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The productivity of Mexican astronomers in the field of outflows from young stars

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We carry out a bibliometric study of the activity of astronomers in the field of Herbig-Haro (HH) objects. Through an appropriate choice of keywords, we recover the papers on HH objects from the ADS (Astrophysics Data Service) and ISI ("Web of Knowledge") databases. From the two databases we recover number of papers and citations which differ by ~10% .

We analyze an 11-year period, restricting ourselves to authors with at least 10 papers within the period. We analyze the number of papers and citations, as well as the H index of this set of authors.

Within this sample, we identify the authors belonging to Mexican institutions. We find that the Mexican researchers perform very well, having higher publication and citation rates than the ones of the full sample of authors active in the field of HH objects. The Mexicans have a degree of specialization (measured as ratios between the production in the chosen field and the total production of the individual authors) similar to the one of the full sample. They collaborate in somewhat larger groups than the authors of the full sample.

Finally, we have carried out a study of the impact in the chosen field of different astronomical journals. We find that the *Revista Mexicana de Astronomia y Astrofisica* is well placed in the "second tier" of astronomical publications.

1. Introduction

The field of outflows from young stars (HH objects and molecular outflows) has traditionally received relatively strong attention among Mexican astronomers. This is not surprising given the fact that Guillermo Haro (who together with George Herbig discovered HH objects: [HERBIG, 1951; HARO, 1952]) was a Mexican researcher. In this paper, we carry out a bibhometric evaluation of the activity in this field of Mexican researchers, as compared to the researchers in all countries.

Many bibliometric evaluations of research activity in astronomy have been carried out. For example, evaluations of observational facilities such as all space-based astronomical facilities [TRIMBLE & AL., 2006] have been made. Also, studies of the

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impact of specific instruments have been made (Hubble Space Telescope: [MEYLAN & AL., 2004], Canada-France-Hawaii Telescope: [CRABTREE & BRYSON, 2001]).

A comparison of the citation performance of researchers from different countries was made by SANCHEZ & BENN [2004]. This work of course shows a dominant USA, followed by the EU countries. Many countries with relatively small investments in research (such as Mexico) do not even appear in this study.

Also, some studies have focussed on particular countries. For example, BLUSTIN [2007] has carried out a bibliometric study of UK researchers, obtaining parameters for evaluating individual researchers and astronomy departments within the UK. ISAKSSON [2007] has carried out an evaluation of Finnish astronomy, comparing the production of Finland with the ones of all Scandinavian countries.

In the present study, we focus on the activity in one particular subject (outflows from young stars), and carry out a comparison between the population of researchers from one country (Mexico) and the world population. This study is used to evaluate the performance of the Mexican researchers in the chosen field.

2. Methodology

We have carried out searches in the data base (DB) of the ISI (Institute of Scientific Information) through the ISI Web of Knowledge platform and in the ADS (Astrophysics Data Service) data base of the Smithsonian Astrophysical Observatory and NASA. We will refer to these two data bases as the ISI and ADS data bases, respectively.

Our searches have been made with the combination of keywords : (molecular AND outflows) OR (hh AND objects) OR (t and tauri) OR (ism: AND jets AND outflows). This combination of keywords yields a lists of papers which are dominated by papers in the field of outflows from young stars. For recovering papers from the ADS database, we have activated the flag for "astronomy" papers only.

An interesting point is that if one includes "stars: pre-main sequence" as an additional keyword, the number of papers and citations recovered from the ISI and ADS data bases increases by a substantial factor. This is a result of the fact that this keyword is used in papers on galaxy formation and on active galactic nuclei, which are actually not close to the chosen field of HH objects. Because of this, we have avoided the use of this keyword.

From the ISI and ADS data bases we have then created two reduced data bases (which we will call ISI_0 and ADS_0, respectively) by carrying out a search for the 11-year period 1997–2007 of refereed papers with the keywords described above. These "outflow" data bases include the published papers and the citations to these papers during the same, 1997–2007 period. We have "normalized" these data bases so that all of the authors appear under a single, unique denomination.

For comparing the two data bases, we compute the total number of papers P_a and the total number of citations C_a for each author *a* (in the ISI_0 and ADS_0 data bases described above). We then compute the deviations

$$\Delta(\text{papers}) = 100 \times \frac{P_a(ADS_0) - P_a(ISI_0)}{P_a(ADS_0)}, \quad (1)$$

$$\Delta(\text{cit.}) = 100 \times \frac{C_a(ADS_0) - C_a(ISI_0)}{C_a(ADS_0)}, \quad (2)$$

between the ADS_0 and ISI_0 papers and citations (Eqs 1 and 2, respectively) given as percentages of the ADS_0 values for each of the authors. In Figure 1, we plot these deviations for the 20 most productive authors (i. e., the authors *a* with the 20 largest values of N_a) of the ADS_0 database.

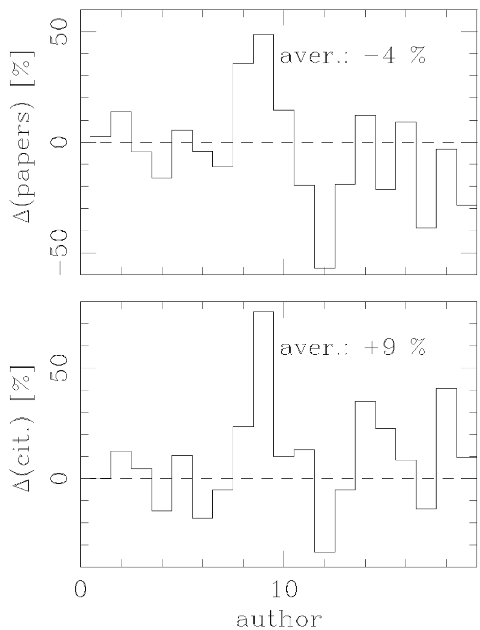

Figure 1. Deviations in the total number of papers (above) and citations (below) between the ADS_0 and ISI_0 databases for the 20 most productive authors of the ADS_0 database. The definitions of A(papers) and A(cit.) are given in the text

From Figure 1, we see that the 20 most productive authors show deviations between the ADS_0 and the ISI_0 databases with typical values of ~10% (both in citations and in number of papers). If we add over these authors, the ADS_0 database has 4% fewer papers and 9% more citations than the ISI_0 database.

These results are consistent with the comparison between the two databases carried out by ABT [2006]. This paper also finds that more citations are recovered from the

ADS database. This is a result of the fact that while the ISI database is restricted to refereed papers, the ADS includes a number of citations (to refereed papers) from non-refereed papers (even when one restricts the search to refereed papers only). ABT [2006] also finds that the number of refereed papers is larger in the ISI database (than in the ADS) because it includes a larger number of secondary physics journals with astrophysically related papers.

This comparison between the two databases is meant as an evaluation of the uncertainties likely to be found in the number of papers and citations recovered from the ADS database. The exercise described above yields an estimated uncertainty of ~5% in the number of papers and of ~10% in the citation numbers derived from the two databases. The analyses presented in §§3 and 4 are based on results obtained from the ADS_0 database. The results of §5 are based on the ADS_0 database.

We have also identified the authors that have been associated with Mexican institutions at least for half of the 1997–2007 period which we are studying. We have counted faculty members, post-docs and post-graduate students as being associated to the institutions in which they have carried out the published work. Identifying the appropriate researchers is straightforward, since they belong to three institutes (Instituto de Astronomia, Centro de Radioastronomia y Astrofisica Teorica and Instituto de Ciencias Nucleares) of our university (the UNAM), so that their presence or not in the payroll can be checked.

The authors in our ADS_0 and ISI_0 databases are dominated by researchers who have done a single contribution in the field of outflows from young stars. In order to have a sample of researchers who are active in the field, we have made three reduced databases: ISI_{10}, ADS_{10} and ADS_{20}, which only have authors who have published at least 10 or at least 20 papers in the chosen, 11-year period.

The ADS and ISI databases have drivers with different properties. For example, in the ISI database it is straightforward to select papers from authors from different countries or institutions (this information not being present in the ADS database, which is organized only on an "author" basis). The ADS database is much smaller, as it is strongly concentrated towards fields related to astrophysics. This makes it very convenient for searches of papers from individual authors (within the chosen astrophysical field), as many fewer name duplications occur. Because of their characteristics, each of the databases is more appropriate for carrying out different kinds of studies.

In the present paper we have used the ADS_{10} and ISI_{10} databases to derive the productivity of the authors in the chosen field (determined by the combination of keywords described above) measured as numbers of papers and citations in the chosen period. As can be seen from sections 3.1 and 4.1, the two databases give consistent results. The considerably smaller ADS_{20} database (with authors with 20 or more papers in the field in the chosen period, see above) was used to carry out a study of the degree of specialization of the authors (see section 3.2), which involves searches of the full production (with no restriction of field) of the individual authors. Finally, studies of the number of authors per paper and the distribution of the publications over the different journals was carried out with the ISI_{10} database.

3. Analysis of the ADS database

3.1 Productivity of the authors

In this section, we use the ADS_{10} database of authors who have published at least 10 papers in the 1997–2007 period in the field of outflows from young stars (see §2). The ADS_{10} database has a total number of 152 authors (10 from Mexican institutions) with a total number of 2891 papers (320 with at least one Mexican author) which have received 53994 citations (5162 of these corresponding to the papers with at least one Mexican author). The Mexicans as a group therefore represent 6.6% of the total number of researchers, participate in 11.1% of the papers, and receive 9.6% of the citations. Therefore, the Mexican group as a whole has a factor of 1.68 more publications and 1.45 more citations than the full sample of authors.

We now analyze the performance of individual authors. We produce lists of authors in order of decreasing productivity (i. e., number of publications) and citations. With these lists we produce frequency distributions giving the number of authors binned into ranges of productivity (i. e., number of publications) and citation rates. The result of this exercise is shown in Figure 2 for both the total sample and for the Mexican researchers.

In the top panel of Figure 2, we see that the total sample has a peak at low productivities, with ~73% of the authors publishing between 10 and 19 papers. The distribution has a long tail, extending out to ~100 papers in the chosen period. For the "Mexican sample", the low productivity peak has a value of 40% (for authors publishing between 10 and 19 papers), and a wing extending out to the 70→79 publication bin which clearly lies above the publication distribution of the total sample. The distribution for the total sample has an average productivity of 1.73 papers per year per author, and the one for the Mexican sample has a productivity of 3.20. This difference clearly indicates that the Mexicans (seen as individual researchers) are more productive than the total sample.

If we look at the citation frequency diagram (bottom panel of Figure 2), we again see that the distribution of the Mexican authors has a tail extending to large citation numbers which is higher than the tail of the distribution obtained with the total sample. The distribution for the total sample has an average rate of 32.3 citations per year per author, and the one for the Mexican sample has a citation rate of 46.9.

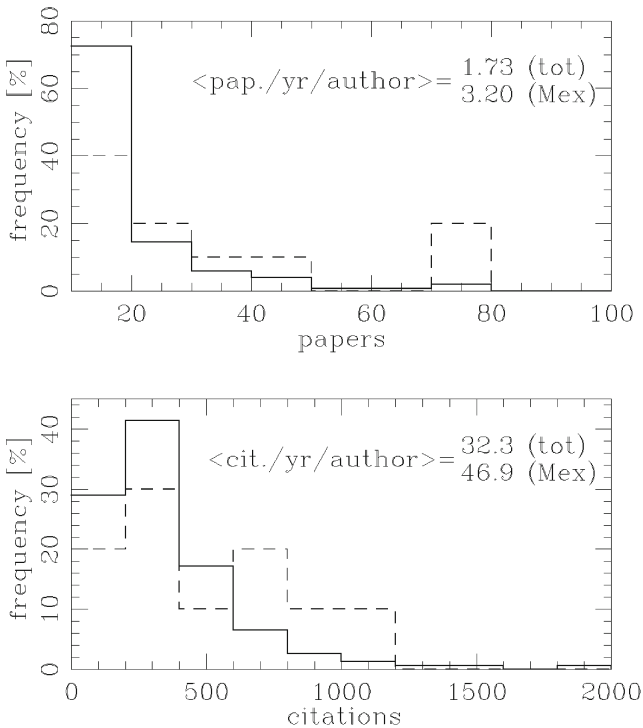

Figure 2. Frequency distributions giving the percentage of authors with different number of papers (above) and receiving different number of citations (below). The distributions obtained for the total sample (of papers in the 1997–2007 period, publishing in the field of outflows from young stars) are shown with solid lines, and the ones for the sample of Mexican researchers are shown with dashed lines.

From these results, we see that the Mexicans (analyzed as individual researchers) have a factor of 1.85 more publications and a factor of 1.45 more citations (to these papers) than the full sample of authors. If we consider that the estimates of the uncertainties in the ADS database (derived from the comparison with the ISI database described in §2) is ~5% for the number of papers and ~10% for the citations, it is clear that the result that the Mexicans have more publications and citations lies clearly above the estimated errors of the database.

If we take the papers and citations of the ADS_{10} database, we obtain a total of 18.7 citations per paper for the full sample, and 16.1 citations per paper for the Mexican authors. Therefore, though the productivity of the Mexican researchers (measured either as number of papers or citations per author) is higher than the one of the full ADS_{10} sample, the number of citations per paper that they receive is ~15% lower. We come back to this point in the analysis of the ISI_0 database presented in §5.

We should point out that from the analysis of the Mexicans as a group (first paragraph of this section) we find that the Mexicans publish more than the full sample by a factor of 1.73 (per author). However, when analyzed as individual researchers, the

Mexicans have a factor of 1.85 publications more than the full sample. This difference might be associated with the fact that the Mexicans publish papers with a somewhat longer average author list than the researchers in the full sample (see §5).

3.2 Degree of specialization

Let us now consider the full productivity (regardless of subject area) of the authors who are active in the field of outflows from young stars. In order to do this, we have taken the ADS_{20} database (with authors who have published at least 20 papers on the subject in the 1997–2007 period, see §2), which has 40 authors (including 5 from Mexican institutions). For these authors, the database gives us the number pap_{HH} of published papers and the number cit_{HH} of citations received by these papers during the same period.

For the 40 authors in the ADS20 database, we have carried out individual ADS searches, with no restriction of subject area for the publications. For each author we have determined the total number pap_{tot} of refereed papers published during the period (regardless of subject area) and the total number of citations cit_{tot} received by these papers during the same period.

In Figure 3, we show the ratios pap_{HH}/pap_{tot} and cit_{HH}/cit_{tot} as a function of pap_{HH} for all of the ADS_{20} authors. From the corresponding graphs we see that the Mexicans have values of these ratios that are typical of the full sample, indicating that their degree of specialization does not differ qualitatively from the one of the full sample of authors.

We obtain average values giving $r_p = \langle pap_{HH}/pap_{tot} \rangle = 0.42$ and $r_c = \langle cit_{HH}/cit_{tot} \rangle = 0.40$, where the averages represent the total number of papers or citations (per author) for all of the ADS20 authors. If we carry out the averages only over the 5 Mexican authors of the ADS20 database, we obtain ratios $r_p(M) = 0.52$ and $r_c(M) = 0.45$. Therefore, if we take these ratios as an estimate of the degree of specialization of the authors we conclude that the Mexicans are more specialized by ~20% if we consider the r_p ratio (i. e., considering the average publication numbers) and by ~15% in the r_c ratio (i. e., in the citation numbers).

From this study, we conclude that the production of the Mexican astronomers appears to be somewhat more concentrated (by ~15%. see above) on the field of outflows from young stars than the production of the full, ADS_{20} sample (see §2). The difference between the degree of specialization of the Mexicans and the full sample is therefore relatively small. The results of §3 then also imply that the Mexican astronomers (included in our study) are more active than the full sample, even if one removes subject area requirements for the published papers.

Also, from the individual ADS searches (for the authors of our ADS20 database, see above) we have determined the H index for all of the papers published during 1997–2007 (with no subject restriction) by each author. From a list of papers ordered in decreasing citation numbers, the H index is equal to the paper with the largest order number which is greater or equal to its number of citations. HIRSCH [2005] proposed the H index as an indicator of the productivity of a researcher, which incorporates both the total productivity (measured by the citation count) as well as the width of the citation distribution of the published papers.

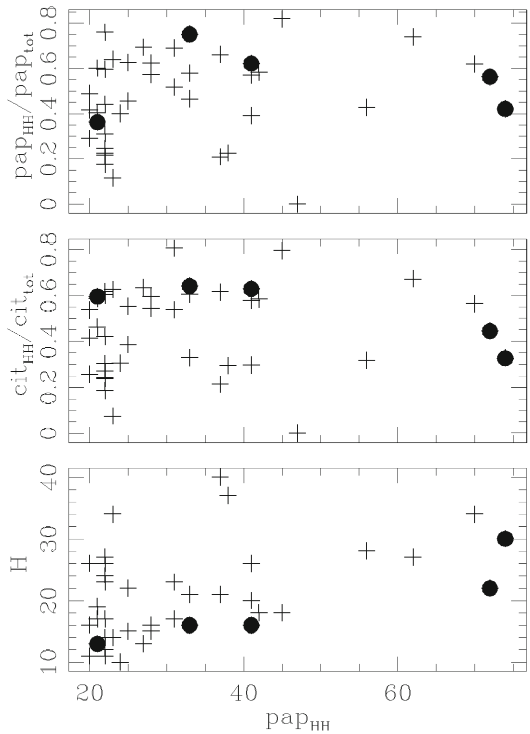

Figure 3. Top: ratio between the number of papers pap_{HH} in the ADS_{20} database (see §2) and all of the papers pap_{tot} published in the same period by the authors (with no restriction of topic) as a function of the ADS_{20} number of papers pap_{HH}. Center: ratio between the number of citations cit_{HH} in the ADS_{20} database (see §2) and all of the citations cit_{tot} recieved by all of the papers published in the same period by the authors. Bottom: H index (computed with all of the papers in the period for each author, see the text) as a function of pap_{HH}. In all of the plots, the filled circles correspond to the Mexican astronomers, and the crosses to the other authors of the ADS_{20} database (see the text)

In the bottom panel of Figure 3, we show the H index obtained for the ADS_{20} authors, considering the citations to all of the papers published in the 1997–2007 period (regardless of subject area). In this graph, we see that the H indices of the Mexicans appear to lie within the general distribution of the ADS_{20} authors. If we compute the average H index we obtain <H>=20.6 (19.4), where the number in parentheses corresponds to the 5 Mexicans in the sample. The average H index of the Mexicans is therefore similar to the one of the full ADS20 sample.

For the determination of the H indices, we have not divided the citations by the number of co-authors of each paper (to obtain the "normalized citations" per co-author). This is consistent with the fact that in this section we have considered the total number of papers and citations per author (without dividing by the number of co-authors). Actually, one can argue that all analyses of individual researchers should be carried out with "normalized" counts of papers and citations. This of course produces large effects in fields with papers with large numbers of co-authors.

4. Analysis of the ISI database

4.1 Number of citations per paper

From the total number of papers and citations from the ISI_{10} database, we can compute the ratio between the total citations and papers. For the whole sample we then obtain a number of citations per paper of 17.2, and for the Mexicans 16.8 citations per paper (only 2.4% lower than the value for the whole sample of authors). These ratios are roughly consistent with the ones obtained from our ADS_{10} database (18.7 for the whole sample and 16.1 for the Mexicans, see §3).

4.2 Number of authors per paper

We also obtain the number of authors per paper for all of the papers in the ISI_{10} database. We obtain a number of 4.3 authors per paper for the full sample, and 5.3 authors per paper for the papers with at least one Mexican author.

In Figure 4 we show the frequency distributions of the number of authors per paper for the full sample and for the Mexican papers (i. e., the papers with at least one Mexican author). The main distribution has a principal peak at 3 authors per paper. The Mexican distribution is somewhat broader than the one of the full sample, and has a principal peak at 4 authors per paper. The Mexican distribution also has a stronger "large group" wing than the full sample.

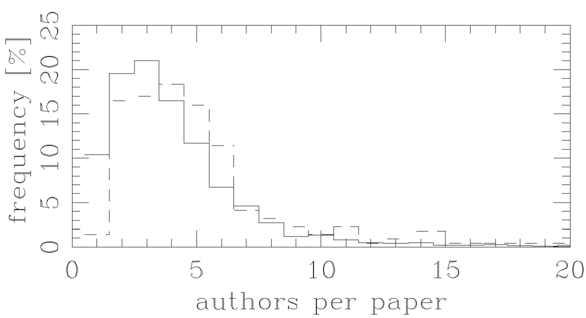

Figure 4. Frequency distribution of the number of authors per paper obtained from the ISI_0 database. The distribution of the full sample of papers is shown with the solid line, and the distribution obtained from the papers with at least one Mexican author is shown with the dashed line

Interestingly, the "Mexican distribution" has a very low number of single-author papers. This is in sharp contrast with the distribution of the full sample, which has a much higher percentage single-author papers.

4.3 Distribution over different journals

Using the ISI_{10} database (see §2), we first count the number of papers which appear in each journal, and then create a normalized list of journals in order of decreasing number of publications (in the subject of outflows from young stars, in the 1997–2007 period). We limit the list to journals with at least 20 publications. This list is shown in Table 1, in which we give the names of the journals, the percentage of the papers of our ISI_{10} database that appear in each journal, and the number of citations per paper (calculated for the ensemble of papers published in each journal). In Table 1 we also show the percentage of papers of the Mexican group published in each journal (together with the corresponding citation rates).

Table 1. Papers, citations and impact parameters

Journal[a]	Full sample			Mexicans		
	papers [#]	papers [%]	IP[a]	papers [#]	papers [%]	IP[b]
Astrophys. J.	1141	37.9	20.2	96	44.0	24.2
Astron. Astrophys.	891	29.6	16.0	31	14.2	10.8
Astron. J.	354	11.8	21.4	33	15.1	13.9
Mon. Not. R. Astron. Soc.	299	9.9	13.5	11	5.0	7.9
Astrophys. Space Sci.	93	3.1	1.4	5	2.3	1.4
Astrophys. J. Suppl. Ser.	50	1.7	23.7	7	3.2	26.4
Publ. Astron. Soc. Jpn.	37	1.2	7.9			
Astro. Rep.	36	1.1	2.6			
Astron. Lett.	33	1.1	3.6			
Rev. Mex. Astron. Astrofis	29	0.9	4.2	27	12.4	4.5
Astron. Astrophys. Suppl. Ser.	27	0.9	27.0			
Astronom. Nachr.	20	0.6	6.7			

[a]The abbreviations of the journals are taken from [ALKIRE, 1989].
[b] The impact parameter IP is defined as the ratio between the total number citations and papers (in our ISI_0 database, see §2) for each journal.

It is evident that there is a leading group of four journals (namely. *Astrophys. J.*, *Astron. Astrophys.*, *Astron. J.* and *Month. Not. R. Astron. Soc.*) in which are published ~89% of the papers in the field of outflows from young stars. The papers in this group of journals receive ~95% of the citations. This group of journals has "impact parameters" (i. e., number of citations per paper in our database, see Table 1) ranging from 20.2 to 13.5.

Immediately following this leading group, we find *Astrophysics and Space Science* (*Astrophys. Space Sci.*), in which are published ~3% of the papers in the field. This journal has a low impact parameter of 1.4 citations per paper, which is similar to the impact parameters normally found for non-refereed papers. This is not surprising given the fact that *Astrophys. Space Sci.* publishes many conference proceedings as issues of the main journal (even though they are refereed).

The rest of the journals of Table 1 include two supplement series (the *Astrophys. J.* and *Astron. Astrophys.* supplement series), which have a small number of papers, but very high impact parameters. This is also to be expected given the nature of the papers which typically appear in a supplement series.

The remaining journals (*Publ. Astron. Soc. Jpn.*, *Astronom. Nachr.*, *Rev. Mex. Astron. Astrofis.*, *Astro. Rep.* and *Astron. Lett.*, in order of decreasing impact parameter) represent a "second tier" of journals. In these journals are published ~5% of the papers, receiving ~1.5% of the total citations.

The Mexican researchers publish a larger fraction of their papers in the leading USA journals (*Astrophys. J.* and *Astron. J.*) than the whole sample, and a lower fraction in the two leading European journals (*Astron. Astrophys.* and *Month. Not. R. Astron. Soc.*, see Table 1). This is not surprising given the geographical proximity between Mexico and the USA. Also interesting is that while the impact parameter of the Mexican publications in the *Astrophys. J.* is higher than the one of the full sample, the impact parameters of the Mexicans in *Astron. J.*, *Astron. Astrophys.* and *Month. Not. R. Astron. Soc.* are lower than the ones of the full sample.

Notably, 27 out of the 29 papers in the chosen field published in the *Rev. Mex. Astron. Astrofis.* have at least one Mexican coauthor. At the same time, the Mexican researchers basically do not publish in any of the other "second tier" journals. This is not surprising, as many of these are regional journals (with the exception of *Astrophys. Space Sci.*). We therefore conclude that the Mexican researchers are able to give their local journal (the *Rev. Mex. Astron. Astrofis.*) an impact parameter which places it well within the range of other regional journals in the field of HH objects.

5. Conclusions

Based on data retrieved from the Astrophysics Data Service (ADS) and the Institute of Scientific Information (ISI) databases, we have carried out an analysis of the published papers and citations during an 11-year period (1997–2007) for the field of outflows from young stars. Our analysis is aimed at evaluating the performance in this field of the "Mexican researchers" (i. e., the researchers associated with Mexican institutions during at least half of the 1997–2007 period).

We first carry out a comparison between the ADS and ISI database (for papers in the field and period which we are considering). We find that for groups with sizes of ~20 researchers the two databases give counts of papers and citations consistent to within ~10% (see §2).

From an ADS study of the authors who published at least 10 papers in outflows from young stars in the 1997–2007 period (see §3.1), we find that the Mexicans (10 out of 152 authors) have factors of 1.7–1.9 more publications (the first number corresponding to an analysis of the Mexicans as a group, and the second one considering them as individual researchers) and 1.5 more citations than the full sample of authors. These results imply that the Mexican group is clearly more active than the full sample, since the ratios quoted above are significantly above unity (as compared to the ~15% error propagated from the estimated uncertainty in the databases). A study of the distributions of numbers of publications and citations shows that the Mexicans have a population with a high productivity wing which lies clearly above the one of the full sample of authors (see §3.1).

From the ADS study we also find that the number of citations per paper for the Mexican group is ~15% lower than the one for the whole sample of authors (see §3.1). However, from a study of the ISI database (see §4.1), we find that the average citations per paper for the Mexicans is lower than the one of the full sample by only ~2%. Therefore, we conclude that within the errors of our study we can only say that the total citations per paper of the Mexicans appear to be marginally lower than the ones of the full sample of authors.

From an ADS study of the authors who published at least 20 papers within the 1997–2007 period (see §3.2), we find that the Mexicans (5 out of 40 authors) have a degree of specialization which is marginally higher than the one of the full sample of authors. From an analysis of the ratios between papers and citations with and without subject restriction, we find that the Mexicans are more specialized (in the field of outflows from young stars) by ~15%. This effect is comparable to the expected error propagated from the estimated uncertainty in the databases, and is too small to account for the superior productivity of the Mexican researchers.

We have used the ISI_{10} database to compute the average number of coauthors per paper in the papers published in the 1997–2007 period in the field of outflows from young stars (see §4.1). We find that the average number of authors per paper is 4.3 for the full sample, and 5.3 for the Mexican authors. The frequency distribution (of number of authors per paper) of the Mexican group appears to differ from the distribution of the full sample (see Figure 4). The difference between the two distributions (e. g., in their average values and in the positions of the peaks) might be a result of the fact that the Mexicans form a group of collaborators, while the full sample might have relatively important contributions from researchers working individually or with very few collaborators.

We have also used the full sample from the ISI_0 database (of papers in the field of outflows from young stars in the 1997–2007 period, see §2) to study the distribution of the publications in different journals (see §4.2). We find that the Mexicans publish a higher fraction of their papers in the *Astrophys. J.* than the full sample of authors, and less than the full sample in the other three leading astronomical journals (*Astron. Astrophys.*, *Astron. J.* and *Mon. Not. R. Astron. Soc.*).

We end our discussion by pointing out that our study shows that Mexican institutions have a strong group active in the field of outflows from young stars. This strength is evidenced both by the number of papers and by the number of citations received by these papers, as compared to the corresponding numbers for the sample of all of the authors active in the field. We have shown that this result is not due to a higher degree of specialization (on the field of outflow from young stars) of the Mexican researchers, and that it reflects the Mexican group is indeed well placed within the complete sample of authors. It is a heartening conclusion that the field of Herbig-Haro objects is alive and well in the country of Guillermo Haro.

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