Swift Publication Statistics: A Comparison With Other Major Observatories

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ABSTRACT. Swift is a satellite equipped with γ-ray, X-ray, and optical-UV instruments aimed at discovering, localizing, and collecting data from gamma-ray bursts (GRBs). Launched at the end of 2004, this small-size mission finds about a hundred GRBs per year, totaling more than 700 events as of 2012. In addition to GRBs, Swift observes other energetic events, such as active galactic nuclei (AGNs), novae, and supernovae. Here we look at its success using bibliometric tools; that is, the number of papers using Swift data and their impact (i.e., number of citations to those papers). We derived these from the publication years 2005 to 2011, and compared them with the same numbers for other major observatories. Swift provided data for 1101 papers in the interval 2005–2011, with 24 in the first year, to 287 in the last year. In 2011, Swift had more than double the number of publications as Subaru, it overcame Gemini by a large fraction, and reached Keck. It is getting closer to the ~400 publications of the successful high-energy missions XMM-Newton and Chandra, but is still far from the most productive telescopes, VLT (over 500) and HST (almost 800). The overall average number of citations per paper, as of 2012 November, is 28.3, which is comparable to the others, but lower than Keck (41.8). The science topics covered by Swift publications have changed from the first year, when over 80% of the papers were about GRBs, falling to less than 30% in 2011.

Online material: color figures

1. INTRODUCTION

The scientific impact in its fullest sense of individual scientists, research institutes, or universities is rather hard to quantify and may take a long time to become apparent. One of the several approaches commonly used, in the absence of a better metric, is bibliometrics, which measures publication and citation numbers. Bibliometrics applies statistical methods to scientific publications, and, as is generally done for all subject areas, in astronomy it measures the impact of a given entity through the total number of citations to its papers. It is used nowadays by all major astronomical observatories, including HST, VLT, Keck, and Chandra, and is generally well documented. HST, ESO telescopes (e.g., VLT), Keck, and VLA have made available their bibliometric statistics beginning in the nineties. The space missions Chandra and XMM-Newton (the high-energy space missions) started their publication statistics more recently, as they were launched later.

All of the above-mentioned observatories are medium- to large-size projects, with budgets above half a billion USD, whose well-proven successful publication statistics are instrumental in advocating for support from major space agencies or national and international institutions. Here we present the first complete bibliometric investigation for the years 2005–2011 of the small-size (budget <300 million USD) Swift GRB Explorer Mission (Gehrels et al. 2004). The impact of Swift in the astronomical community has already been shown by Madrid & Macchetto (2009). In their list of the most successful observatories for the year 2006, small projects, including SDSS and Swift, are competing and performing even better than big “monster telescopes” such as HST or VLT.

To perform a meaningful comparison with other observatories in our analysis of publication statistics, Swift papers are selected by following the same strict criteria that other major observatories use. First, only peer-reviewed publications are considered. Next, a paper is considered as a Swift paper if Swift data are used. No theoretical papers (i.e., papers with no use of data) are included, even if Swift-based results from other publications are mentioned. Papers not considered Swift papers include those which only mention an object discovered by Swift, use the coordinates of an object discovered with Swift, or concern work triggered by a Swift discovery. Our work is organized as follows: A short description of the mission is given in § 2. The details of the methodology used are provided in § 3. In § 4, we describe the results, in § 5 we discuss the science topics covered by Swift publications, and in § 6, we draw the conclusions of our survey.

2. THE SWIFT MISSION

Swift is a dedicated satellite primarily intended and designed to detect, localize, and observe GRBs. Built by NASA and an international consortium from the United States, United
Kingdom, and Italy, it was launched in 2004 November and has been operating ever since. It carries three instruments: the Burst Alert Telescope (BAT; Barthelmy et al. 2005) is a γ-ray instrument which detects GRB events and localizes them to arcmin precision; the X-ray Telescope (XRT; Burrows et al. 2005) provides a more precise position with an error radius <2 arcsec in 90% of cases (Evans et al. 2009); the 0.3 meter Ultraviolet/Optical Telescope (UVOT; Roming et al. 2005) provides sub-arcsec localization when the GRB is optically bright.

The position is communicated within 1 minute via the Tracking and Data Relay Satellite System (TDRSS) to the Mission Operations Center at Penn State University (Pennsylvania) and the Gamma-ray Coordinates Network (GCN) at the Goddard Space Flight Center (GSFC, near Washington, D.C.). The scientific community is publicly alerted for rapid follow up with ground-based telescopes or orbiting satellites before the blast becomes too faint. Data, which are made public as soon as they are taken, are stored and analyzed at the Swift Science Data Center (at GSFC), at the University of Leicester (UK), and at the ASI Data Center (near Rome).

Swift is operated by 3–4 scientists working on-line simultaneously, rotating from a team of 14–15 people. The satellite reached routine observations early on. Considering that BAT has triggers disabled for 18% of the time due to the South Atlantic Anomaly and during slews, which is an additional 17% of the time, Swift works at a very high efficiency of 98%. It detects about 100 GRBs every year and, as of end of 2012, has produced data for more than 700 GRBs. The total budget covering launch and the first eight years of operation (∼6 million USD per year) has been about 300 million USD, including contributions from outside the US. The costs also include about 1.5 million USD per year awarded as grants to US scientists through a Guest Investigator Program. Thanks to its recognized success, NASA has recently granted financial support until 2014.

3. METHODOLOGY

The methodology we applied to identify Swift papers consists of two parts. First, we use a Full-Text-Search tool (FUSE) to spot papers that mention the word “Swift” in the text, then we visually inspect each paper to classify it. The peer-reviewed journals we screened are A&A, A&ARv, AJ, ApJ, ApJS, AN, ARA&A, EM&P, Icarus, MNRAS, Nature, NewA, NewAR, PASJ, PASP, P&SS and Science.

3.1. FUSE

FUSE is a program developed and maintained by the European Southern Observatory (ESO) Library. A description can be found in Erdmann & Grothkopf (2010) and Meakins & Grothkopf (2012). FUSE is used by telescope bibliography compilers of several major observatories, including HST, Gemini, and Subaru.

The program relies heavily on the NASA Astrophysics Data System (ADS) Abstract Service. FUSE converts PDFs of specific journals into text files, scans them for user-defined keywords, and provides highlighted results in context. The sole keyword searched for in our study was Swift.

3.2. Visual Inspection and Classification

Papers selected with FUSE that contain the term Swift anywhere in the text were inspected visually to determine whether Swift data were actually used for the research or whether the term was mentioned in another context (e.g., future observations with Swift). Papers which use Swift coordinates as finding charts or as the basis for observations with other facilities are not included. Likewise, papers which merely quote results presented in other papers are excluded. Finally, papers discussing Swift instruments and calibrations (we found 8 in total) are excluded too. About 20–50% of the examined papers from 2005 to 2011 are included in the Swift bibliography. When we identify a Swift data paper, we also check which instruments were used and keep track of the scientific subject covered. An overview of the number of Swift papers, along with the total and average citations (as of 2012 November 14), is given in Table 1.

3.3. Other Observatories

For ground-based optical/NIR publication statistics, we included those provided for Gemini, Keck, Subaru, and VLT. For UV and X-ray satellites, we used HST, Chandra, and XMM-Newton9 publication statistics. For more details, see Apai et al. (2010) on HST bibliometrics, Rots et al. (2012) on Chandra, and Grothkopf & Meakins (2012) on ESO telescopes (including VLT). For the ground-based telescopes and HST, statistics are obtained using the same rigorous method described in § 3.2, and therefore results can be considered comparable with Swift’s. For Chandra and XMM-Newton, a different methodology is used, giving generally higher numbers. For example, a paper could describe models or a theory which are based on Chandra results published in another paper. According to Chandra publication statistics, both papers are Chandra papers, whereas, according to our method, only the original paper

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9 For more information please see heasarc.gsfc.nasa.gov/docs/xmm/xmmbiboverview.html.
8 For more information please see www.eso.org/libraries/telbib_pubstats_overview.html.
7 For more information please see archive.stsci.edu/hst/bibliography.
6 For more information please see cxc.harvard.edu/cda/bibstats/bibstats.html.
5 For more information please see www.naoj.org/Observing/Proposals/Publish.
4 For more information please see www2.keck.hawaii.edu/library/keck_papers.html.
3 For more information please see www.gemini.edu/science/publications.
TABLE 1

SWIFT PUBLICATIONS AND CITATIONS IN THE YEARS 2005–2011

| Year | # papers | # citations | Cites/paper |
|------|----------|-------------|-------------|
| 2005 | 24       | 2165        | 90.2        |
| 2006 | 81       | 4976        | 61.4        |
| 2007 | 152      | 6204        | 40.8        |
| 2008 | 143      | 4070        | 28.5        |
| 2009 | 190      | 5846        | 30.8        |
| 2010 | 224      | 4020        | 17.9        |
| 2011 | 287      | 3860        | 13.4        |
| All  | 1101     | 31141       | 28.3        |

NOTE.—Columns: (1) Year of publication. (2) Number of Swift peer-reviewed publications. (3) and (4) Total and average number of citations, obtained from ADS as of 14 November 2012.

4. RESULTS

In Figure 1, we compare Swift papers to publications of major observatories for the years 2005–2011. First Swift publications appeared in 2005. All other observatories in this study started earlier, e.g., HST in 1992 and VLT in 1999. Figure 2 shows publication statistics for early years for all considered observatories. One way to measure the impact of Swift is by counting the number of papers which use Swift data, and the related number of citations. We did this for the years 2005–2011, and compare these numbers with all major observatories listed in § 3.3.

4.1. Number of Publications

Swift started successful operations right away after its launch in 2004 September. The first GRB was detected 2004 December 17, called GRB 041217. The first Swift papers appeared in 2005, the year following its launch, due to the normal delays in the publication process. The number of publications shows an almost steady increase (Fig. 1), starting with 24 papers in 2005, and increasing to 287 in 2011. In the last year, Swift publications were more than those for Gemini, twice those for Subaru, and equalled those of one of the most successful observatories ever, Keck. The total number of Swift publications in 2005–2011 is 1101. Details are reported in Table 1, whereas Figure 1 shows the comparison with major observatories. The distribution of journals where these papers were published is shown in Table 2, and the comparison with VLT and HST in Table 3. Almost half of the Swift papers appeared in the American journal ApJ, while 45% were equally distributed in the two European journals A&A and MNRAS. This reflects the multi-national aspect of the mission. The fraction of VLT publications in European (A&A and MNRAS) and American (ApJ, AJ, PASP) core astronomy journals is 67% and 28%, respectively (Table 3). The situation for HST is reversed: European and American publications are 31% and 60%, respectively. The journals with particularly high impact factors, Science and Nature, together published 3% of all Swift papers, more than what is typically found for other, more mature observatories (1.7% and 1.5% for VLT and HST, respectively).

Publication statistics are generally affected, e.g., by the number of telescopes (VLT has four) and instruments of an observatory, hours of observation, construction costs and maintenance, and the number of years of operation (HST started observations more than 20 years ago). Moreover, ground-based
telescopes are affected by poor weather conditions, variable seeing and bright time, as well as by the fact that they cannot observe during the day. Publications based on data from any observatory typically start the year following the first light. In Figure 2 we display the number of publications for the first 7 years of publication for the observatories considered here. The steady increase is common to all. This is related to the organization of observatories, with instruments coming online successively during the first years. A steady regime for Swift has likely not been reached yet as of 2011. For 2012, preliminary predictions indicate over 350 papers, getting closer to the larger high-energy missions XMM-Newton and Chandra, which in 2011 published about 450 papers.

4.2. Impact: Citations

A key parameter in evaluating the success of an observatory is the number of citations of its papers for each year or for all years. Of course the number of citations of papers of a given year is a dynamical measure, as it keeps growing with time. In Figure 3, the number of citations (as measured in 2012 mid-November, provided by the ESO Library for VLT and obtained from ADS for all other telescopes) relative to publications of 2005–2011 is reported for Swift and other major observatories. The highest number of citations is obviously attached to the oldest papers, because they have had more time to accumulate citations. The first year of publication was particularly successful, with a very high number of average citations per paper of ~90. Among the 24 papers published in 2005, 6 were in Nature and one in Science, which helps explain the high citation number. The overall average number of citations per paper (the total number of citations divided by the total number of papers) is 28.3, which is comparable to the others (HST: 29.2, VLT: 29.6, Gemini: 31.2, Subaru: 31.8), but lower than Keck (41.8). Among Keck publications, several are very successful (which results in a higher average number of citations), while the citations of other observatories are more uniformly distributed.

Another way of measuring the success of publications is by considering the number of so-called high impact papers

### Table 2

| Journal   | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Total | %    |
|-----------|------|------|------|------|------|------|------|-------|------|
| ApJ/ApJS  | 14   | 46   | 78   | 74   | 90   | 103  | 127  | 532   | 48.3 |
| A&A       | 2    | 19   | 49   | 37   | 37   | 41   | 67   | 252   | 22.9 |
| MNRAS     | 1    | 9    | 18   | 20   | 53   | 70   | 75   | 246   | 22.3 |
| AJ        | 0    | 1    | 4    | 4    | 6    | 4    | 3    | 22    | 2.0  |
| PASP      | 0    | 0    | 1    | 0    | 1    | 0    | 2    | 2     | 0.2  |
| Nature    | 6    | 6    | 0    | 5    | 3    | 0    | 5    | 25    | 2.3  |
| Science   | 1    | 0    | 0    | 1    | 0    | 2    | 4    | 8     | 0.7  |
| Others    | 0    | 0    | 2    | 2    | 1    | 3    | 6    | 14    | 1.3  |

### Table 3

| Journal   | Swift | VLT | HST |
|-----------|-------|-----|-----|
| ApJ/ApJS  | 532   | 48.3| 824 | 25.1| 2407 | 48.3|
| A&A       | 252   | 22.9| 1623| 49.4| 755  | 15.1|
| MNRAS     | 246   | 22.3| 591 | 18.0| 775  | 15.5|
| AJ        | 22    | 2.0 | 91  | 2.8 | 493  | 9.9 |
| PASP      | 2     | 0.2 | 16  | 0.5 | 72   | 1.4 |
| Nature    | 25    | 2.3 | 42  | 1.3 | 52   | 1.0 |
| Science   | 8     | 0.7 | 14  | 0.4 | 24   | 0.5 |
| Others    | 14    | 1.3 | 86  | 2.6 | 406  | 8.1 |
| All       | 1101  | —   | 3287| —   | 4984 | —   |

**Note.**—Columns: (2), (4) and (6) Total numbers of publications for a given journal. (3), (5) and (7) Fraction over the total.

a Obtained from ESO Telescope Bibliography (http://telbib.eso.org).

b Obtained from HST Bibliography (http://archive.stsci.edu/hst/bibliography/).

### Figure 3

Number of citations per paper for Swift (red histogram), HST, VLT, Gemini, Subaru and Keck, for papers published 2005–2011 (as of 2012 mid-November). The citations build up over time for older papers, so the trend is naturally downwards for more recent papers. See the online edition of the PASP for a color version of this figure.
TABLE 4

| Year | Swift | VLT | HST | Keck |
|------|------|-----|-----|------|
|      | Total papers (×10^3) | # papers | HIPs | % | # papers | HIPs | % | # papers | HIPs | % | # papers | HIPs | % |
| 2005 | 24.8 | 24 | 4 | 16.7 | 361 | 7 | 1.9 | 681 | 13 | 1.9 | 231 | 13 | 5.9 |
| 2006 | 25.3 | 81 | 6 | 7.4 | 414 | 16 | 3.9 | 714 | 25 | 3.5 | 277 | 14 | 5.2 |
| 2007 | 23.3 | 152 | 3 | 2.0 | 494 | 11 | 2.2 | 724 | 27 | 3.7 | 311 | 16 | 5.1 |
| 2008 | 26.2 | 143 | 3 | 2.1 | 486 | 10 | 2.1 | 689 | 17 | 2.5 | 265 | 14 | 5.3 |
| 2009 | 27.3 | 190 | 5 | 2.6 | 471 | 15 | 3.2 | 676 | 15 | 2.2 | 270 | 12 | 4.4 |

Note.—Column (2) Total number of peer-reviewed publications, according to ADS, in units of 1000. (3), (6), (9) and (12) Number of papers for the given observatory. (4), (7), (10) and (13) Number of high impact papers. (5), (8), (11) and (14) Fraction of high impact papers over the total.

5. SCIENCE TOPICS

While the main aim of Swift is to detect GRBs, the satellite also successfully observes other energetic events. This is demonstrated by the distribution of the absolute number (Fig. 5) and the fraction (Fig. 6) of papers for the different science topics. It is clear that in the first 2 years GRB science was dominant, accounting for over 80% of the publications. In the following year, 2007, the majority are still GRB papers, almost 60%. During the years 2008–2011, the science done by Swift is mostly non-GRB (which drops to a range of 28–35%). A large fraction is dedicated to galactic sources: ~1/4 of the papers in 2008–2011 are about X-ray binaries, pulsars, and supernovae. Among all topics, after GRBs, the most popular is AGN, which in our classification includes AGNs, distant QSOs, BL Lac and blazars. Swift produced interesting results on many other subjects which are summarized in Figures 5 and 6 as “Other”. These are mainly extragalactic papers, including X-ray background radiation, galaxy surveys, galaxy clusters and groups, and radio galaxies. Five papers (out of 1101) deal with X-ray and UV emission of comets. It is notable that the absolute number of publications about GRBs in the interval considered, 2005–2011, is not obviously changing; i.e., the GRB publication rate is not declining in absolute terms.

Table 5 lists the details of the most successful Swift papers per year, for 2005–2009, as indicated by the citation count. The science topic covered by the majority, 21 out of 27 papers, is GRB. One is about AGN, two about supernovae, and one about the black hole in the X-ray galactic source Cygnus X-1. Out of the 27 papers, 11 are published in Nature, one in Science. Three (11.1%) are papers with a female first author (Soderberg et al. 2006; Racusin et al. 2008; Soderberg et al. 2008). Although this number is not particularly significant (large statistical error), it is relatively high. For comparison, in a recent investigation, Conley & Stadmark (2012) pointed out that women commissioned to write articles in News & Views in Nature and Perspectives in Science for 2010 and 2011 were underrepresented. For instance, the proportion for physical sciences articles is 8.1%, whereas the proportion of female scientists in the same disciplines in the United States is much higher.

10 According to the company Thomson Reuters (producers of the Science Citation Index, SCI), HIPs of a given year are the top 200 most cited papers for that year. These can also be found by using ADS, and include only refereed papers, generally between ~24,800 to ~27,300 in total in the years 2005–2009 (Table 4). We counted the number of papers among the top 200 most cited ones for Swift, HST, VLT and Keck for these years (we do not show the results for the years 2010 and 2011 due to a lack of significant statistics). Results are in Table 4. In the first year of publication for Swift, 4 out of 24 papers (almost 17%) are HIPs, which is much more than the total fraction for the following 4 years (3.0%). For VLT and HST, the total fraction is 2.7% and 2.8%, respectively. Keck, as already mentioned in the previous paragraph, is a very successful observatory, with an average percentage of HIPs of 5.1%

Finally, we extended the concept of successful publications by considering the top 5% based on the number of citations (as given by ADS in November 2012). For the years 2005–2011, the top 5% in terms of citations correspond to approximately the top 1,200–1,300 papers. Figure 4 shows how these are distributed among journals in a cumulative way for the years 2005–2011. The fraction of papers in the high-impact journals Nature and Science is 18% for Swift, while the same fraction for the other observatories is in the range 5–8%. This is perhaps expected, because Swift is newer than the other observatories we considered. We notice that the distribution of the most successful papers for Swift, VLT, and HST for different journals shown in Figure 4 differs from the overall distribution for these observatories for each journal reported in Table 3. For instance, the fraction of Science and Nature papers increases from 3% in all Swift publications (Table 3) to 17.7% for the most successful publications. In contrast, the number of A&A papers for all Swift, VLT and HST publications decreases from 15–49% to 10–36% when only the most successful publications are considered.
higher, 16% (but much lower when considering full professors or high-level positions).

In Table 6 we list the number of Swift papers distributed according to the use of the three instruments. About 31.5% of publications report XRT data without use of BAT or UVOT data. For 43.9%, XRT data are used in combination with the other two instruments BAT and UVOT. The least used instrument is UVOT: 6.4% alone, 28.1% in combination with the others. BAT is used 17.3% alone, 29.8% with the others.

Figure 4.—Distribution per journal and for different observatories of the most successful publications, in 2005–2011. Most successful means the top 5% in terms of citations of all publications. Citations obtained in 2012 November from ADS and the ESO Library. See the online edition of the PASP for a color version of this figure.

Figure 5.—Number of papers for Swift ordered according to the science topic, for the years 2005–2011. An AGN paper also deals with distant QSOs, BL Lacs or blazers. BH indicates massive or stellar black holes. SN includes supernova and supernova remnant. See the online edition of the PASP for a color version of this figure.

Figure 6.—Fraction of papers over the total for Swift ordered according to the science topic, for the years 2005–2011. Labels are as in Fig. 5. See the online edition of the PASP for a color version of this figure.
| Authors          | Bibcode     | Title                                                                 | # citations<sup>a</sup> | Instruments         |
|-----------------|-------------|------------------------------------------------------------------------|--------------------------|---------------------|
| Gehrels et al.  | 2005 Natur. 437. 851G | A Short γ-ray Burst Apparently Associated with an elliptical Galaxy at Redshift z = 0.225 | 303                      | BAT/XRT/UVOT        |
| Burrows et al.  | 2005 Sci... 309.1833B | Bright X-ray Flares in Gamma-Ray Burst Afterglows | 291                      | BAT/XRT/UVOT        |
| Fox et al.      | 2005 Natur. 437..845F | The Afterglow of GRB 050709 and the Nature of the Short-Hard γ-ray Bursts | 278                      | XRT                 |
| Barthelmy et al.| 2005 Natur. 438.994B | An Origin for Short γ-ray Bursts Unassociated with Current Star Formation | 212                      | BAT/XRT             |
| Tagliaferri et al.| 2005 Natur. 436..985T | An Unexpectedly Rapid Decline in the X-ray Afterglow Emission of Long γ-ray Bursts | 172                      | BAT/XRT             |
| Nousek et al.   | 2006 ApJ... 642..389N | Evidence for a Canonical Gamma-Ray Burst Afterglow Light Curve in the Swift XRT Data | 455                      | XRT                 |
| Campana et al.  | 2006 Natur. 442.1008C | The Association of GRB 060218 with a Supernova and the Evolution of the Shock Wave | 342                      | BAT/XRT/UVOT        |
| O’Brien et al.  | 2006 ApJ... 647.1213O | The Early X-Ray Emission from GRBs | 254                      | BAT/XRT/UVOT        |
| Gehrels et al.  | 2006 Natur. 444.1044G | A New γ-ray Burst Classification Scheme from GRB060614 | 213                      | BAT                 |
| Bloom et al.    | 2006 ApJ... 638..354B | Closing in on a Short-Hard Burst Progenitor: Constraints from Early-Time Optical Imaging and Spectroscopy of a Possible Host Galaxy of GRB 050509b | 206                      | XRT                 |
| Soderberg et al.| 2006 Natur. 442.1014S | Relativistic Ejecta from X-ray Flash XRF 060218 and the Rate of Cosmic Explosions | 206                      | BAT/XRT             |
| Schaefer        | 2007 ApJ... 660..16S | The Hubble Diagram to Redshift > 6 from 69 Gamma-Ray Bursts | 208                      | BAT                 |
| Evans et al.    | 2007 A&A... 469..379E | An Online Repository of Swift/XRT light Curves of γ-ray Bursts | 184                      | XRT                 |
| Willingale et al.| 2007 ApJ... 662.1093W | Testing the Standard Fireball Model of Gamma-Ray Bursts Using Late X-Ray Afterglows Measured by Swift | 162                      | BAT/XRT             |
| Albert et al.   | 2007 ApJ... 665L..51A | Very High Energy Gamma-Ray Radiation from the Stellar Mass Black Hole Binary Cygnus X-1 | 144                      | BAT                 |
| Butler et al.   | 2007 ApJ... 671..656B | A Complete Catalog of Swift Gamma-Ray Burst Spectra and Durations: Demise of a Physical Origin for Pre-Swift High-Energy Correlations | 142                      | BAT                 |
| Racusin et al.  | 2008 Natur. 455..183R | Broadband Observations of the Naked-Eye γ-ray burst GRB080319B | 221                      | BAT/XRT/UVOT        |
| Tueller et al.  | 2008 ApJ... 681..113T | Swift BAT Survey of AGNs | 163                      | BAT/XRT             |
| Soderberg et al.| 2008 Natur. 453..469S | An Extremely Luminous X-ray Outburst at the Birth of a Supernova | 159                      | BAT/XRT/UVOT        |
| Sakamoto        | 2008 ApJS... 175..179S | The First Swift BAT Gamma-Ray Burst Catalog | 103                      | BAT/XRT             |
| Liang et al.    | 2008 ApJ... 675..528L | A Comprehensive Analysis of Swift XRT Data. III Jet Break Candidates in X-Ray and Optical Afterglow Light Curves | 85                       | XRT                 |
| Prieto et al.   | 2008 ApJ... 681L..9P 2009 | Discovery of the Dust-Enshrouded Progenitor of SN 2008S with Spitzer | 85                       | UVOT                |
| Tanvir et al.   | 2009 Natur. 461.1254T | A γ-ray Burst at a Redshift of z ~ 8.2 | 240                      | BAT/XRT             |
| Evans et al.    | 2009 MNRAS. 397.1177E | Methods and Results of an Automatic Analysis of a Complete Sample of Swift-XRT Observations of GRBs | 224                      | BAT/XRT/UVOT        |
| Salvaterra et al.| 2009 Natur. 461.1258S | GRB090423 at a Redshift of z ~ 8.1 | 217                      | BAT/XRT             |
| Fynbo et al.    | 2009 ApJS... 185..526F | Low-Resolution Spectroscopy of Gamma-ray Burst Optical Afterglows: Biases in the Swift Sample and Characterization of the Absorbers | 126                      | BAT/XRT             |
| Greiner et al.  | 2009 ApJ... 693.1610G | GRB 080913 at Redshift 6.7 | 123                      | XRT                 |

<sup>a</sup> Number of citations as of November 2012.
6. CONCLUSIONS

Our study confirms that, along with large observatories, it is extremely important for science to invest in and build medium- and small-size missions, and support them for the longest possible time. \textit{Swift} is an international small high-energy mission, launched in 2005 and operated by a team of 15 scientists. Including launch and 8 years of operation, it cost 300 million USD. The success of \textit{Swift} has already been demonstrated by Madrid & Macchetto (2009), who also point out that the most successful observational project of the last decade is the Sloan Sky Digital Survey and its 2 m telescope. \textit{Swift} showed early on that it would be a success, with a total of 24 papers in 2005. In 2011, it produced 287 papers, much more than Gemini, doubling Subaru, and reaching one of the most successful observatories ever, Keck. Citations per paper are around the average for the other observatories, with Keck generally achieving the highest citation rate. It is clear that saturation for \textit{Swift} might very likely not yet have been reached in 2011 and we expect the number of publications for 2012 to be higher than in the year before.

Similar conclusions are reached by Abt (2012), who indicates that the extra costs of large ground-based telescopes are not totally compensated by the higher number of citations. This comparison between large and small facilities relates to recent conclusions by Loeb (2012): Most important discoveries occur serendipitously, and serendipity must go together with large planned projects. Similarly, if we consider the means used to make discoveries, we argue that successful small missions are very important, should continue to be supported as long as possible, and should not be regarded as competition for larger ones.

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\begin{table}[h]
\centering
\caption{Use of Instruments for \textit{Swift} Papers}
\begin{tabular}{|c|c|c|c|c|c|c|c|}
\hline
Year & BAT/XRT/UVOT & BAT/XRT & XRT/UVOT & BAT/UVOT & BAT & XRT & UVOT \\
\hline
2005 & 5 & 4 & 3 & 0 & 4 & 8 & 0 \\
2006 & 24 & 16 & 7 & 0 & 10 & 20 & 2 \\
2007 & 18 & 34 & 18 & 1 & 19 & 57 & 5 \\
2008 & 11 & 25 & 22 & 0 & 25 & 44 & 16 \\
2009 & 20 & 32 & 33 & 3 & 35 & 56 & 11 \\
2010 & 30 & 37 & 33 & 2 & 46 & 64 & 12 \\
2011 & 31 & 34 & 47 & 2 & 51 & 98 & 24 \\
\hline
\end{tabular}
\begin{tabular}{c|c|c|c|c|c|}
Fraction & 12.6\% & 16.5\% & 14.8\% & 0.7\% & 17.3\% & 31.5\% & 6.4\% \\
\hline
\end{tabular}
\end{table}