

Middle East Africa Regional Meeting MEARIM 2008

5 – 10 April 2008, Cairo, Egypt
contact: Ahmed Abdel Hady <aahady@yahoo.com>

10th Asian-Pacific Regional Meeting (APRIM 2008)

1 – 4 August 2008, Kunming, Yunnan, China
contact: Dr. Jiancheng Wang <jcwang@ynao.ac.cn>

Call for IAU Scientific Meetings in 2009

The IAU is soliciting proposals for scientific meetings in 2009. There will be three regular 5-day IAU Symposia, to be held at least three months before or after the IAU XXVII General Assembly. In addition, a number and scientific meetings will be held at the IAU XXVII General Assembly, Rio de Janeiro, Brazil, 3 - 14 August 2009. It is expected to have six 3.5-day IAU GA Symposia, up to twenty 0.5-1.5-day IAU GA Joint Discussions. up to ten 0.5-3.0-day IAU GA Special Sessions.

For all these scientific meetings, prospective proposers should observe the Rules and Guidelines for IAU Scientific Meetings, as presented at <http://www.iau.org/Rules_Guidelines.200.0.html>. Note that for meetings held at the GA, no LOC or registration fee has to be proposed.

Letters of Intent for IAU Scientific Meetings in 2009 should be submitted to the IAU Assistant General Secretary, Dr. Ian F. Corbett <icorbett@eso.org>, on or before 15 September 2007 in accordance with the IAU Rules and Guideline for IAU Scientific Meetings.

Final proposals have to be submitted to the IAU Proposal Web Server <http://solarphys.uio.no/IAU/> on or before 1 December 2007, following the instructions given in that Server. Proposals submitted after the deadline may be rejected.

It is essential that all IAU Scientific Meetings cover important areas of topical interest, demonstrating continued progress in astronomy research.

Members are reminded that proposals for all Symposia, GA-Symposia, GA-Joint Discussions and GA-Special Sessions have to be backed by a coordinating IAU Division and endorsed by a reasonable number of IAU Divisions, IAU Commissions and IAU Working Groups. A report of the communication with Division and Commission presidents on the proposal has to be included in the proposal. The AGS will appreciate advance notice of such reports.

Selection of the IAU Scientific Meeting 2009 programme will be made by the IAU Executive Committee and Division Presidents in late May 2008.

New Space Science Missions to be Selected by ESA

The long-awaited call for proposals for new space science missions within ESA's Cosmic Vision 2015-2025 programme was finally issued on 5 March. A large number of Letters of Intent were received by 30 March, covering all fields of research of space sciences, and including missions in astrophysics, fundamental physics or exploration of the solar system. A briefing meeting to clarify questions raised by the proponents took place on 11 April at ESTEC with the participation of many European scientists as well as members of the Executive of ESA, including the Director General and the Director of Science.

The call for proposals follows the analysis of the response to the call for themes and the issue of a document by the SSAC on the most promising areas for future developments within the European Science Programme. The objective of this call is to define new missions to complement the current projects including those in orbit (HST, Newton, Integral, Akari, Ulysses, SOHO, Cluster, Double Star, Hinode, Rosetta, Mars Express and Venus Express), under development (Herschel, Planck, LISA Pathfinder, JWST, GAIA and Bepi Colombo), or selected but still to be adopted (Solar Orbiter and LISA). The planning is to keep one launch every 15 to 18 months on average. Within the Cosmic Vision 2015-2025 programme a call for new proposals every 3 to 4 years should therefore be envisaged.

The present situation is that the final proposals should be submitted by 29 June followed by the usual selection process carried out by the Science Programme advisory structure. Before doing so, explicit rules for dealing with potential conflicts of interest are being discussed. The evaluation of the proposals will follow in the months of July to September by ESA experts together with Peer Review Teams. By October, the Working Groups of the Advisory Structure of ESA and the SSAC, will select 6 missions for assessment study: 3 of medium-type class and 3 of large type.

The separation into two classes, as described in the call for proposals, is essentially dictated by their envelope cost to ESA (300 or 650 million euros). The planning is also different for each class. For medium missions, the 3 assessment studies will be carried out until mid 2009, and the results presented in September-October 2009 followed by the selection of 2 missions for definition studies through competitive industrial studies. After two more years, a final selection of one mission will be made, in November 2011, leading to the issue of the corresponding ITT and aiming to launch by mid 2017.

In the case of large-type missions, there is a similar plan but leading to a launch by the autumn of 2018. In this case, non-selected missions during the processes of 2009 and 2011 are kept in the programme for further technology development if considered relevant, thus becoming candidates for selection in next slot. In other words, while M-type missions are selected as such and the "loser" has to be proposed again, the competition for L-type missions is more about maturity after proving their scientific relevance.

The new missions can be fully European or cooperative efforts with other Agencies. It is very important, though, that the commitments of other partners, as well as the contribution of National agencies to the corresponding payloads, are well documented. Payload definition and financial support at national level is one of the key aspects of the present call. Out of the criteria for selection, scientific value and innovation dominates, followed by technical feasibility and budgetary realism. Proposals are of course welcome in the area of Mars and Lunar exploration. For this purpose a close coordination with the Directorate for Human Spaceflight and Exploration has been ensured to optimize the opportunities of the best proposals. A special situation is that of LISA that will compete for the first L-type launch opportunity but does not need to be proposed again. Missions studied within previous call for ideas, like Darwin or Xeus, will also be considered but have to be proposed with a clear scheme of cooperation to make them realistic both from the technical and budgetary point of view.

A new window has been opened to the European scientific community. We have to make sure that this is used properly in the context of the next ministerial conference to ensure additional resources for science but even more to inspire new generations of European scientists into space research.

Prof. Alvaro Gimenez
Research and Scientific
Support Department, ESTEC

Productivity and Impact of Astronomical Facilities: A European View

In 2001 and 2002, 7768 papers, published in 20 journals of astronomy and astrophysics, presented or analyzed data gathered at about 330 ground-based optical and infrared telescopes, about 90 ground-based radio telescopes (including millimeter, plus COBE, VSOP. and a few balloon-borne detectors), and 80 space-based missions (rockets, probes, Shuttle, and satellites). These were cited an average of 14.6 times each over the next three years (that is 2002-04 for the 2001 paper$ and 2003-05 for the 2002 papers), the range extending from zero to 632, according to the on-line (Web of Science) version of Science citation Index, which appears to be somewhat more complete than the Astrophysics Data Service equivalent.

Papers were originally collected separately for optical, radio. and space samples (and the 2001 data published that way as Trimble, Zaich, and Bosler, 2005 and 2006 and Trimble and Zaich 2006), and remain so here. But, within each wavelength band, "credit" for each paper and for the citations to it is equally divided among all telescopes (etc.) that were used. A number of other publications in the area of publication and citation analysis give full credit to some one telescope (HST, VLT, Keck or whatever) that the writers happen to be interested in, independent of what else might have been used.

A surprising number of papers come from small not very famous telescopes, for instance about 250 in 2001 from optical facilities with primary mirrors less than 1.9 meters in diameter, though these are often not very highly cited papers. Complete tables are, therefore exceedingly cumbersome (though the data exist). We also have data on citations per paper as a function of topic, from solar system to cosmology. Some are much more popular than others, and this is not just a function of numbers of citing papers or community size. Papers on binary stars outnumber those on cosmology but gather only about 5 citations in three years vs. about 30. The subset of highly cited solar system papers come from orbiters and landers not ground-based observations. About 14% of the papers are multi-wavelength using our very crude three-way division, and are somewhat more frequently cited than single-band papers. They almost never go completely uncited in three years — less than 1%, vs. 3.5% for single-wavelength ones.

What is compiled here is numbers for a subset of telescopes and groups of telescopes (etc.) responsible for some of the larger collections of papers and highly cited papers. They are grouped rather differently from the scheme in the first set of papers and a forthcoming one that will have, as nearly as possible, all the data, with the intent of emphasizing facilities heavily used by European astronomers. There is no uniquely satisfactory way to do this. If Keck and the VLT are to be compared, then should other groups be called "Mauna Kea other" and "ESO other" or "CTIO + KPNO" and "La Silla", or something else? You can see in the Table what choices were made and what the numbers look like. Our experience from earlier publications and presentations of these and related data is that every reader will be annoyed by something and that every number will annoy someone (not always the same numbers and same people !)

A few NASA-style bullets:

- ❑ HST produces very many papers though they are not more highly cited than others
- ❑ Europe was definitely winning in the millimeter and submillimeter
- ❑ For the years under consideration, neither the VLT nor Keck was yet running at full strength, while TNG and Gemini weren't really represented at all.
- ❑ There is nothing else quite like the VLA.
- ❑ Data from X-ray and infrared satellites remain important long after their flying days are over.
- ❑ The one facility pair where one might want to separate the two years of data is XMM and Chandra. For 2001, the XMM numbers are 3627 citations, 83.5 papers, C/P=43.4, Chandra 6092 citations, 175.8 papers, C/P=34.6. For 2002, the XMM numbers are 1724 citations, 86.9 papers, C/P=19.8, Chandra 5837 citations, 258.8 papers, C/P= 22.6. And it should be noted that 2001 included a large set of Letters to Astronomy and Astrophysics describing the XMM mission and first results, several of which gathered more than 300 citations in the next three years. Nothing comparable happened to either satellite in 2002 !

- ❑ The Australians are clearly doing something right, though there are other facilities, including CFHT (mostly work an large scale structure), and the Lick 3-meter (exoplanet searches), that produced moderate numbers of very highly cited papers.
- ❑ We don't know whether the UK counts as part of Europe or not (and honourably pay dues to both EAS and RAS), and you can merge the numbers if you wish.

We are most grateful to D. Tammy Bosler, former UCI graduate student, and Paul Zaich, high school intern now an undergraduate at Stanford University, for collecting the raw citation numbers for the 2001 papers; to NOAO, NRAO, and the Chandra Science Center for support of page charges, allowing the 2001 data to see light of print; and to editor V. Charmandaris for this space in the EAS newsletter.

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PAPERS (2001+2002) AND CITATIONS (THREE YEARS) FROM MAJOR ASTRONOMICAL FACILITIES

Facility	Citations (C)	Papers (P)	C/P
SPACE			
XMM	5346	170.4	31.4
Chandra	11929	434.6	27.5
ISO	4503	294.8	15.3
IRAS	1456	117.4	12.8
ROSAT	3269	236.2	13.8
Beppo SAX	2181	143.3	15.2
ASCA	2303	171.2	13.4
RXTE	3145	232.0	13.6
SPACE TOTAL	43769	2597	16.8
RADIO (including mm and sub-mm)			
JCMT	1951	102.2	19.1
IRAM (both)	1469	97.7	15.0
OVRO + BIMA	1038	81.9	12.7
VLA	5634	380.9	14.8
VLBA + comp. dishes	809	69.9	11.6
Merlin + Jodrell	479	52.5	9.1
EVN + dishes	1221	149.7	8.7
Australia (all)	2274	179.9	12.6
RADIO TOTAL	21216	1676	12.7
OPTICAL and INFRARED			
HST	10044	728.7	13.8
VLT	2566	176.5	14.5
Keck	4560	234.2	19.5
Canarias (all)	3180	279.8	10.4
ESO (all other)	2895	387.7	7.5
ESO (3.6 + NTT)	1599	149.5	10.7
CTIO (all)	1477	139.8	10.4
KPNO (all)	2461	179.9	13.7
CTIO-4 + KPNO-4	1524	113.9	13.4
Australia (all)	3190	154.4	20.7
SDSS	3271	80.3	40.7
OPTICAL & IR TOTAL	68077	4695	14.5
TOTAL	**113153**	**7768**	**14.6**

SPACE X-RAY AND GAMMA-RAY FACILITIES

THE CHANDRA X-RAY OBSERVATORY

Introduction

NASA's Chandra X-ray Observatory was launched on July 23, 1999 and has operated very successfully for the past 7.5 years. Covering the energy range from ~100eV to 10keV, Chandra achieves a substantial increase in capability relative to previous x-ray missions by virtue of its ~1/2 arcsec angular resolution. The small point spread function reduces the background level in a detection element, enabling Chandra to detect point sources nearly 100 times fainter than previously possible. Precise Chandra source locations facilitate identifications with counterparts at other wavelengths. Finally, Chandra resolves x-ray structures which were previously indiscernible, starting with the detection of the central compact object in the Cassiopeia A (Cas A) supernova remnant in Chandra's First Light image. NASA's Great Observatories span the spectrum from IR to gamma-rays with the Spitzer Space Telescope, the Hubble Space Telescope, Chandra, and the now defunct Compton Gamma Ray Observatory. Chandra's high angular resolution is also beautifully complemented by the higher throughput of ESA's XMM-Newton Observatory.

Observatory

The heart of the Chandra X-ray Observatory is the High Resolution Mirror Assembly (aka the telescope), comprised of four pairs of mirrors and their support structure. X-rays are reflected at grazing incidence with incoming rays nearly parallel to the walls of the parabolic and hyperbolic surfaces. Two reflections are required to obtain quality imaging over a field of view ~1/2 degree across, and four pairs of mirrors are nested inside one another to increase the utilization of the front aperture. The glass surfaces were exquisitely polished by Hughes Danbury Optical Systems, the mirrors were coated with highly-reflective iridium by Optical Coating Laboratories, Inc, and the individual pieces were assembled into the telescope by Eastman Kodak. The telescope and the science instruments were calibrated on the ground at a special facility with a 500m long x-ray pipe and a large, ultra-clean vacuum chamber at Marshall Space Flight Center (MSFC) which had overall management responsi-

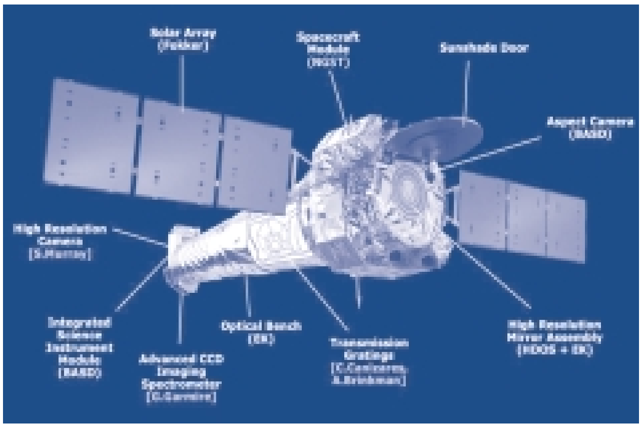

Figure 1. Schematic of the Chandra X-ray Observatory.

bility for Chandra. The NASA Project Scientist from inception of studies in 1977 to the present has been Martin Weisskopf from MSFC.

Chandra has two focal plane instruments and a pair of transmission gratings which can be inserted and removed from the optical path depending on the science objectives of an observation. The focal plane instruments are the Advanced CCD (Charge-Coupled Device) Imaging Spectrometer (ACIS) built by Penn State U, MIT, Lockheed-Martin and Lincoln Laboratories with Gordon Garmire of Penn State as the Principal Investigator (PI), and the High Resolution Camera (HRC) built by the Smithsonian Astrophysical Observatory (SAO) with Steve Murray as the PI. Each of the focal plane instruments has a square set of detectors primarily for imaging, and each has a linear array primarily for reading out the x-rays dispersed by the transmission gratings when they are in the beam.

The two transmission gratings diffract x-rays using finely spaced wires or bars. The Low Energy Transmission Grating (LETG) was built in Europe by the Space Research Organization of the Netherlands (SRON) and the Max-Planck-Institut fur extraterrestrische Physik, with Bert Brinkman from SRON as PI. The High Energy Transmission Gratings (HETG) built at MIT with Claude Canizares as the PI have a period of 0.2 microns for the gratings behind the the two inner-most mirrors and a period of 0.4 microns for the gratings behind the two outer-most mirrors. The gratings spread out the «light» with the longest wavelength x-rays dispersed the most. By converting the x-ray energy to a spatial location which can be measured with high precision, the Chandra gratings achieve a resolving power slightly exceeding 1000 at the long wavelength limit for each grating.

The spacecraft was built by TRW, the prime contractor for the project. It includes solar panels and an associated power system, a thermal control system for the entire observatory, which is especially critical for the telescope, the communications system to uplink commands to the observatory and to downlink telemetry data, and the on-board computer system to control the overall operation of the satellite. The spacecraft also provides gyroscopes and reaction wheels as part of the attitude control system needed to maneuver and stably point the telescope. Ball Aerospace provided a very accurate aspect camera to measure star positions to determine where the telescope is pointing on the sky, and a Science Instrument Module (SIM) to house the focal plane instruments, adjust the focus, and swap from one detector to another by a linear translation stage.

Launch, orbit, and operations

Chandra was launched aboard the Space Shuttle Columbia commanded by Eileen Collins. Several hours after launch Chandra was deployed by Mission Specialist Cady Coleman. Almost immediately thereafter, the Boeing Inertial Upper Stage boosted Chandra to a much higher elliptical orbit. Over the next 2 weeks several firings of the spacecraft's liquid apogee engines raised the perigee and apogee of the orbit to intial parameters of ~10,000km and 140,000km respectively with an orbital period of just over 2.5 days. While the orbit evolves with time, Chandra spends just over 80% of its time well above the radiation belts swaddling the Earth. Science observations take place with an efficiency typically ranging between 65 and 70% of the total time. The number varies a bit with solar activity (Chandra instruments are moved out of the focal plane during times of high radiation events), and there are modest overheads associated with slewing from target to target, acquiring guide and aspect stars, and changing science instruments.

Under contract to NASA, the Chandra X-ray Center (CXC) located in Cambridge, MA runs Chandra science and operations and supports the observers. The CXC annually solicits proposals and organizes a Peer Review for the 700-800 proposals received. In the most recent review, 23% of the approved observing proposals and 20% of the approved time was awarded to non-US PIs, primarily European. A long-term observing schedule sorts the selected targets into an efficient sequence while taking into account viewing constraints requested by the observers or imposed by the Observatory. The planners convert the long-term schedule into a detailed set of targets and commands on a weekly basis. Occasionally the pre-planned program is interrupted and re-planned following the triggering of a Peer Review approved Target of Opportunity or a successful request for Director's Discretionary Time. The loads - detailed lists of commands for pointing and configuring the Observatory - are reviewed by the science and engineering staff and after approval are uplinked to Chandra. Data are downlinked through the NASA Deep Space Network, with contacts typically spaced by ~8 hours. During contacts, the health and safety of the Observatory are checked against expected parameters, and the preceding 8 hours of science and housekeeping data are downloaded for transmission to the CXC.

Standard scripts and pipelines are used to capture the data, determine the aspect (pointing direction), and generate event files – photon lists containing detector and sky coordinates, energy, and time information. Scientists use a standard set of software tools (Chandra Interactive Analysis of Observations - CIAO) or software of their own choosing to analyze the event files generating images, spectra, light curves and the like. In addition to developing software tools and running pipelines, the CXC data system staff verify the quality of the processed data and populate the archive with the results. Nominally, Chandra observers have a 1-year proprietary period for analysis and interpretation of their data before the archived products become public. CXC scientists generate specifications for new software tools, and work with the developers to test and document new software. CXC scientists update the calibration of the Chandra optics and instruments on an ongoing basis. CXC scientists and engineers along with members of the PI teams monitor the instrument and Observatory performance. The Director's Office and other CXC staff operate a Help Desk and provide expert assistance to users upon request.

Science Highlights

Chandra images and spectra are changing our understanding of nearly every type of astronomical object or system. Deep surveys have detected the faint individual sources - mostly active galactic nuclei powered by accreting supermassive black holes - which dominate the cosmic x-ray background at least up to ~5keV. Clusters of galaxies show surprising

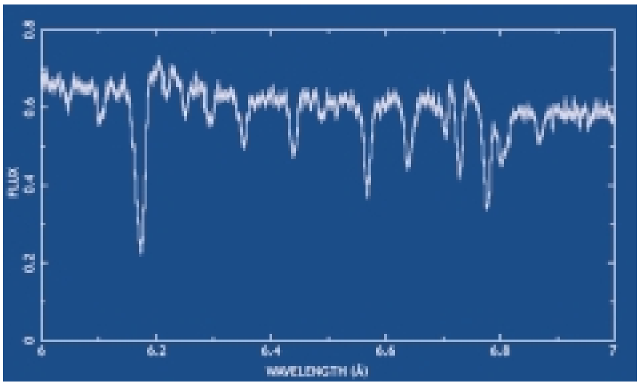

Figure 2. Chandra X-ray Spectrum of GRO J1655-40 from J. Miller et al (2006). The dips seen in the spectrum are produced by absorption from a wide variety of ions in the gas around the black hole, ranging from oxygen to nickel.

structure down to the arcsec level with cooling flows, shocks, and wakes tracing the collisions and mergers of sub-cluster groups. Cooling flows expected at the center of some clusters based on previously observed x-ray radiation losses have been shown by Chandra images and XMM-Newton spectra to be quenched in many cases by a feedback process whereby energetic jets launched by a supermassive black hole in the central galaxy provide sufficient energy to halt the gas inflow and stem the cooling. This mechanism can limit the growth of massive galaxies and quench the highly luminous quasar phase resulting in a transition to a galaxy with a hot corona and limited ongoing star formation. Chandra images of the x-ray emitting hot gas provide something akin to a fossil record of the activity over 10's and 100's of millions of years, allowing us to combine x-ray and radio data to determine the energetics and timescales for the whole process.

X-ray data from Chandra and optical lensing data from the VLT, Magellan, and Hubble graphically illustrate the dramatic spatial separation of dark matter from hot gas in the so-called bullet cluster. Since the hot gas is the dominant baryonic component of the cluster, the data demonstrate that modified laws of gravity involving only baryons and bypassing dark matter cannot explain the observations.

A high resolution Chandra image and ACIS spectra show the presence of two supermassive black holes at a separation of ~1.5 arcsec in the galaxy NGC6240 where we are actually witnessing the ongoing merger of two smaller galaxies. Observations of modest amounts of extended hot gas around Sgr A*, the few million solar mass black hole at the center of our Milky Way Galaxy, show that there is enough gas present to power an AGN much brighter than we see. Similar results were obtained for M31, the nearby Andromeda galaxy. One interpretation is that we may be dealing with inefficient accretors where the infalling ions carry most of the energy across the event horizon before it can be radiated away. Another interpretation is that much of the energy and angular momentum from the accreting gas is ejected in some form of a jet or wind.

Chandra observations of supernova remnants have mapped the distribution and measured the abundances of the heavy elements, conclusively shown that Kepler was a type 1a supernova (explosion of a white dwarf) although possibly with a more massive progenitor than previously thought possible for such objects, and enabled us to see a ring-like shock feature generated by the initial interaction of particles accelerated by the Crab pulsar with the surrounding interstellar medium.

Detailed Chandra spectra of the x-ray binary GRO J1655-40 during a 2005 outburst found absorption features which indicate that ~30% of the gas in the system is blowing away rather than accreting onto the black hole. The temperature and intensity of the winds imply that powerful magnetic fields must be present. These magnetic fields, likely carried by the gas flowing from the companion star, create magnetic

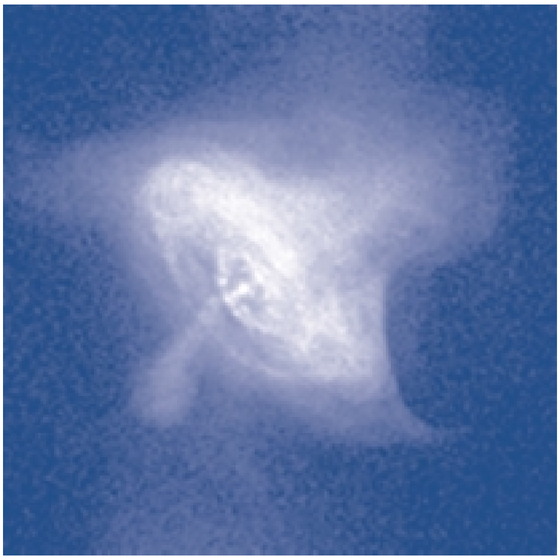

Figure 3. Chandra image of the Crab Nebula from J Hester et al (1999).

turbulence that generates friction in the gaseous disk and drive winds from the disk that carry momentum outward as the gas falls inward. Magnetic friction also heats the gas in the inner part of the disk to X-ray emitting temperatures. A 10-day Chandra exposure on the Orion Nebula detects more than 1500 x-ray sources, most of them associated with young stars formed in the last several million years. Chandra has also detected x-ray emission from a number of solar system objects, demonstrating that x-rays from comets are generated when heavy ions such as nitrogen and oxygen in the solar wind capture electrons from the cold cometary gas. After capturing the electrons in an outer shell, the ion emits an x-ray as the electron transitions to a more tightly bound state.

Future prospects

Chandra was designed nominally as a 5-year mission with all expendibles carrying a 100% margin. As stated above we are now at 7.5 years and all is working incredibly well, with perhaps 3 issues worth noting. (1) The front-illuminated CCDs (8 of 10 ACIS chips) sustained some damage due to ~100Kev protons focussed by the telescope during passage through the radiation belts during the first several weeks of the mission. Increased charge transfer inefficiency somewhat degraded the energy resolution of these CCDs, although much of the capability was subsequently recouped via further cooling of the chips and application of corrective algorithms. Further damage has been limited by translating ACIS away from the telescope focus during high radiation times. (2) Over the course of the mission outgassing of a contaminant of unknown origin has deposited an absorbing layer of carbon-like material on the ACIS UV blocking filter. This contaminant has reduced the low energy throughput of ACIS at 1/4 keV to close to nil, and has reduced the throughput at 0.6 keV to about 1/2 of its original value. The build-up over time has appeared to nearly level off, and the Chandra team has not yet exercised a capability to warm the instrument to drive off the contaminant due to possible risks involved. (3) Finally, the thermal aging of the observatory is a bit more rapid than some of us had anticipated, leading to added restrictions with regard to where on the sky Chandra can point and for how long at a particular time of the year. This condition makes mission planning and scheduling more challenging and at times precludes our being able to implement a fast turn-around TOO which would have easily been accommodated during the early years of the mission.

At present, there are no known issues which would threaten the mission lifetime, and we anticipate at least another 5 spectacular years of science with Chandra. It is actually reasonable to speculate about several more years beyond that.

Harvey Tananbaum
Director, Chandra X-ray Center

The XMM-Newton Space Observatory

XMM-Newton, ESA's X-ray observatory was launched on 10 December 1999 on an Ariane V rocket into a highly eccentric orbit with a 48-hr period. XMM-Newton provides sensitive X-ray imaging and spectroscopic observations of a wide variety of cosmic sources from nearby comets to the most distant black holes to a large community of users. The instrumentation consists of the European Photon Imaging Camera (EPIC), the Reflection Grating Spectrometer (RGS) and the Optical Monitor (OM). EPIC consists of 3 imaging spectrometers each located at the focus of an X-ray optic consisting of 58 nested Wolter I geometry mirrors. Two of the EPIC cameras are based on MOS-CCD technology and share the mirrors with RGS grating arrays, while the detector based on pn-CCD technology is located behind a fully open telescope position. EPIC allows for 0.3-12 keV spectroscopy of cosmic X-ray sources with a limiting flux of 10^{-15} ergs/cm^2/s and can be used to detect X-ray sources with fluxes as low as a few times 10^{-16} ergs/cm^2/s. The overall effective aperture is 0.45 m^2 at 1 keV and the spatial resolution is 15 arc seconds (half-energy width) with a field of view of ~30 arc minutes diameter. The RGS provides 0.35-2.4 keV spectra with an outstanding energy resolution ($E/\Delta E$) of 300-700 (1st order). The effective area for the two grating arrays is in the range of 40-200 cm^2 over the specified energy range. The OM can detect sources down to 22nd magnitude in a few thousand seconds (depending on spectral type). The OM is powerful enough, both in sensitivity and positional accuracy, to allow for identification of counterparts to many of the new X-ray sources detected with XMM-Newton.

XMM-Newton was originally approved for 2.2 year of operations with a design lifetime of 10 years and ESA's Science Programme Committee has approved extensions of operations until March 2010, subject to performance and mission status reviews every 2 years. A further extension request is being prepared. Operations continue smoothly with all the spacecraft systems and ground segment performing nominally. At the current rate of consumption there are ample consumables for well beyond the approved lifetime. There has been no unexpected degradation of the solar arrays, batteries, or any other system and there has been no loss of redundancy. On the payload side, two of the 18 RGS CCDs failed early in the mission, but without causing loss of energy coverage due to the redundancy of the two RGS units. In addition, 4 micrometeoroid impact events in 7 years have resulted in the loss of 1 in 14 of the MOS CCDs.

ESA's Research and Scientific Support Department has overall responsibility for the mission and is directly responsible for science operations. The XMM-Newton Science Operations Centre (SOC) is located in ESAC, near Madrid. Mission operations are conducted from ESOC, Darmstadt and the nationally provided Survey Science Consortium is led by Leicester University. The main ground stations are located at Perth (Australia) and Kourou (French Guyana). The SOC has to support a large user community. The size of which can be estimated from the 2000 registered users of the science archive, the fact that the latest XMM-Newton Science Analysis System (SAS), version 7.0 was downloaded about 1000 times and is used by an estimated 2000 scientists, and from the >1500 scientists participating in each observing announcement of opportunity. This large community is the result of a scientifically highly productive mission. In 2006 a total of 305 refereed papers, directly based on XMM-Newton results, were published. XMM-Newton papers are highly cited. As an example, from papers published in the last year, 7.8% were in the top 1% of astrophysical papers cited and 50% were in the top 10% of cited papers.

The last call for observing proposals was AO-6 which closed on 6 October 2006. 594 valid proposals were received with a very high temporal over-subscription factor of 6.9. A total of 41 proposals for "Large Programs" were submitted. Triggered observations are requested in 21 proposals. For a joint XMM-Newton Chandra program 17 proposals were received and for a joint XMM-Newton ESO (VLT and VLTI) program 9 proposals were in competition. These proposals were written by 425 different principal investigators from 29 countries, mostly ESA member states, the United States and Japan. Considering principal investigators and co-investigators, about 1550 individual scientists were involved in the response to AO-6. The next chance to obtain observing time on XMM-Newton (other than by a request of a Target of Opportunity (TOO) observation) will be AO-7 which is expected to open on.

One of the most popular ways of accessing XMM-Newton data is through the Science Archive (XSA) which can be found at www.sciops.esa.int/xsa. This contains the latest (pre-release) source catalogue (the 2XMM serendipitous source catalogue) containing detections drawn from 2400 XMM-Newton EPIC observations made between 2000 February 4 and 2006 April 20. The catalogue contains 153,105 X-ray source detections from 123,170 unique X-ray sources. The median 0.2-12 keV flux of the catalogue sources is 2.4 10-14 erg cm^{-2} s^{-1}. In addition to source catalogues, it is possible to search the archive for XMM-Newton science products such as spectra, images and light curves from selected sources and transfer these to user's computers for further analysis.

For the past four years, as XMM-Newton slewed between different targets ready for the next observation, it has kept its cameras open and used this spare time to quietly observe the sky. The result is a 'free-of-charge' mission spin-off – a survey that has now covered an impressive 25% of the sky. The rapid slewing of the satellite across the sky means that an X-ray source passes through the telescope field of view in about 10 seconds. However, the large collecting area of the XMM-Newton mirrors, coupled with the efficiency of its imaging sensors, is allowing thousands of sources to be detected. In addition, XSA has recently been modified to allow external users access to the sources detected in the slews. Eventually, the slew survey should cover at least 80% of the sky, providing a tremendous legacy for the future.

Every 3 years the SOC organizes a large X-ray conference around an XMM-Newton theme, The last one had the title "The X-ray Universe 2005" and was held in El Escorial, Madrid. Around 360 scientists participated and around 120 talks were given. The talks and posters were published in the two-volume conference proceedings ESA/SP-640. On 4-6 June 2007 a workshop dedicated to the next decade of XMM-Newton science will be held at ESAC followed by a workshop on 5-7 September 2007 on the study of X-ray emission from nearby galaxies.

The science highlights from XMM-Newton are almost too numerous to mention. Recently these have included the first detection of a black hole in the globular cluster NGC 4472 by Maccarone et al., (2007, Nature, 445, 183), X-ray evidence supporting a new class of Type I supernovae by Borkowski et al. (2007, Ap. J., 652, 1259) with more massive younger progenitors than previously expected and the first 3-dimensional map of the Universe's dark matter scaffolding by Massey et al. (2007, Nature, 445, 286) from observations of the Cosmic Evolution Survey (COSMOS) carried out by a team of 70 astronomers. More than 1000 hours of HST and 400 hours of XMM-Newton observations together with ground based observations were combined to reveal the web-like 3-dimensional distribution of baryonic and Dark matter in a small (1.6 square degree) region of sky. The map provides the best evidence yet that normal matter accumulates along the densest concentrations of dark matter. The map reveals a loose network of filaments, intersecting in massive structures where clusters of galaxies are located. The map, which stretches halfway back in time to the beginning of the Universe, also reveals how dark matter has recently grown increasingly clumpy as it continues to collapse under gravity.

XMM-Newton was the subject of 24 ESA web stories in the last two years. These included the announcement of the 1000th top class science result (on 25 Jan 2006), results of observations of Jupiter, neutron stars, gamma-ray bursts, distant galaxies, supernova remnants, black holes, and the NASA "Deep Impact" with comet Tempel 1. A gallery of visually striking XMM-Newton results is maintained for public use at the XMM-Newton web site.

I would like to thank the XMM-Newton Project Scientist, N. Schartel, the SOC managers, J. R. Muñoz and L. Metcalfe, and the spacecraft operations manager, D. Heger, for assistance with this article.

Arvind N. Parmar
XMM-Newton Mission Manager

Swift:
Exploring Gamma-Ray Bursts and More

Introduction

The Swift gamma-ray burst (GRB) mission is a multi-wavelength, space-borne observatory designed to carry out the detection and rapid localization of gamma-ray bursts, as well as make subsequent X-ray, optical and ultraviolet observations. The key features of Swift include 1) the continuous monitoring of one sixth of the sky for gamma-ray bursts, 2) the ability to autonomously reorient the spacecraft to observe a burst within a few tens of seconds of the burst trigger, 3) the rapid dissemination of the burst information via the Internet to the astronomical community, and 4) the ability to carry out follow-up observations with sensitive instruments for as long as the burst afterglows are detectable. Swift became operational in February 2005, and has since provided unprecedented observations of more than 200 gamma-ray bursts, as well as unique observations of other transient events. Swift has also produced the finest hard X-ray all-sky survey to date.

Mission Overview

Swift is a collaborative effort between the United States, Italy and the United Kingdom, and is part of NASA's Medium Explorer (MIDEX) program. The mission carries three instruments: the Burst Alert Telescope (BAT), the X-Ray Telescope (XRT), and the UltraViolet/Optical Telescope (UVOT).

The BAT is a product of Goddard Space Flight Center. The BAT has 32,768 CdZnTe detectors that reside in a plane 1 meter behind a coded aperture mask consisting of more than 50,000 lead tiles. The BAT is about 2.5 times more sensitive than BATSE on CGRO, and provides GRB localizations to within a few arc minutes for roughly 100 bursts per year.

The XRT is a product of Penn State University, the Brera Astronomical Observatory, and the University of Leicester. The XRT consists of a Wolter 1 grazing incidence telescope that focuses onto a cooled CCD, which is sensitive to 0.2 to 10 keV X-rays. The XRT has a field of view of 23.6 arc minutes by 23.6 arc minutes. Positions of GRB afterglows to within 6 arc seconds are provided quickly, and to 2 arc seconds after reprocessing.

The UVOT is a product of Penn State University, and the Mullard Space Science Laboratory. The UVOT is a 30-cm aperture modified Ritchey-Chrétien design with a microchannel-plate-intensified CCD detector. It is sensitive to photons from 170 to 650 nm. The UVOT has a field of view of 17 arc minutes by 17 arc minutes, and has a detection limit of B = 22 in only 1000 seconds.

The Swift spacecraft was built by Spectrum Astro.

Swift was launched on November 20, 2004 from the Kennedy Space Center on top of a Delta 7320 rocket. Swift was placed into a 600-km altitude circular orbit with a 20.6 degree inclination. The mission became operational on February 1, 2005. The orbital lifetime is expected be roughly 20 years.

The telemetry is carried out in two manners. First, the on-demand, two-way telemetry rate for Swift is 2 kbps via TDRSS. Second, there are seven opportunities per day for a two-way telemetry rate of 2.25 Mbps via the Italian Ground Station in Malindi, Kenya.

The BAT operates in survey mode most of the time, during which it continuously monitors one third of the observable sky for high-energy transients. The BAT localizes, to within a few arc minutes, any GRB that sets off the trigger. The spacecraft is autonomously reoriented in a few tens of seconds to put the burst within the fields of view of the XRT and UVOT. Swift can slew 50 degrees in less than 75 seconds.

The key burst information is sent via a TDRSS relay satellite and subsequent systems to the ground, and these data are rapidly distributed worldwide over the Internet via the GCN (Gamma-ray burst Coordinates Network). The BAT burst position is disseminated in roughly 20 seconds after the burst trigger, the XRT position is distributed in roughly 60 seconds, and the UVOT finder chart is sent out after roughly 4 minutes. The observatory is operated by the Swift Mission Operations Center at Penn State University.

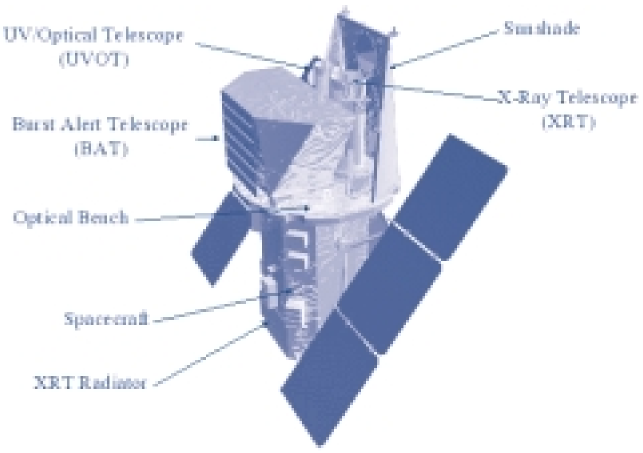

Figure 1: The Swift spacecraft and instruments.

Data Distribution and Proposals

Swift is a community facility, and the GRB observations are disseminated to the astronomical public in near real time, primarily via the GCN. Researchers subscribe to the GCN (http://gcn.gsfc.nasa.gov/) to receive the notices and data. Instructions for submitting a Swift Target of Opportunity request can be found at http://www.swift.psu.edu/too.html . Information regarding other Swift observing proposals can be found at http://heasarc.gsfc.nasa.gov/docs/swift/proposals/ .

Scientific Highlights

Swift observations have had a tremendous impact on GRB research. First, here are some basics about the bursts. Generally speaking, the GRBs come in two types: long and short. Two seconds is roughly the dividing line in duration between the two groups, although there is significant overlap. The long bursts are spectroscopically softer than the short bursts. The currently accepted picture is that the long GRBs are produced by collapsars, and represent the birth events of black holes.

The year 2005 was the breakthrough year for the short GRBs. Swift discovered GRB050509B, and detected its afterglow, a first for a short burst. This burst was associated with an early-type (elliptical) galaxy at z = 0.225. Two months later, HETE localized the afterglow of the short burst GRB050709, and Swift subsequently localized the afterglows of the short bursts GRB050724, GRB050813, and several others.

These bursts together provide circumstantial evidence that short GRBs are due to mergers of neutron-neutron star binary systems, although this is certainly not yet proven. A collapsar origin for the short bursts is definitely ruled out, because the short burst locations are not correlated with either star forming galaxies or star forming regions within galaxies. Also, no short burst has ever been associated with a supernova.

Here are some of the other GRB discoveries by Swift.

Swift discovered GRB050904 with a spectroscopic redshift of z = 6.29 (measured via the Subaru Telescope), and is the first burst identified at such large distance. This GRB is still the record holder, but hopefully this record will be broken many times over, since such bursts can be used as probes of the early Universe.

Swift discovered X-ray flash XRF060218 (z = 0.0331), which lasted 33 minutes, and preceded Type Ib/c SN 2006aj. The latter turns out to be the best observed supernova ever at early times, because many astronomers had their telescopes trained on its location for the burst observations.

Swift discovered GRB060614 (z = 0.125), which was neither clearly a short nor a long GRB. The burst lasted 100 seconds, but no supernova was detected, which should have been easily seen for such a relatively nearby event. Apart from its duration, this burst was more like a short burst than a long burst. Perhaps the word “short” is too simple a description for a class of GRBs.

Swift discovered GRB060729 (z = 0.54), which had an X-ray afterglow that lasted more than 200 days, an unprecedented length. To have the afterglow powered for so long implies there must be continuous injection of energy from the central engine for an extended period of time. Also, it is curious that Swift’s XRT did not reveal a “jet break” in the X-ray afterglow of GRB060729, nor has such a break been detected via the XRT for any GRB or XRF. The XRT provides the most consistent and continuous observational coverage of burst afterglows, and the implication of a non-detection of breaks in the X-ray light curves due to beaming of the source is that perhaps such breaks do not exist after all.

An emerging picture is that the magnetars are the central engines of some GRBs. Magnetar birth events have been proposed to explain certain GRBs and XRFs (e.g., GRB060218). Magnetar superflares (like the December 27, 2004 event from SGR 1806-20) have been suggested to explain GRBs that are not accompanied by supernova events (e.g., GRB060614). Magnetars have also been invoked to explain long-lived GRB afterglows that require the continuous injection of energy for extended periods of time (e.g., GRB060729).

Other Swift GRB discoveries include the detection of 1) late-time flares in afterglows (e.g., GRB050502B and XRF050406), 2) bright early afterglow components (e.g., GRB050724), and 3) pre-curser events (e.g., GRB061121).

The Swift GRB archive is at http://swift.gsfc.nasa.gov/docs/swift/bursts/index.html , and a Swift GRB look-up table is at http://swift.gsfc.nasa.gov/docs/swift/archive/grb_table/ .

Swift has, of course, observed much more than GRBs. The Swift non-GRB transient catalog containing over 400 objects can be found at http://swift.gsfc.nasa.gov/docs/swift/results/transients/ .

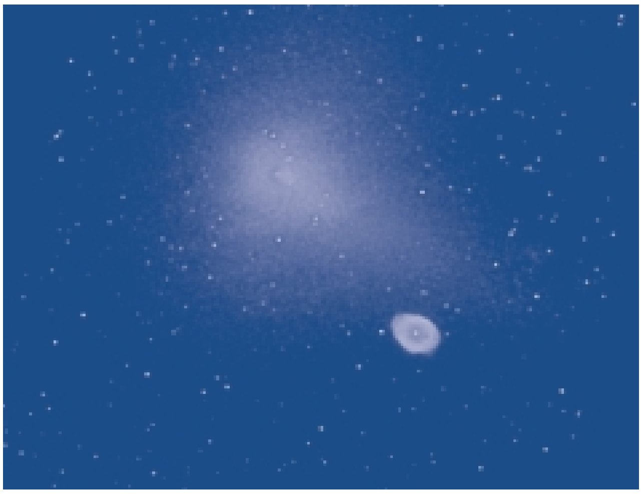

Figure 2: An UVOT image of Comet Schwassmann-Wachmann 3 and the Ring Nebula.

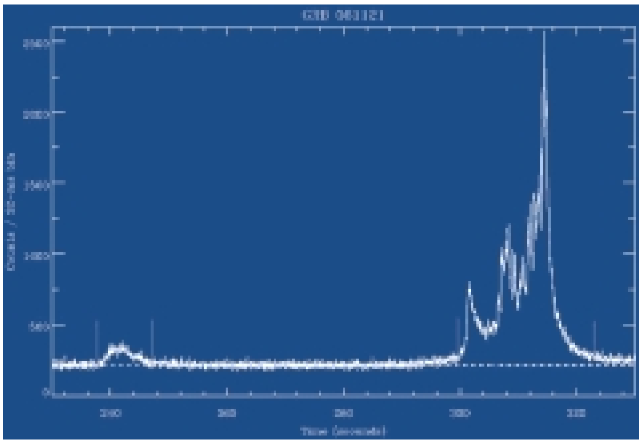

Figure 3: The light curve of GRB061121 showing an apparent pre-curser event.

The Swift all-sky hard X-ray (14 to 195 keV) survey has found that most Active Galactic Nuclei (AGNs) are obscured by gas, and so they are missed by traditional observing techniques. The Swift catalog will contain around 400 AGNs when it is complete, and it will be the most volume complete AGN sample ever.

The Swift observations of a few dozen supernovae (from SN 2005am to SN 2007aa, and counting) can be found at http://swift.gsfc.nasa.gov/docs/swift/sne/swift_sn.html .

The Swift data archive is at http://swift.gsfc.nasa.gov/docs/swift/archive/ .

The Future

Swift has the potential to provide many more years of additional observations of GRBs of all kinds, and will also provide observations of supernovae, soft gamma repeaters, and other transients, as well as AGNs.

Many questions regarding the GRBs remain to be answered. Are all the long bursts due to collapsars? Are all the short GRBs due to compact object mergers? How distinct are the long and short GRBs? Are magnetars responsible for some GRBs?

Swift has given us unprecedented observations of GRBs, but the bursts never cease to mystify.

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