

# A Preliminary Study of Institutional International Research Collaboration in Astronomy

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## Abstract

The main objective of this study is to investigate whether the professional equipment and research manpower affect international research collaboration (IRC) among the worldwide astronomical institutions. These two factors are relevant to research context of astronomical institutions. Previous research has indicated that the high rate of IRC in Astronomy can be attributed to the equipment-related research, and small countries tend to have IRC more. However, little empirical evidence can be found in IRC at institutional level. Most scholars considering the effect of scientific size have emphasized the factor on productivity, rather than researchers. Therefore, the author attempts to explore the phenomenon and to examine the factors in institutional IRC in Astronomy. This preliminary study collected the papers in the *Astronomical Journal* (AJ) in 2007. 448 research papers that involve 462 institutions of fifty countries are reviewed. The result shows that IRC is related to international observatories and small institutions (in terms of number of authors). Based on the analyzed data, this study also visualizes the institutional IRC network to illustrate the status and the intellectual connections of an astronomical institution in this diagram of network.

## Introduction

International research collaboration (IRC) has become a prevailing trend in science. Many scientists, organizations, and governments are keen to establish cross-national scientific connections. The significance has provoked considerable discussion on IRC in scientometric studies. So far a great deal of research have been made to investigate the phenomenon of IRC in many scientific areas (e.g. Andersson & Persson, 1993; Glänzel, 2001; Luukkonen, Persson, & Sivertsen, 1992; Miquel & Okubo, 1994; Wagner & Leydesdorff, 2005).

Despite the large number of studies focusing on international collaborative research, most statistics was focused on collaborating countries rather than institutions. Most studies only demonstrate the extent to which a country has engaged in IRC. This study, however, argues that cross-institutional collaborations shall not be ignored. Analyzing IRC at institutional level can provide an informative evaluation to science and technology policy makers, since it considers institutional differences in a country.

A variety of factors affect IRC activities in scientific community. They include researchers' personal capability and interests, as well as the infrastructure in the context of research setting. Regarding the research context, professional equipment and research manpower are two of the significant factors in institutional IRC. It has been pointed out that a lot of collaborative research is driven by the need of access to instrumentation and expertise (e.g. Beaver & Rosen, 1978; Esterle & Zitt, 2000; Katz & Martin, 1997; Luukkonen, et al., 1992; Velho, 1995). Scientists may turn to foreign partners when they need external supports of facilities and experts, from this viewpoint. Indeed, the association between research collaborations and the dependence on professional equipment has been noticed in prior studies (e.g. Abt, 2000; Beaver & Rosen, 1978; Katz & Martin, 1997). Nevertheless, we need more empirical evidence of the causality. Moreover, the influence of research manpower on IRC also needs to be examined. Even though a substantial body of literature has indicated that small countries tend to produce more (e.g. Andersson & Persson, 1993; Frame & Carpenter, 1979; Gómez, Fernández, & Sebastián, 1999; Schubert & Braun, 1990), most of researchers measured the national scientific size with productivity, rather than the number of researchers.

This study attempts to provide relevant findings on the effect of the scientific size on IRC, with emphasizing on research manpower.

Astronomy has been indicated as an internationalized field because of the high proportion of internationally co-authored papers (Abt, 1990, 2007; Hearnshaw, 2007). Researchers have attributed the phenomenon to the dependence of astronomical research on sophisticated professional equipment (Abt, 2000; Adams, Black, Clemmons, & Stephan, 2005; Beaver & Rosen, 1978; Esterle & Zitt, 2000; Luukkonen, et al., 1992). It is said that astronomers from different countries may be brought together to build, maintain, and use high-cost telescopes and observatories, and thus have a great of transnational linkages in research. This study aims to provide empirical evidence on this point and investigate whether the small institutions have more IRC, as they are expected. Furthermore, the analytical results of this preliminary study are also transformed into a network. The diagram of collaboration network is made to indicate the position and the connections of an astronomical institution.

## **Methods**

The principal method used for investigating IRC among astronomical institutions is co-authorship analysis. Despite the facts that research collaboration does not always generate co-authored papers, and that co-authorship does not necessarily represent actual research collaboration, it is widely agreed that co-authorship is a proper measure of research collaboration (Bordons & Gómez, 2000; Katz & Martin, 1997; Melin & Persson, 1996). In this study, an institutional IRC is defined as “a paper for which the authors give institutional affiliations from more than one country” (Luukkonen, et al., 1992, p. 104). Single author papers are not regarded as IRC outputs no matter how many institutions are affiliated by the authors.

In this preliminary study, all papers published in the *Astronomical Journal* (AJ) in the year of 2007 are scanned. There are 448 research papers in total, involving 462 institutions from fifty countries. Although the present data set is limited to a few representational samples of astronomical publications, it helps us to illustrate what and how IRC can be analyzed at institutional level.

Several common bibliometric indicators are used to demonstrate IRC among astronomical institutions: the number and the proportion of IRC papers/authors/institutions and the frequency of international co-authorship. The network analytic software, *Ucinet 6* (Borgatti, Everett, & Freeman, 2002), is the primary computing tool for visualizing the IRC links among astronomical institutions.

## **Results**

Among the papers published in the AJ in 2007, 408 out of 448 are co-authored papers (91.07%) and 215 are cross-national presentations. The present sample also shows that 374 out of 462 institutions (80.95%) produced IRC papers. This statistic result indicates that “Institutional IRC” is prevalent and pivotal in modern Astronomy.

The majority of the investigated astronomical institutions have IRC publications; however, the number of cross-nation papers produced by each of the fifty countries is different. The U.S. published the most number of IRC papers (172 papers), while the proportion of IRC papers to the total is not very high (51.96%). With the most number of astronomical institutions, the U.S. is self-reinforced, and much of its research can be carried out domestically. China has relative lowest proportion of IRC papers (40.74%) among the fifty countries.

*Profile of the collaborating institutions*

Table 1 lists the astronomical institutions that published at least 10 papers in the AJ in 2007. It shows that international cooperating observatories like the NOAO and the ESO are most likely to have more IRC activities. Universities and other academic institutions have different levels of IRC. Institutes with small number of papers and authors tend to hold a higher percentage of IRC papers (e.g. the York University and the University of Chicago), while the percentage in the large institutes is relatively small (e.g. the California Institute of Technology and the Harvard-Smithsonian Center for Astrophysics). Moreover, the result also shows that the number of foreign partners is related to the amount of IRC research. Institutions having links with more foreign counterparts are found to have relative high proportion of IRC papers (e.g. The Spanish National Research Council, the University of Toronto, and the York University).

**Table 1. Number of papers published by each institution in the AJ in 2007. (IRC papers  $\geq 10$ ).**

Institution	Country	Institution (abbr.) <sup>1</sup>	No. of papers		No. of IRC partner inst.	No. of authors <sub>3</sub>
			Total	IRC (%)		
Space Science Telescope Inst.	USA	US_STSCI	37	22 ( 59.46)	41	50
California Inst. of Technology	USA	US_CALTECH	42	20 ( 47.62)	38	72
Nat'l Optical Astronomy Obs.	USA	US_NOAO*	27	20 ( 74.07)	38	43
The Pennsylvania State Univ.	USA	US_PSU	31	20 ( 64.52)	28	22
Univ. of Arizona	USA	US_UARIZONA	27	20 ( 74.07)	59	42
Nat'l Optical Astronomy Obs.	Chile	CL_NOAO*	18	18 (100.00)	62	31
Univ. of Hawaii	USA	US_UHAWAII	30	16 ( 53.33)	38	34
Univ. of Washington	USA	US_UWASHINGTON	27	16 ( 59.26)	27	34
Instituto de Astrofísica de Canarias	Spain	ES_IAC	18	15 ( 83.33)	44	39
Harvard-Smithsonian Center	USA	US_HARVARD	34	15 ( 44.12)	41	50
Herzberg Inst. of Astrophysics	Canada	CA_HIA	22	14 ( 63.64)	35	17
Univ. of Toronto	Canada	CA_UTORONTO	14	14 (100.00)	71	17
Max Planck Inst. for Astronomy	Germany	DE_MPIA	15	14 ( 93.33)	61	26
Australian Nat'l Univ.	Australia	AU_ANU	14	13 ( 92.86)	64	20
Nat'l Inst. of Astrophysics	Italy	IT_INAF	17	13 ( 76.47)	60	32
Johns Hopkins Univ.	USA	US_JHU	15	13 ( 86.67)	29	16
Princeton Univ.	USA	US_PRINCETON	16	13 ( 81.25)	23	15
Univ. of Tokyo	Japan	JP_UTOKYO	13	12 ( 92.31)	42	19
Nat'l Autonomous Univ. of Mexico	Mexico	MX_UNAM	19	12 ( 63.16)	32	34
York Univ.	Canada	CA_YORKU	12	11 ( 91.67)	70	2
European Southern Obs.	Chile	CL_ESO*	11	11 (100.00)	63	10
Spanish Nat'l Research Council	Spain	ES_CSIC	12	11 ( 91.67)	78	23
Univ. of Chicago	USA	US_UCHICAGO	12	11 ( 91.67)	32	12
Univ. of Texas	USA	US_UTEXAS	19	11 ( 57.89)	34	24
Apache Point Obs.	USA	US_APO	10	10 (100.00)	28	10

Note: 1. The abbreviation consists of a country code and an institution code. A star mark is used when an institution is affiliated to different countries.

2. Authors are repeatedly counted if they affiliate to different institutions in the data set.

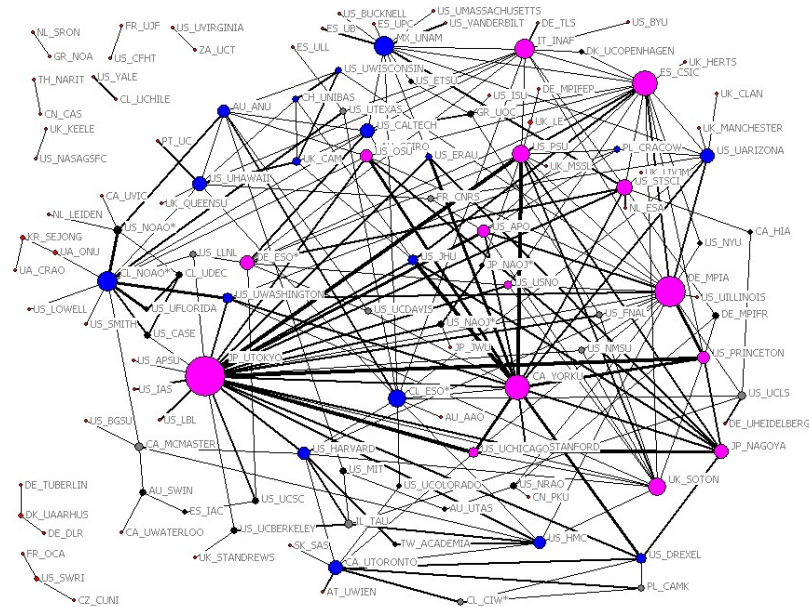
Although the U.S. dominates in astronomical research, it is revealed that the percentages of IRC papers are varied with the universities and institutes in the countries – The University of Chicago has a high proportion of IRC papers (91.67%) and the Harvard-Smithsonian Center for Astrophysics (including the Department of Physics and the Department of Astronomy at Harvard University) has the lowest one (44.12%). As for non-U.S. universities and institutes, many of them have high percentage of IRC papers: the University of Toronto (100.00%) and the York University (91.67%) in Canada, the Max Planck Institute for Astronomy in Germany

(93.33%), the Australian National University (92.86%), University of Tokyo (92.31%), and Spanish National Research Council (91.67%) and Instituto de Astrofísica de Canarias (83.33%).

### *Research collaboration network*

The result of network analysis shows that many astronomical institutions published IRC papers together only for once. Only 23.41% (1,159 out of 4,951) of the frequency of international co-authorship can be accounted for the multiple papers produced by a pair of collaborating institutions.

Figure 1 illustrates the IRC network consisting of the 124 institutions which published at least two papers with the same foreign counterparts. It indicates that the strongest ties exist in several pairs of institutions: “CA\_YORKU and US\_JHU” (8 papers), “JP\_UTOKYO and US\_PSU” (8 papers), “CA\_YORKU and US\_PSU” (7 papers), “JP\_UTOKYO and US\_PRINCETON” (7 papers), and “JP\_UTOKYO and US\_UCHICAGO” (7 papers). The figure also reveals that the University of Tokyo, the Max Planck Institute for Astronomy, the Spanish National Research Council, and the York University perform as the active participants in the IRC. These institutions connected with many foreign counterparts and published multiple papers with each of the partners in the investigation period.



**Figure 1. International research collaboration network consisting of the institutions in the AJ in 2007 (IRC papers by each pair of institutions  $\geq 2$ ,  $N = 124$ ).**

### **Conclusion**

The results of this current study show that institutional IRC is prevalent in modern Astronomy. Most countries and institutions have established the cross-national scientific connection in astronomical research. However, the scales of IRC are different among the institutions. International cooperating observatories are found to have more IRC activities. The finding provides supportive evidence for the hypothesis that international observing facilities affect the production of IRC papers. In addition, the result also suggests that institutional scientific size is a notable factor. The institutions with small research manpower tend to have more IRC activities. It seems true that scientists in small institutions would feel not easy to find local experts and thus turn to international sphere.

Moreover, the study reveals that the strongest ties exist between American and Canadian institutions and American and Japanese institutions. Various reasons can account for those

linkages. International cooperating observatories and small institutions are not found to have significantly more links to foreign counterparts in the collaboration network.

Future research needs to follow up on the intriguing patterns indicated by this preliminary study. It requires collecting large-scale data as well as examines institutional and national factors for modelling institutional IRC. In term of the network analysis, some developed indicators, such as density and centrality, can be reported to detail features of an institutional IRC network. Statistical evidence of institutional IRC networking is also needed in further studies.

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