How to cite this article: Jamali, H. R. and Nicholas, D. (2009), "E-print depositing behavior of physicists and astronomers: an intradisciplinary study", *Journal of Academic Librarianship*, 35, (2), 117-125.

Article DOI: 10.1016/j.acalib.2009.01.005

E-print depositing behavior of physicists and astronomers: an intradisciplinary study

Hamid R. Jamali

Assistant Professor, PhD;

Address: Department of Educational Technology, Faculty of Psychology and Education, Tarbiat Moallem University, No 49, Mofateh Ave, P.O.Box: 15614, Tehran, Iran

Email: h.jamali at gmail.com

David Nicholas

Director of CIBER (Centre for Information Behaviour and the Evaluation of Research) and Professor at and Director of the School of Library, Archive and Information Studies (SLAIS), University College London.

Address: School of Library, Archive and Information Studies (SLAIS), University College London, Henry Morley Building, Gower Street, London WC1E 6BT

Abstract

This article investigates the e-print depositing behavior of physicists and astronomers. Fifty-six PhD students and staff at the Department of Physics and Astronomy at the University College London were interviewed. A survey was also carried out (47.1% response rate). The study investigates the relation between variables such as research area, type of research (theoretical, experimental and so on), and the amount of reading on the patterns of e-print depositing. The findings showed that clear intradisciplinary differences exist among different subfields of physics and astronomy.

Keywords – physics and astronomy, e-print archives, depositing

Paper Type – Research article

Introduction

'E-prints' are electronic copies of academic research papers. They may take the form of pre-prints (papers before they have been refereed) or post-prints (after they have been

refereed). They may be journal articles, conference papers, book chapters or any other form of research output. An e-print archive is simply an online repository of these materials[1]. E-print archives are more than a decade old and a well-established source of information in several scientific fields such as chemistry, physics, astronomy, mathematics and so on. They have some advantages that have given rise to the increasing importance of e-print archives. E-prints speed up the process of scholarly communication and open new ways for communication among scientists. However, some disadvantages are attributed to the materials that are normally deposited in e-print archives, the most important of which is lack of peer review.

Like most of other scientific areas, the literature of physics and astronomy is traditionally largely based on journal publications[2]. However, physicists and astronomers have a long and rich preprint culture. The practice of sending out preprints, although common among many fields of science, has long been established among physicists and many scholars have remarked about this distinctive preprint culture in physics[3]. Physicists have used preprints for over thirty years[4] and the initial electronic equivalents of preprints started about 1991 on a very small scale but rapidly grew to a current astronomical level of tens of thousands transactions per day[5]. The first e-print archive, Los Alamos National Laboratory e-print archive, was established by Paul Ginsparg[6], a physicist, in 1991. Physicists and astronomers are heavy users of e-print archives[7]. The statistics of arXiv.org monthly submission[8] shows steady increase in the submission rate since 1991.

As important as e-print archives are as a source of information and a means of scholarly communication, it is vital to have a sound understanding of scientists' interaction with them. One aspect of their interaction is their depositing behavior. A PhD thesis[9] that studied information behavior of physicists [end of page 117] and astronomers included the investigation of their e-print depositing behavior. This article highlights the findings of the study on the e-print depositing behavior of physicists and astronomers because of the importance that e-prints have in physics and astronomy as explained above. More specifically the aims of the article are to see whether scientists in different areas of physics and astronomy deposit their papers in e-prints archives and why, and when they choose to deposit their papers. The article has an intradisciplinary approach as it looks deeply into different subfields of physics and astronomy. The intradisciplinary approach helps us gain a deeper and more focused understanding of the scientists' depositing behavior and avoid any over-generalisation that might be made by putting scientists active in a range of different research fields under the umbrella of 'physics and astronomy'.

Related works

Institute of Physics Publishing (IoPP) conducted an unpublished world wide survey of physicists in mid 1990s. Singleton[10] mentioned some of its results in a presentation. They sent a large questionnaire to over 13,000 physicists around the world. Some 3,500 were completed and returned. The main focus of the survey was issues concerning scholarly communication and publishing. Physicists were asked about their knowledge

of e-print servers which at the time already existed in most major subfields of physics. Just over half (54%) did not know whether there was one in their field, but over three fourth of these (and those who thought they did not have one) said they would like one. They were asked about what should happen to an e-print when a final version was published. Forty-four percent thought it should be deleted immediately and the 56% disagreed. Most of those who disagreed asked for later deletion.

The popularity of e-print archives which are open access sources of information has attracted attention of researchers with regard to the impact of open access papers and physics has always been a good subject to investigate this issue. One of the studies that investigated the citation to open access material in physics is Brown's[11] study. Using various sections of arXiv and the SPIRES-HEP database, she examined the citation rates of e-prints by e-prints and concluded that e-prints have come of age in the literature of physics. Her results indicated that e-prints are used to a greater extent by physicists than previously measured and that e-prints have become an integral and valid component of the literature of physics. Moreover, her findings showed that High Energy Physics Experiment (hep-ex) had the highest citation rate at 14.5%, while Mathematical Physics (math-ph) had the lowest at 0.95%. She also used SciSearch database to analyze the citation pattern of journal articles to e-prints. In addition Brown stated that High Energy Physics Theory (hep-th) had the highest citation rate while Physics had the lowest at 0.07%. Citation rate by e-prints to e-prints was 20 times greater than the citation rate by journal articles to e-prints.

Another study by Hajjem, Harnad and Gingras[12] performed a 10-year citation tracking of different fields and showed that open-access articles have a greater impact on research compared to closed-access articles. The research showed that physics had the highest ratio of citations of open-access articles to citations of closed-access articles published in the same issue of a given journal.

Lawal[13] surveyed a random sample of 473 scholars from different fields and found that 18% of respondents used e-prints and 82% did not. Of those who used e-prints, 54.2% were in Physics/Astronomy, 27.7% were in Mathematics and Computer Science. Chemists used the e-prints the least due to publishers' policies. One hundred percent of those who utilized e-print archives also searched e-print archives but only 90.7% cited them in their articles while 9.3% did not. There were a large number of respondents in all areas that felt that e-print archives were not relevant to them. A relatively small number named technology constraints as a barrier to use. Forty percent of physicists and astronomers replied that they would use e-print archives if the barriers were removed, 40% said no and 20% did not reply. Among physicists and astronomers 81.25% posted their paper to the e-print archive before publication and 17.5% after publication. 83.4% of those who posted their paper before publication published their article later. Seventy-two percent of respondents who used e-print archives said they did so for rapid and wider dissemination of information and fourteen percent said they do so for visibility and exposure.

Lawal explained why physicists have high usage of e-print archives. She stated that:

> Theoretician physicists depend on the work of their predecessors. The information most important to them is often too recent to have been published; hence they use e-print archives. Experimentalists are more concerned with the way in which experimental procedures are carried out. Experiments in high-energy physics are very expensive; often physicists cannot wait for formal publications. High-energy physicists have depended on preprints for a long time… Preprints are most valued in physics because they provide an instantaneous publication channel. Physics is also collaborative in nature. It is not unusual to find a physics paper with over one hundred authors. These reasons, with a long existing e-print archive explain why physicists have the highest use.

The only qualitative study on the use of e-print archives by physicists in the past is the study by Wertman[14]. She interviewed twelve physicist and chemists at the University of Maryland. Besides cross disciplinary differences between physics and chemistry, she found differences within physics. The study concluded that particle physicists and condensed mater physicists used e-print archives more than the other subfields of physics did. It was also demonstrated that theoreticians, especially, gravitated to the archives because the medium supports this wonderful way of communicating ideas [end of page 118] quickly and fluidly, almost replicating a conversation. Experimentalists were less likely to use the archives, and it may be because they do not want to wade through unrefereed papers. It was thought that one reason for more use of e-print archives by theoreticians might be because recognizing poor science may be easier in the theoretical fields that spawned the first bulletin boards than in experimental fields, where a reviewer has to evaluate experimental design and statistics as well as mathematical reasoning. Wertman's study also showed that while graduate students and post-doctoral researchers were called on to navigate the technical difficulties of electronically submitting papers, it was the older more established scientists who promote usage.

As we can see, most of the studies on the interaction of physicists and astronomers with e-print archives deal with their awareness and use of e-print archives. There is still lack of information about the interaction of physicists and astronomers with e-print archives in terms of depositing habits and especially with regard to similarities and differences that might exist amongst different subfields of physics and astronomy. This is an area to which this article aims to contribute.

Methodology

The data presented here was obtained from a mixed-method research project conducted as a PhD thesis[15]. The research included interviews, critical-incident data as well as a questionnaire survey of staff and PhD students in the Department of Physics and Astronomy at University College London (UCL). This article presents part of the findings of the interviews and the survey study.

About UCL

UCL department is a research oriented department that at the time of data collection of this study (2005-06) had about 150 academic and research staff and more than 100 research students.

The department consisted of four research areas and contributed to six research centres that each had their own researchers. The four research areas were:

Astronomy, Astrophysics and Atmospheric Physics
Atomic, Molecular, Optical and Positron Physics
Condensed Matter and Materials Physics
High Energy Physics

Although the main structure of the department was based on the four aforementioned research groups, some of these groups were composed of smaller research groups that were quite characteristic and could be studied separately rather than as part of the bigger research group. For instance, although Atmospheric Physics is part of the broader research group "Astronomy, Astrophysics and Atmospheric Physics" (the first research group), it is a quite distinctive research group with its own laboratory and research areas that are not very related to astronomy. Or in the case of the second research group "Atomic, Molecular, Optical and Positron Physics", two subgroups of "Optical Science Laboratory" and "Theoretical Molecular Physics" could be separated as two distinctive groups. Therefore the researchers have decided to consider the following seven research groups as the research areas in the department and units of analysis in this study wherever appropriate.

- Atmospheric Physics (AP)
- High Energy Physics (HEP)
- Condensed Matter and Materials Physics (CMMP)
- Astronomy and Astrophysics (AA)
- Theoretical Molecular Physics (TMP)
- Atomic, Molecular, Optical and Positron Physics (AMOP)
- Optical Science Laboratory (OSL)

Interview

Fifty-six semi-structured face-to-face interviews were carried out with 26 PhD students and 30 members of staff (academics) between October 2005 and April 2006. In total 56 interviewees is equal to 23% of the population of the department, which is a good sample size for a qualitative study. The interview was about information seeking behavior and some aspects of communication patterns of the participants. However, they were also asked an open-ended question about their interaction with e-print archives and this forms the basis of the qualitative data presented in this article.

Survey

A self-administered web-based questionnaire was designed for conducting the survey. The questionnaires went online on the 3rd of May, 2006. To conduct the survey, a personalized email was sent to all staff and PhD students in the department with a link to the questionnaire. This was followed by two sets of reminder emails with about ten day intervals.

There was no need for sampling in the survey as it was possible to include all PhD students and staff in the Department in the survey. However, the respondents were self-selective due to what is known as the phenomenon of non-response. This phenomenon refers to the difference between the initial sample (all individuals about whom we want to collect information) and the final sample (the cases we manage to get information on). This phenomenon is composed of different aspects including refusal to participate (because of lack of time or other personal reasons) in a survey or to be interviewed[16] (Gobo, 2004, p. 441). As the participation in the survey was voluntary, the refusal by some to take part in the questionnaire was the main reason for the non-response phenomenon in this study.

The questions that form the basis of this article were the following three questions. It must be said that as the survey was conducted after the qualitative part of the research (interviews) the multiple-choice questions asked through the survey and the choices presented were affected by the outcome of the interviews. The survey in a way was used to triangulate the findings of the survey as well as serving as a complementary means of [end of page 119] data collection. For example the first option in the third question (I can't be bothered) is something that was mentioned by a few interviewees and it was included in the survey to see how significant this reason was.

1. Do you deposit most of your articles in an e-print archive such as arXiv.org?

Yes (move on to next question) No (go to question after the next)

2. When do you generally deposit your articles in e-print servers (such as arxiv.org)?

Before I submit to journal
When I submit to journal
When accepted by a journal

3. What is the reason for not depositing your articles in e-print archives? (If you do deposit, move on to next question).

Because I cannot be bothered
Because I don't see any benefit in it
Because it is not common or a tradition in my subfield
Because the copyright of the journals I publish in doesn't allow it
Other (specify)

Results

Characteristics of the sample

There were 129 staff and 113 PhD students (total 242 people) in the department that were all invited to take part in the survey. The survey achieved 47.1 percent response rate with 114 respondents. This is a good response rate given that the academic Web-based surveys' participation rates range from 3% to 62% for electronic surveys[17].

Seventy-one percent (n=81) of respondents of the survey were male and 29 percent (n=33) were female. This was a reflection of the general population of the Department, of which 75 per cent were male academics and research students. A high percentage of respondents as we can see in Table 1 were research students (57%) followed by research fellows (17%). There were also ten professors among the respondents.

Forty-seven percent of the interviewees were PhD students and 53% were academic staff. Twenty-five percent of the interviewees were Researcher, 14% were Professors, and 4% were Lecturer. Readers and Senior Researchers each accounted for 5% of the interviewees. 19.6% of the interviewees were male and 80.4% were female.

Table 1. Distribution of the respondents by academic status

Academic Status	Interviews		Survey	
	No	%	No	%
PhD Student	26	47	65	57
Research Fellow	14	25	20	17.5
Senior Researcher	2	4	6	5.3
Lecturer	3	5	11	9.6
Reader	3	5	2	1.8
Professor	8	14	10	8.8
Total	**56**	**100**	**114**	**100**

Seven main subfields of physics and astronomy (research group entities inside the department) were used to categorize the respondents (Table 2). Twenty-five percent of the interviewees were members of Condensed Matter and Materials Physics (CMMP). Astronomy and Astrophysics (AA) accounted for 21% of the interviewees. High Energy Physics (HEP) and Atomic, Molecular, Optical and Positron Physics (AMOP) accounted for 20% and 16% of participants respectively. Nine percent of interviewees were from Theoretical Molecular physics (TMP). Atmospheric Physics (AP) and Optical Science Laboratory (OSL) which are smaller research groups in the department had fewer participants (5% and 4% respectively).

Table 2. Distribution of the participants by research group

Research Group	Interviews		Survey	
	No	%	No	%
Atmospheric Physics (AP)	3	5	11	9.6
High Energy Physics (HEP)	11	20	18	15.8
Condensed Matter and Materials Physics (CMMP)	14	25	36	31.6
Astronomy and Astrophysics (AA)	12	21	22	19.3
Theoretical Molecular Physics (TMP)	5	9	11	9.6
Atomic, Molecular, Optical and Positron Physics (AMOP)	9	16	13	11.4
Optical Science Laboratory (OSL)	2	4	3	2.6
Total	**56**	**100**	**114**	**100**

In the survey, CMMP accounted for 31.6 per cent of the respondents. CMMP is the biggest research group in the department and it encompasses a considerable number of smaller research groups that research on very specific topics. After CMMP, AA accounted for the second highest number of respondents with 22 (19.3%) [end of page 120] respondents. This research group also covers many smaller research groups such as hot stars, star formation and so on. The smallest number of respondents belonged to the OSL with three respondents who all do instrumentation-kind of research.

Table 3 shows the distribution of respondents by the type of their research. The highest number of respondents belonged to those involved in theoretical research in the field of physics (31.6%), followed by 33 respondents (28.9%) who did experimental research in physics. The smallest proportion belonged to those who did instrumentation research with only four respondents who fell into this category.

Table 3. Distribution of the respondents by type of research

Type of Research	No	%
Theory (physics)	36	31.6
Experiment (physics)	33	28.9
Observation (astrophysics & astronomy)	13	11.4

A bit of both	10	8.8
Theory (astrophysics & astronomy)	18	15.8
Instrumentation	4	3.5

Findings

Table 4 shows that the respondents of the questionnaire survey were distributed relatively evenly with regard to their habit as to whether they deposit their articles in e-print archives or not. Thirty-seven percent did and 38% did not. A quarter of the survey respondents also said that they did not know about depositing; they were all PhD students in early years of their studies that they did not know about depositing or had not written any articles. From those who said they did deposit their articles, 36% did it before they submitted their articles to journals, 33% said they did it at the time of submission and 31% did it after their articles were accepted (see Table 5).

Table 4. Distribution of respondents by whether they deposit their articles in e-print archives.

Depositing	**No**	**%**
Don't know	29	25
No	43	38
Yes	42	37
Total	**114**	**100**

Table 5. Time of depositing articles in e-print archives.

Time of depositing	**No**	**%**
Before I submit	15	36
When I submit	14	33
Once accepted	13	31
Total	**42**	**100**

As Table 6 illustrates, the most common reason for not depositing articles in e-print archives was that they thought that it was not common or a tradition in the subfields of those who did not deposit. 44% of those who said they did not deposit opted for this reason. The other common reason was the statement ‘I can’t be bothered’, with 21% of those respondents who did not deposit. A few of respondents used the provided textbox to mention some other reasons. Two respondents were concerned about their ideas being stolen. One respondent wrote ‘sometimes it's better to keep some results secret for 3 months longer’. Another one said “not been important so far - use ISIS facility (best place in world for neutron diffraction from liquids) which means that no one’s going to repeat my experiment!” One respondent also blamed lack of time. In the interviews,

some respondents stated that they were simply being lazy or they could not be bothered to deposit their papers. It is also worth mentioning that most of the papers in physics and astronomy have multiple authors. In those situations when there is a student or a younger research fellow among the authors, they are the ones who do the depositing and older authors such as professors are less likely to do it personally. This is contradicting the findings of Wertman[18] who interviewed 12 physicists and concluded that mid-level and older scientists were consulting the e-print archives more than the younger scientists. This may not be surprising as Wertman's research is already almost a decade old and things have changed since then.

Table 6. Reasons why not depositing articles in e-print archives.

The reason of not depositing	N	%
Doesn't have any benefits	5	12
It's not common	19	44
Copyright doesn't allow	1	2
Can't be bothered	9	21
Other	9	21
Total	43	100

Sixty-four percent of respondents in Astronomy and Astrophysics deposited their articles, which is the [end of page 121] highest figure among all research groups. People in Atomic, Molecular, Optical and Positron Physics (AMOP) research group (54%) and High Energy Physics (44%) also had a high rate of depositing articles. In some areas such as HEP, physicists nowadays must deposit the preprint of their papers in the archive. This is because some journals in physics request authors to submit their manuscripts through arXiv. Authors have to submit their manuscripts to arXiv and notify the journal, then the journal takes the manuscripts from arXiv and puts it in the review and publication process, therefore all of the articles that are supposed to be submitted to some journals have their preprint versions available on arXiv. This is something that a reader in HEP explained, when he was asked whether he deposited his papers in arXiv

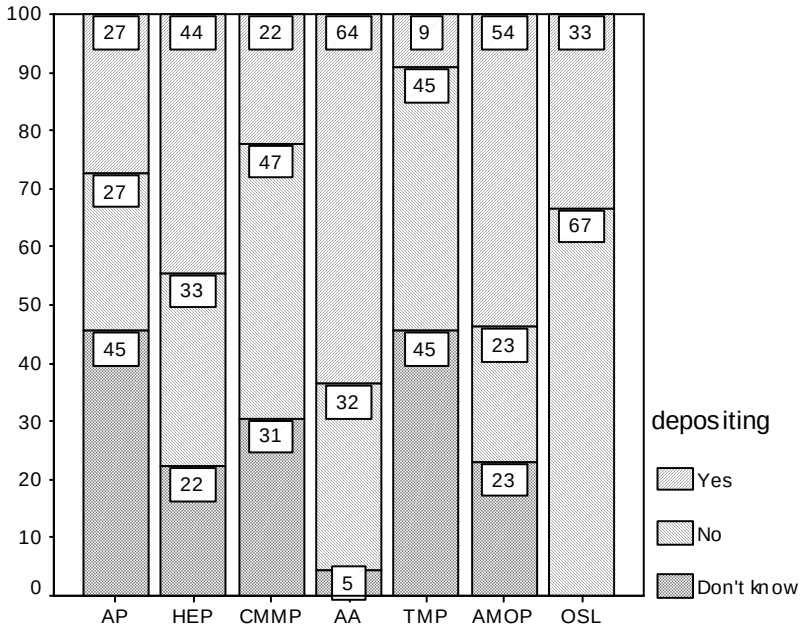
> Yes we submit it to the… well yeah, because actually if you want to submit it to *Physics Letters* or any journal it has to have gone to the archive first because they then upload it from the archive. So the publishers, actually the journal uploads it from the pre-print server as well.

The lowest depositing rates belonged to Theoretical Molecular Physics (9%) and Condensed Matter and Material Physics (22%). These variations among different research groups were also evident from the outcome of the interviews. A professor from the CMMP group said that preprints are not very popular in his area. This contradicts Wetman's[19] finding that indicated that e-print archives were more popular in CMMP compared to the other subfields of physics. It should be noted that Wertman's sample

was small and CMMP is one of those subfields in physics encompass a diverse range of smaller research areas.

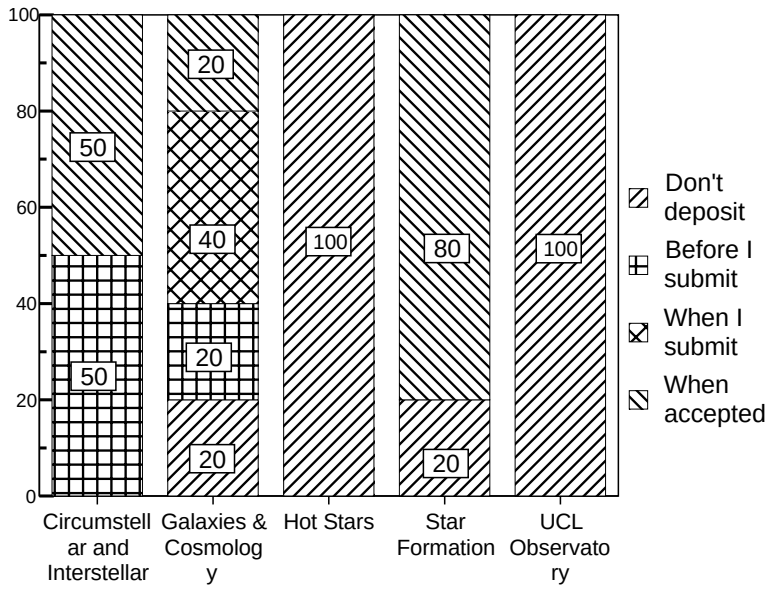
> The preprint archives are not really an active operation in condensed matter physics. I'm thinking at the moment with a colleague of sending something to pre-print archive, largely for a tactical reason, but I don't look at the pre-print archives.

Figure 1. Percentage frequency distribution of respondents by whether they deposit their articles by research groups.



To understand the depositing behavior of users with e-print archives even better, 22 survey respondents in the Astronomy and Astrophysics group were broken into their main six subgroups. Figure 2 reveals that while in some subgroups of Astronomy and Astrophysics such as Observatory, or Hot Stars, respondents did not deposit their articles at all. In some others such as Star Formation they tended to deposit their articles after the acceptance of articles in the journals. Two-fifth of respondents in Galaxies and Cosmology deposited at the same time when they submitted their articles to journals. Respondents in Circumstellar and Interstellar usually deposit their articles before they are submitted to journals.

Figure 2. Percentage breakdown of depositing behavior by subgroups of astronomy and astrophysics.



These findings approved what the interviewees said. Interviews also showed differences among different subfields of astronomy in terms of their interaction with e-print archives. While people in Cosmology deposit their papers in e-print archives as soon as they submit to journals, people in Hot Stars deposit once the papers have been accepted. The reason interviewees stated for this early submission of papers to archives in cosmology is that their field is more competitive compared to some other subfields of astronomy.

> The cosmology group they submit it to Astro-ph as soon as they submit to a journal and their reasoning which I think is right in their field, is that their field is just so competitive. If you wait until the paper is being published, the results will be superseded by ten other groups, so they have to, in fact I was told by some cosmologist that some of them actually submit it to Astro-ph even before submitting to a journal, so as soon as they put together the results, they just submit it because they need to get the results out in the community, so in their field I think it's a bit more dangerous say for a student, because a student may not know the different groups. Some download something from Astro-ph and it could be wrong, because it hasn't been refereed at all, nor even submitted. In our field I actually don't know anyone [end of page 122] in star formation who submits as soon as they, submit it so Astro-Ph as soon as they submit it to a journal, although I have been told that people are starting doing that so

> we may be where we are all headed, which means in a way that Astro-Ph is replacing journals, right, so it may well be in ten years' time we all do, but so far certainly it depends on the field that you're in. [a lecturer from Observatory group]

A professor also stated the same reason about early submission by cosmologists by saying that they seem to feel that they need to get stuff out immediately. Another professor considered a cultural element in this variation. This refers to the culture in a research community. He also maintained that the older people at his age would be different from younger people.

> I think younger workers in my field [hot stars] won't think twice of just submit to Astro PH automatically. Older ones probably won't. [a professor]

This difference is because older people tend to be more concerned about the validity of the data and the peer review process therefore they might tend to wait until the paper has been accepted and then put the final version on the e-print archive.

Figure 3 presents a cross-tabulation of the type of respondents' research and whether they deposit their articles in e-print archives. It shows that generally those who conduct research in the field of astrophysics and astronomy (whether theory or observation) were more likely to deposit their articles. Seventy-three percent of theoretician astrophysicists and astronomers said they did deposit. On the other hand, instrumentalists and experimental physicists were least likely to deposit their articles as 75% and 59% said they did not respectively. These findings somewhat lends supports to the findings of Wertman[20] and Lawal[21] indicating that theoretical physicists favours e-print archives more than experimental physicists.

Figure 3. Percentage frequency distribution of respondents by whether they deposit their articles by type of their research.

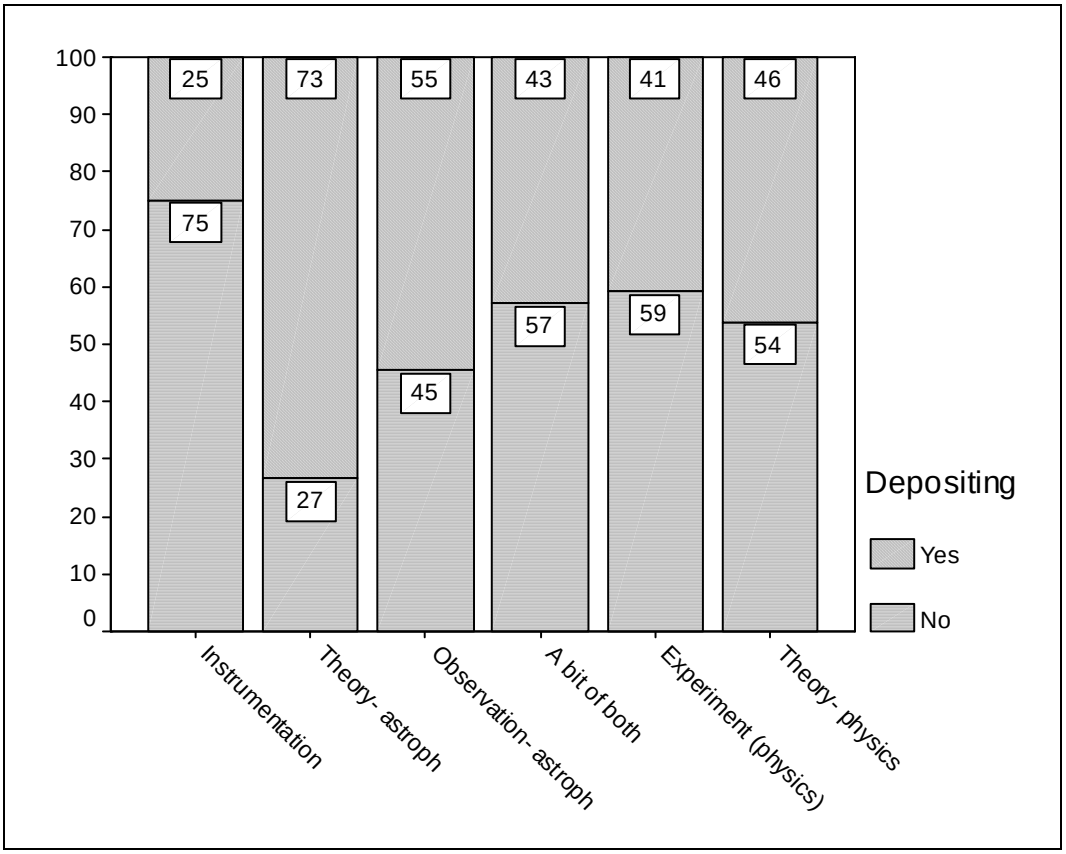


Figure 4. Percentage frequency distribution of respondents by time of depositing and type of research.

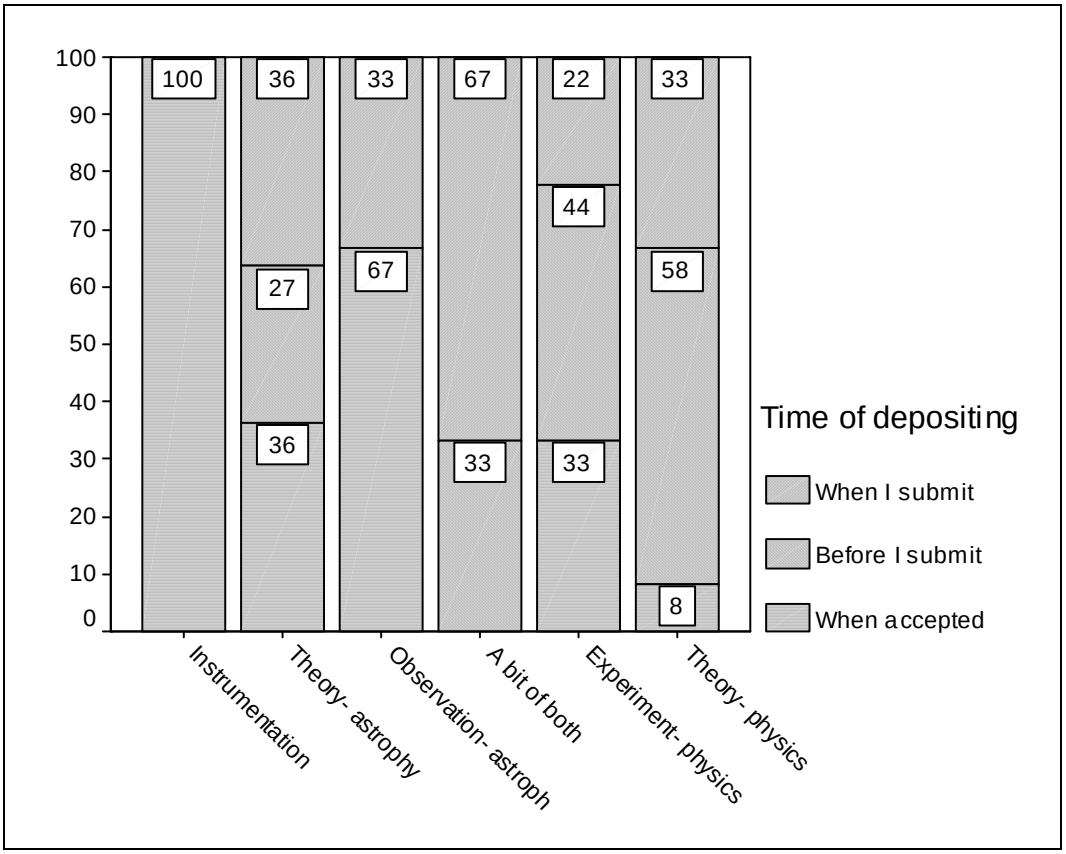
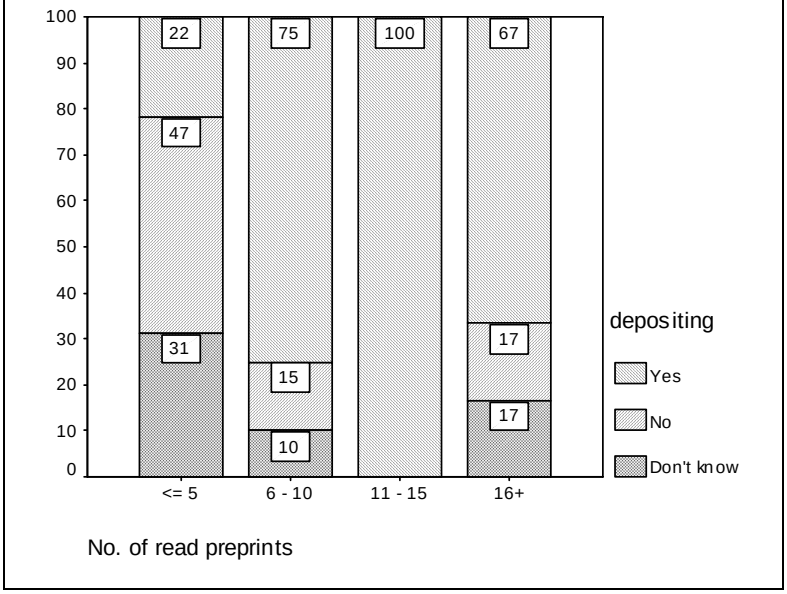


Figure 5. Percentage frequency distribution of respondents by whether they deposit their articles by number of preprints they read in a month.



Among those said they deposit their papers in e-print archives, the majority of instrumentation physicists (100%) and observation astronomers (67%) deposited their papers once they are accepted by journals. Theoretical physicists, however, tended to

deposit their papers before they are submitted to journals, 58% said they did so. Figure 4 relates. Among theoretical astrophysicists and astronomers, there did not appear to be a common pattern as 36% deposited whey they submitted to journals and 36% deposited after the acceptance of their papers. [end of page 123]

To see whether there was any relationship between the amount of preprints read and the depositing pattern, the respondents were asked about the number of preprints they had read during a month. Figure 5 gives percentage frequency distribution of respondents by whether they deposited their articles by number of preprints they read in a month. Although there is not a steady increase in the likelihood of depositing articles in e-print archives as the number of articles read increases, those who read the fewest number of e-prints (5 or less) were least likely to deposit their articles, just about two-fifth did. Those who read in average 11-15 preprints a month were most likely to deposit their articles.

Conclusions

The article used interviews and a questionnaire survey to study the e-print depositing behavior of physicists and astronomers. The study revealed clear intradisciplinary differences among different subfields of physics and astronomy. These findings highlight the need for focusing on smaller and more specialized subject communities and research units for a deeper understanding of their scholarly communication. This type of research would be helpful in improving the service that e-print archives are meant to provide for different scientific fields. This need for a narrower approach to the study of subject communities has already been pointed out by Kling and McKim[22] and Fry and Talja[23].

The article showed high popularity of e-print archives in some subfields such as Astronomy and Astrophysics; Atomic, Molecular, Optical and Positron Physics and High Energy Physics, and their lower popularity in some other subfields such as Theoretical Molecular Physics and Condensed Matter and Material Physics. The main reason for use or non-use of e-print archives appeared to be the traditions that exist in each subject community. The qualitative part of the study shed some lights on the reasons behind these traditions; for instance fast moving research areas are more likely to use e-print archive. Walsh and Bayma[24] also mentioned a few factors such as size of research field, market penetration, locus of critical information, degree of interdependence between research units, and technical limitations as structural factors affecting usage patterns of computer-mediated communication. However, a deep understanding of the rational and the motivations for the use and non-use of e-print archives needs further research.

Acknowledgement

The senior author would like to thank the Iranian Ministry of Science, Research and Technology for funding the study.

References

[1] Stephen Pinfield, Mike Gardner, and John MacColl, “How do physicists use an e-print archive? Implications for institutional e-print services,” *D-Lib Magazine* **7** (12) (2001), Available: http://www.ariadne.ac.uk/issue31/eprint-archives/intro.html (25 June, 2008).

[2] C. C. Gould, and K. Pearce, *Information Needs in the Sciences: an Assessment (*Research Library Group: Mountain View, CA, 1991), Cited in: Ibironke Lawal, “Scholarly Communication: The Use and Non-Use of E-Print Archives for the Dissemination of Scientific Information,” *Issues in Science and Technology Librarianship* No. 36 (2002), Available: http://www.istl.org/02-fall/index.html (25 June, 2008).

[3] Donald W. King, and N. K. Roderer, “Communication in physics - the use of journals,” *Physics Today* (October) (1982), pp. 44-47.; J. M. Hurd, “High energy physics”. *in* "From print to electronic: The transformation of scientific communication" Edited by S. Crawford, J.M. Hurd, and A.C. Weller (Information Today, Medford, NJ. 1996).

[4] Cecelia M. Brown, “The Coming of Age of E-Prints in the Literature of Physics,” *Issues in Science and Technology Librarianship* **31** (Summer) (2001), Available: http://www.istl.org/01-summer/refereed.html (25 November, 2007).; Cecelia M. Brown, “The E-volution of Preprints in the Scholarly Communication of Physicists and Astronomers,” *Journal of the American Society for Information Science and Technology* **52** (3) (2001), pp. 187-200.

[5] Edward J. Valauskas, “Waiting for Thomas Kuhn: First Monday and the evolution of electronic journals,” *First Monday* **2** (12) (1997), Available: http://www.firstmonday.dk/issues/issue2_12/valauskas/ (25 June, 2008).

[6] Paul Ginsparg, "First steps towards electronic research communication," *Computers in Physics* **8** (4) (1994), pp. 390-396.

[7] Rob Kling, and Geoffrey McKim, "Not just a matter of time: Field differences in the shaping of electronic media in supporting scientific communication," *Journal of the American Society for Information Science and Technology* **51** (14) (2000), pp. 1306-1320.; Jenny Fry, *The cultural shaping of scholarly communication within academic specialisms*, (University of Brighton, Brighton, 2003).

[8] arXiv, *arXiv monthly submission rate statistics*, (2007) Available: http://arxiv.org/show_monthly_submissions (25 June, 2008).

[9] Hamid R. Jamali, Information-seeking behaviour of physicists and astronomers: an intradisciplinary study (University College Lodon, Unpublished PhD thesis, 2008).

[10] Alan Singleton, "Journal and the electronic programme of the Institute of Physics," *The Serials Librarian* **30** (3-4) (1997), pp. 149-161.

[11] Brown, "The Coming of Age of E-Prints".

[12] Chawki Hajjem, Stevan Harnad, and Yves Gingras, "Ten-year cross-disciplinary comparison of the growth of open access and how it increases research citation impact," *IEEE Data Engineering Bulletin* **28** (4) (2005), pp. 39–47.

[end of page 124]

[13] Ibironke Lawal, "Scholarly Communication: The Use and Non-Use of E-Print Archives for the Dissemination of Scientific Information," *Issues in Science and Technology Librarianship* (36) (2002), Available: http://www.istl.org/02-fall/index.html (25 November, 2007).

[14] Ellen R. Wertman, *Electronic preprint distribution: a case study of physicists and chemists at the University of Maryland* (Blacksburg, VI.: Department of Science and Technology Studies, Virginia Polytechnic Institute and State University, 1999).

[15] Hamid R. Jamali, Ibid.

[16] Giampietro Gobo, "Sampling, representativeness and generalizability", In: *Qualitative research practice*, Edited by C. Seale, G. Gobo, J.F. Gubrium, and D. Silverman (London: Sage, 1994), p.441.

[17] Bradley M. Hemminger, Dihui Lu, K.T.L. Vaughan, and Stephanie J. Adams, "Information seeking behavior of academic scientists," *Journal of the American Society for Information Science and Technology* **54** (14) (2007), pp. 2205-2225.

[18] Wertman, "Electronic preprint distribution"..

[19] Ibid.

[20] Ibid.

[21] Lawal, "Scholarly Communication".

[22] Kling, and McKim, "Not just a matter of time".

[23] Jenny Fry, and Sanna Talja, "The cultural shaping of scholarly communication: explaining e-journal use within and across academic fields", In: *the American society for information science and technology annual meeting on managing and enhancing information: cultures and conflicts*. , 13-18 November", (Providence, Rhode Island, 2004).

[24] J. Walsh, and P. Bayma, "Computer networks and scientific work," *Social Studies of Science* **26** (3) (1996), pp. 661–703.

[end of page 125]