The Effectiveness of the Canada-France-Hawaii Telescope

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ABSTRACT

We have investigated the productivity and impact of the Canada-France-Hawaii Telescope (CFHT) during its twenty-year history. CFHT has maintained a database of refereed publications based on data obtained with CFHT since first light in 1979. For each paper, we analysed the cumulative number of citations and the citation counts for each year, from data supplied by the NASA Astrophysics Data System (ADS). We have compared citation counts retrieved from the ADS with those from the Institute for Scientific Information (ISI) for a small sample of papers. We have developed a procedure that allows us to compare citation counts between older and newer papers in order to judge their relative impact. We looked at the number of papers and citations not only by year, but also by the instrument used to obtain the data. We also provide a preliminary look as to whether programs given a higher ranking by the Time Allocation Committee (TAC) produced papers with a higher number of citations.

Subject headings: telescopes

1. Introduction

Astronomers use telescopes to investigate a wide range of scientific problems with almost as diverse a range of instrumentation. The output from these investigations provides an immense amount of data that needs to be reduced and analyzed. The results from the investigation are published in scientific journals, and these papers have an impact, small or large, on future observational and/or theoretical investigations.

Two measures of the effectiveness of a telescope are the number of papers published in refereed journals that are based on data obtained by the telescope, and the citation count of those papers.
The effectiveness, or lack therein, of a telescope can have far-reaching consequences. For example, in Canada the effectiveness of a single major telescope, the Canada-France-Hawaii Telescope (CFHT), may have a significant impact on the funding of future telescopes. Abt (1985) compared the impact of two facility telescopes (the CTIO and KPNO 4-m) with that of two telescopes run by private observatories (the Lick 3-m and the Palomar 5-m). He found no significant difference. Trimble (1995) compared the impact of large US optical telescopes for papers published in 1990-1991. More recently Benn & Sánchez (2001) compared the scientific impacts of telescopes world-wide based on their contributions to the 1000 most-cited papers (1991-98) and the number of papers published in Nature between 1989-1998. They found that CFHT was the most productive and most highly-cited of all 4-m class telescopes during this time period.

Productivity, as measured by the number of papers, and impact, as measured by citation numbers are the two measures we will use to assess the effectiveness of the CFHT over its approximately twenty-year history. Simply counting the number of papers in refereed journals is an easy way to measure effectiveness but misses completely the influence these papers have on the field. It should be noted that citation numbers are not a perfect measure of a paper’s impact, nor are they necessarily a measure of the paper’s scientific value. In this contribution we will examine the productivity and impact history of CFHT papers. We will also examine the productivity and impact of the various instruments that have been used at CFHT during its twenty years of operation. Finally, we will look at how the citation counts for published papers are related to the grade assigned the original observing proposal by the Time Allocation Committee.

2. The Data

CFHT maintains a database of publications in refereed journals that are based on data obtained with the telescope. The database contains information on 1065 papers published between 1980-1999. Papers are identified from four main sources: reprints submitted by authors, scanning of all major journals, observers’ time request forms, and searching NASA’s Astrophysics Data System (ADS) for papers referring to CFHT in the abstract. The following criteria are used to judge whether a paper is considered a CFHT publication:

"A paper must report new results based on significant observational data obtained at CFHT or be based on archival data retrieved from the CFHT archive. If data from multiple telescopes are included, the CFHT data should represent a significant fraction of the total data”.

A staff astronomer examines each paper to judge whether it meets these criteria. Although an author may footnote a paper to indicate that it is based on CFHT observations, the paper may not meet the criteria for inclusion in the database. In our view, this rigorous emphasis on validation of all papers by astronomers within CFHT makes the database unique.
The CFHT publication information is maintained within a Microsoft Access database. Several routines, written in Visual Basic for Applications within the database, query the ADS for information on each publication. These routines utilize an Internet Data Transfer Library (Ashish & Kreft 1998) downloaded from the Internet. The software generates the appropriate query as a URL, sends the URL to the ADS, and parses the returned text to extract the relevant information. The information for each publication in the ADS is accessed by a publication bibliography code, bibcode, which is generated from the year, journal, volume and page information for a publication. One of the many services ADS provides is a verification utility that returns a yes/no as to whether a particular bibcode is valid. For each entry in our database, the ADS bibcode is generated from the publication information and verified with the ADS. The information for those entries with invalid bibcodes is checked and updated, then a new bibcode is generated and verified. This verification of each paper’s bibcode ensures that we have the correct publication information for each entry. Once each publication has a valid bibcode, the ADS is queried for the full title, list of authors, the number of citations, and the number of self-citations (ones in which the first author of the cited and citing paper are the same person). Finally, the bibcodes of each citing paper and the number of citations by year of the citing paper are recorded for each publication. The instrument, or instruments, used to acquire the data used for each publication was identified by browsing each of the papers.

This use of the ADS allows us to verify the basic bibliographic information, obtain a complete list of authors, and collect the citation data for each publication. The citation information in the ADS is incomplete (Kurtz et al. 2000). Much of the citation information in the ADS is based upon a subset of the Science Citation Index purchased from the Institute for Scientific Information (ISI) by the ADS. This subset is seriously incomplete in referring to articles in the non-astronomical literature, as it only contains references that were in the ADS when the subset was purchased. The ADS currently builds citation links itself for all publications in its database. The ADS does not include many physics journals but does include a subset of conference proceedings.

2.1. Comparison of ISI and ADS Citation Counts

ISI, an established and reputable commercial firm, has been considered the best resource for citation information among astronomers and librarians for many years. However, the ADS provides publication and citation information from the Web at no cost. How does the citation information obtained from these two sources compare? We selected three highly cited CFHT papers: Carlberg et al. (1996); Cowie et al. (1996); Lilly et al. (1996), and performed a detailed analysis of citations to these papers using both the ADS and ISI (through the online service DialogWeb). While the total number of citations to the three papers from ISI/ADS are remarkably similar (146/153, 125/124, 172/177), there are interesting differences in the details of the citing papers. The number of citing papers in common to ADS and ISI for the three papers is 142, 109 and 165. Each database missed several citing papers that the other one included. ISI tended to find citations from physics journals
missed by ADS, while ADS had some conference citations and citations from the major journals that were missed by ISI. The citing papers in the major journals were missed by ISI primarily due to incorrect citations (e.g. wrong year or volume) in the citing papers. Our conclusion from this detailed look at a small number of papers is that, on average, the ADS provides citation numbers that are consistent with those obtained from ISI and any differences will have a minimal impact on our study.

3. CFHT’s Productivity and Impact

We define two terms that we will use throughout the rest of the paper: productivity and impact. Productivity refers to the number of publications in the context of the telescope, an instrument or a particular researcher. Productivity is not the same as scientific impact. Impact is usually measured by using citation numbers. Overall impact is measured by summing citation numbers of all the relevant papers. The average number of citations per paper (CPP) measures the average impact.

3.1. Citation Histories

For each entry in the CFHT database, we have retrieved the year of every citing paper and stored the total number of citations for each year in the database. A paper published in 1990, for example, has the number of citations received for each year from 1990 to 1999. These data allow us to investigate the citation rate as a function of the number of years since publication. The solid curve in Figure 1 shows the average citations per paper (CPP) as a function of the number of years after publication for all papers in the database with citations. There are some citations in the year of publication for papers published early in the year; for example, a paper published in January may receive a citation in November. As the number of years since publication increases, the number of papers included decreases since the relevant data for all papers doesn’t yet exist. The papers published in 1999 are included in only the data point for zero years after publication, and 1998 papers are included in the zero and one year data points, etc. This curve peaks at two years after publication and has a fairly smooth decay after that. It has been known for many years that the number of citations a paper receives declines exponentially with the age of the paper (e.g. Burton & Kebler (1960)). This is true of CFHT publications as well. The dashed line in Figure 1 is the fit of a simple exponential decline in citations with a half-life of 4.93 years beginning two years after publication.

Our analysis does not include a correction for a growth in publication numbers over the period 1982-1999. Abt (1981) found a half-life of around twenty years for papers published in the 1961 issues of ApJ, ApJS and AJ. However, he pointed out that the growth in the number of papers published over the eighteen year-period he gathered citation numbers was part of the reason the
half-life was so long. Peterson (1988) shows that number of papers published in those three journals increased by 4.6 times over this period. Kurtz et al. (2000) show that the number of papers in their Big8 journals (ApJ, ApJL, ApJS, A&A, A&AS, MNRAS, AJ and PASP) increased at approximately a 3.7% yearly rate between 1976 and 1998. The astronomical literature has doubled between 1982 and 1999, the years covered in our study.

Has the electronic distribution of preprints and journal articles changed the citation history of papers? To examine this question, we divided the CFHT papers in two groups: those published between 1984 and 1991, and those published between 1992 and 1999. There were 428 and 522 papers in these two groups. In Figure 2 the average citation rate for these two periods is shown along with the fit of a simple exponential model for each period. The citation rate for the newer papers clearly declines more rapidly than that of the older papers. The half-life of the older papers is 7.11 years while the half-life for the newer papers is 2.77 years. We believe that if one were able to sample citation rates monthly, the citations for an average paper in the more recent dataset would peak less than two years after publication. This is the result of more rapid dissemination of results by the electronic distribution of pre-prints (astro-ph) and journal articles. The faster decline in citations for the recent subset also indicate that new results supersede earlier results more quickly than in the past.

3.2. Comparing Papers from Differing Years: A Standard Citation Measure

Comparing the citation numbers for papers published in different years is difficult since the number of citations to a paper increases with time. We have established a method for estimating the total number of citations that a paper can be expected to achieve after a suitably long period. How do we compare papers published over almost twenty years, given the natural growth in citations with time? We have used the average citation history of all CFHT papers to define a growth curve for citations (Figure 3). This curve shows the percentage of the final number of citations, defined as the number eighteen years after publication, for an average paper versus the years since publication. Using this curve we can estimate the final citation count (FCC) for each paper given a citation count and the number of years since publication.

4. Productivity and Impact History

The first CFHT paper was submitted in May 1980 and was published in August of that year (van den Bergh 1980). CFHT’s productivity (Figure 4) rose more or less continuously through the 1980s until it reached a fairly constant level of around seventy-five papers per year between 1991 to 1997. It took approximately ten years for CFHT to hit its stride and reach a consistently high level of paper production. A telescope’s productivity in any one year is linked to many factors such as weather, competitiveness of the available instruments, and the reliability of instruments
and the telescope, all in the several years before the year of publication. We attribute the increase in publications during the first ten years of CFHT to the increase in the reliability of both the instruments and the telescope and to the development of more competitive instruments. There are two possible reasons the number of CFHT publications may be in a slow decline. First, as more 8-10 meter telescopes come on-line, CFHT is no longer a forefront facility. Second, the use of large mosaic CCD cameras has increased at CFHT. These generate a tremendous amount of data, and the time from acquisition of data to the publication of results has likely increased.

Trimble (1995) studied the productivity of large, American optical telescopes including CFHT. She compiled publication data for an eighteen month period beginning January 1990, by examining the major North American journals: ApJ, ApJL, ApJS, AJ, PASP. According to Trimble’s list, CFHT ranked fourth in productivity behind the CTIO 4-meter, Palomar and the KPNO 4-meter; and, as Trimble notes, many CFHT publications appear in journals not included in her study. Taking all of the 1990 papers and half of the 1991 papers, we count sixty-seven CFHT papers (Trimble counted 58.6) that were published in the major North American journals during this period. (Trimble pro-rated each paper based upon the number of telescopes used in the paper, which we have not done.) Our database contains one hundred one CFHT papers published in all refereed journals during this period. If we correct this number by the same factor that our earlier number differs from Trimble’s for only North American journals, we end up with a total of 88.3 papers. The total number of CFHT publication changed significantly by including publications from all journals. While the other telescopes undoubtedly had publications in non-North American journals, except for the Anglo-Australian Telescope, their numbers would not have increased as significantly. Thus, any future study of papers and citations, especially those that compare different facilities, should include all major journals. The average CPP for all papers in a given year, by year of publication, is shown in Figure 5. One would expect the average CPP to grow smoothly with time since publication. However, due to the relatively small number of papers in any given year, the average CPP can be influenced by a small number of highly cited papers. For example, the bump in 1996 is due to two highly cited papers (Lilly et al. 1996, Carlberg et al. 1996) that are based on data taken with MOS, the Multi-Object Spectrograph. The fluctuations in citation numbers are much higher in earlier years when the number of papers was smaller.

4.1. Publications and Citations by Journal

Most CFHT observers are from Canada, France or the University of Hawaii (UH). The French tend to publish in European journals, mainly A&A, while Canadian and UH researchers favor North American journals. How are CFHT publications distributed across the major journals? The distribution of publications across eight journals (we include ApJL with ApJ) is shown on the left side of Table 1. In addition, each paper has been tagged as belonging to one of the three partners based upon the affiliation of the first author or the agency that granted time for the observations. (Canada grants some time to international researchers). The majority of CFHT papers have been
published in the three major journals - ApJ, A&A and AJ account for more than 78% of CFHT papers.

ApJ has the most publications with 33% of all CFHT publications, while A&A receives 25.8% of the publications. The breakdown of publications by journal for different years shows an interesting change. In 1996/1997 33% and 25% of papers were published in AJ and A&A respectively, while for 1998/1999 the numbers were 25% and 45%. One explanation for this change is that the French are publishing more and the Canadians/UH, less in recent years. Only 75 (18.9%) of the French papers appeared in American journals while only 53 (9.7%) Canadian papers, and 6 UH papers (5.1%), appeared in non-North American journals. There is a very strong trend for European authors to publish in European journals and North American authors to publish in North American journals. This may be a result of the fact that A&A has no page charges and subsequently the French do not have a large budget for page charges. This tendency for authors to publish on their side of the “Atlantic Ocean” is particularly meaningful for any comparison of publication activity levels between North American (only) and multinational observatories. The distribution of citations per paper (CPP) across the journals is shown in Table 2. The three major journals, ApJ (including the Letters), A&A and AJ, account for 84.7% of the citations to CFHT papers. While ApJ papers account for 33% of the CFHT total, these papers received almost half (48.1%) of the citations. A&A, A&AS, AJ, MNRAS and PASP all have a citation rate lower than the average CPP of 20.35. Nature has the highest CPP of any journal (2.8%); and yet these represent only 1.6% of CFHT papers.

### 4.2. Publications and Final Citation Count by Instrument

The primary instrument used to acquire the data was identified for each publication. In a few cases, several instruments were grouped together into a single category. For example, FP refers to several different “Fabry-Perot” instruments, Coudé refers to the two Coudé spectrographs that have been used at CFHT, and “Direct Imaging” combines several different direct imaging cameras that have been used at CFHT over the years. HRCam (McClure et al. 1989), which incorporated fast tip-tilt correction, and, MOCAM (Cuillandre et al. 1996) and UH8K (Metzger, M.R., Luppino, G.A., & Miyazaki, S. 1995) two mosaic cameras are identified separately from other direct cameras because they represent new technologies, and we wish to track their impact directly. A total of 39 distinct instrument or instrument categories were identified; however, a large number of instruments produced a very few papers and approximately 70% of CFHT papers were produced by the top five instrument/instrument categories. Table 2 shows the number of papers, the FCC per paper and the FCC per night of scheduled telescope time for the top-ten paper producing instruments. The number of nights of scheduled telescope time was determined by looking at each semester’s schedule from 1982 onward and counting the number of nights for each instrument/instrument group. CFHT is known for its exceptional image quality, and it is no surprise that direct imaging has produced the highest number of papers. It also has the highest efficiency of turning scheduled
nights into citations. The two Coudé spectrographs and the Multi-Object Spectrograph (MOS) produced the 2nd and 3rd highest number of papers. The CFRS (Lilly et al. 1996) and CNOC (Carlberg et al. 1996) studies are a large contributing factor to the high impact of MOS.

5. CFHT’s Prolific Authors

Who have been the most prolific authors over the twenty years of CFHT publications? Table 3 shows the top nine most prolific authors with the total number of publications, the number of publications in four of the major journals, the total number of citations to their papers, their average CPP and their projected FCC assuming they publish no more papers based on CFHT data. The most prolific authors have favoured North American journals. The two French authors in this list have 45% of their papers in North American journals as compared to only 18.9% of all papers designated as French. Citations will be discussed more thoroughly in the next section. However, it is clear that the average CPP for these authors varies significantly.

5.1. Self Citations

The issue of self-citations (ones where the first author of cited and citing paper are the same) is one frequently asked of (and discussed by) librarians. What is the average self-citation rate? As Trimble points out, this number is difficult to determine exactly. Authors do not always use a consistent name (first name or first initial, for example) which may lead to the incorrect counting of self-citations. We have counted self-citations for CFHT papers by matching first authors on the cited and citing papers. The average self-citation rate for all CFHT papers is 6.3%. On average, corrections to citation numbers for self-citations are not important. However, the self-citation rate for individual papers can be much higher. There are almost ninety papers with a self-citation rate of 30% or more and many of these have ten or more citations. Also, certain authors tend to favour their own work. Several authors with four papers, or more, have average self-citation rates of 20% or higher. Highly cited papers had much lower than average self-citation rates. The twenty most cited papers in the database have an average self-citation rate of 3%, less than half of the average rate for all papers.

6. CFHT’s Most Highly Cited Papers

We computed the final citation count (FCC) for each CFHT paper in the database using the growth curve described above. The ten papers with the highest FCC are listed in Table 4. It is interesting to note that the top three papers in this list have the same first author, Simon Lilly. Lilly also has the highest total FCC, summed over all papers, of any author in the CFHT database. Two of the top three papers are based on data from a large, ambitious project undertaken with a
new forefront instrument. The top three papers all have the word “survey” in their title as well.

7. How Effective is the Time Allocation Committee?

The observing time requested by proposals to use any large telescope such as the CFHT, generally outnumbers the available time by a significant factor. A Time Allocation Committee (TAC) is established to review and to rank the submitted proposals, and, in classical scheduling, only the highest-ranked proposals make it to the telescope. However, in queue scheduling, the relative ranking of the proposals will be an important factor in determining which programs are actually executed. The role of the TAC becomes even more critical in the era of queue scheduling. How effective is the TAC in judging the scientific merit of proposals? Most would agree that almost all programs that reach the telescope will likely produce a scientific publication if the weather and the equipment co-operate. However, one would expect that the more highly ranked proposals will, on average, produce publications with a higher impact, i.e. number of citations. We feel this evaluation of the TAC process is important as several large telescopes undertake queue scheduling.

Observing time at CFHT is allocated by country: 42.5% for each of Canada and France, and 15% for the University of Hawaii. Each country runs its own TAC, which assigns the grades. The International TAC meets to deal with scheduling conflicts and program overlaps. We have identified the original proposal associated with twenty-two CFHT papers published between 1997 and 1999. One of us (D.C.) has access to the TAC ranking for these proposals as he served as Senior Resident Astronomer for three years. We are thus able to look at the correlation between the TAC ranking of the proposal and the predicted FCC for the papers resulting from those observations. We selected only those papers that were based on a proposal that used only data from CFHT and data from a single observing run. Figure 5 shows the FCC versus TAC ranking (a small number is a higher ranking) for these twenty-two proposals. Except for one highly ranked, highly cited study, there is a weak inverse correlation from a simple linear fit to the data. Another interpretation of the data is that highly-ranked studies (< 0.4) show small scatter around a constant number of citations, while lower-ranked studies show a much larger scatter. Is the TAC being conservative and ranking sure bets higher while riskier studies end up with lower rankings? We want to emphasise that this result is very preliminary, as only twenty-two papers are included, and it relies on the predicted final citation counts. We found no dependence of the FCC on the number of nights of telescope time awarded for the same twenty-two programs.

8. Conclusions

We have studied the productivity and impact of the CFHT over its twenty-year history by looking at the number of papers in refereed journals and the number of citations to these papers. It took ten years for CFHT to achieve and maintain a high level of paper production. We attribute
this to a fairly long commissioning period for the telescope and the time to develop a competitive suite of instrumentation. Direct imagers (photographic plates, CCD imagers) have been CFHT’s most productive instruments, both in the number of papers and the number of papers per night of scheduled telescope time. The excellent image quality at CFHT is a significant factor in direct imaging’s high productivity.

We retrieved citation counts and the years of the citing papers from the ADS for all CFHT papers in our database. Using this data, we developed a procedure for estimating the number of citations that a paper can be expected to receive after a period of almost twenty years. This estimation allowed us to compare the citation numbers for papers from different years and to compare the impact of different instruments. The instrument that produced the papers with the highest impact (average citations/paper) was the Multi-Object Spectrograph (MOS), which was used in the highly cited CFRS and CNOC studies. Direct imaging had the second highest impact. In looking at the number of citations/night of allocated time, direct imaging had the highest impact, followed by MOS and the two Coudé spectrographs. The efficiency of converting observing nights into papers or citations varies considerably between instruments. For example, there is a factor of five difference in the average final citation count per night between “Direct Imaging” and the FTS. In order to maximize a telescope’s impact, one might consider offering only the “high-efficiency” instruments.

Finally, a look at the correlation between the predicted final citation count and the TAC ranking of the observing proposal, showed a weak negative correlation, i.e. lower-ranked proposals end up with a higher number of citations. An alternative interpretation has higher-ranked proposals with a lower number of citations with a small scatter. Lower-ranked proposals have more scatter in the number of citations and some of these end up with significantly more citations than most of the higher ranked proposals.

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Fig. 1.— The average citation rate as a function of the number of years since publication. The solid line is the data for all CFHT papers and the dashed line is the fit of a simple exponential decline with a half-life of 4.93 years.
Fig. 2.— The average citation rate as a function of years since publication for CFHT split into two groups; 1984-1991 papers and 1992-1999 papers.
Fig. 3—Citation count growth curve for all CFHT publications.
Fig. 4—Number of CFHT Papers by Year of Publication
Fig. 5.— The predicted final number of citations versus the Time Allocation Committee (TAC) grade assign the original proposal for a subset of CFHT publications. A lower TAC grade is “better”. The highest ranked proposal will have a TAC grade near 0.0, while proposals that just make it on the schedule have a grade of 1.0. Note the single point with a very high TAC grade and a predicted high number of citations.
Table 1. Distribution of Papers and Citations by Journal.

| Journal | Number of Papers | Citations/Paper |
|---------|------------------|-----------------|
|         | All C F H        | All C F H       |
| A&A     | 275 34 239 2     | 14.86 8.79 15.82 4.00 |
| A&AS    | 37 4 32 1        | 11.92 4.25 12.91 11.00 |
| AJ      | 209 174 10 25    | 18.70 18.06 15.00 24.64 |
| ApJ     | 351 223 59 69    | 29.73 29.20 22.34 37.77 |
| ApJS    | 22 18 1 3       | 28.00 30.28 2.00 23.00 |
| MNRAS   | 20 10 10 0      | 9.25 11.90 6.60 0.00 |
| Nature  | 18 5 9 3        | 33.72 47.20 19.89 64.00 |
| PASP    | 82 66 5 11      | 11.02 11.33 7.60 10.73 |
| Total/Average | 1065 549 397 117 | 20.35 21.42 15.75 31.30 |
| Instrument                          | Papers | Papers/night | FCC/paper | FCC/Night |
|------------------------------------|--------|--------------|-----------|-----------|
| Direct Imaging                     | 358    | 0.36         | 35.47     | 12.86     |
| Coudé Spectrograph                 | 169    | 0.25         | 28.37     | 6.97      |
| Multi-Object Spectrograph          | 75     | 0.19         | 48.38     | 9.92      |
| Fourier Transform Spectrometer     | 64     | 0.16         | 17.28     | 2.70      |
| HRcam\(^a\)                        | 49     | 0.24         | 27.60     | 6.61      |
| Herzberg Spectrograph              | 34     | 0.24         | 29.11     | 6.86      |
| Fabry-Perot                        | 24     | 0.16         | 19.84     | 3.11      |
| Adaptive Optics near-IR imaging    | 21     | 0.21         | 20.76     | 4.45      |
| SIS\(^b\)                          | 18     | 0.12         | 26.82     | 3.24      |

\(^a\)tip-tilt stablized imager
\(^b\)tip-tilt stablized imager/spectrograph
Table 3. CFHT’s Most Prolific Authors.

| Author       | Papers | Citations |
|--------------|--------|-----------|
|              | Total  | ApJ | A&A | AJ | PASP | Total | per Paper | FCC   |
| Hutlings, J. | 38     | 6   | 0   | 21 | 8    | 909   | 23.9     | 1106  |
| Davidge, T.  | 35     | 12  | 0   | 19 | 1    | 310   | 8.9      | 492   |
| Nieto, J-L.  | 16     | 11  | 0   | 1  | 0    | 282   | 17.6     | 333   |
| Le Fèvre, O. | 15     | 3   | 9   | 0  | 0    | 333   | 22.2     | 525   |
| Kormendy, J. | 14     | 12  | 2   | 0  | 0    | 719   | 51.4     | 1024  |
| Boesgaard, A. | 13   | 1   | 0   | 0  | 3    | 577   | 44.4     | 682   |
| Crampton, D. | 13     | 3   | 1   | 7  | 2    | 200   | 15.4     | 239   |
| Richer, H.   | 13     | 10  | 1   | 0  | 0    | 423   | 32.5     | 515   |
| Harris, W.   | 12     | 3   | 6   | 2  | 0    | 389   | 32.4     | 513   |
Table 4. CFHT’s Most Highly Cited Papers.

| Authors               | Title                                                                 |
|-----------------------|----------------------------------------------------------------------|
| Lilly et al. (1995)   | The Canada-France Redshift Survey. VI. Evolution of the Galaxy Luminosity Function to $Z \approx 1$ |
| Lilly et al. (1991)   | A Deep Imaging and Spectroscopic Survey of Faint Galaxies            |
| Lilly et al. (1996)   | The Canada-France Redshift Survey: The Luminosity Density and Star Formation History of the Universe to $Z \approx 1$ |
| McCarthy et al. (1987)| A Correlation Between the Radio and Optical Morphologies of Distant 3CR Radio Galaxies |
| Carlberg et al. (1996)| Galaxy Cluster Virial Masses and Omega                               |
| Spite & Spite (1982)  | Abundance of Lithium in Un-evolved Halo Stars and Old Disk Stars - Interpretation and Consequences |
| Cowie et al. (1996)   | New Insight on Galaxy Formation and Evolution From Keck Spectroscopy of the Hawaii Deep Fields |
| Kormendy (1985)       | Families of Ellipsoidal Stellar Systems and the Formation of Dwarf Elliptical Galaxies |
| Tyson et al. (1990)   | Detection of Systematic Gravitational Lens Galaxy Image Alignments - Mapping Dark Matter in Galaxy Clusters |
| Pierce et al. (1994)  | The Hubble Constant and Virgo Cluster Distance from Observations of Cepheid Variables |