

SOCIOLOGICAL PROFILE OF ASTRONOMERS IN SPAIN

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Abstract. In this paper the main findings are presented of a recent study made by a team of sociologists from the University of Granada on the professional astronomers currently working in Spain. Despite the peculiarities of this group – its youth, twentyfold increase in size over the last 20 years, and extremely high rate of specialization abroad – in comparison with other Spanish professionals, this is the first time that the sociological characteristics of the group have been studied discretely. The most significant results of the study are presented in the following sections. Section 1 gives a brief historical background of the development of Astronomy in Spain. Section 2 analyzes the socio-demographic profile of Spanish Astronomy professionals (sex, age, marital status, etc.). Sections 3–5 are devoted to the college education and study programs followed by Spanish astronomers, focusing on the features and evaluations of the training received, and pre- and postdoctoral study trips made to research centers abroad. The results for the latter clearly show the importance that Spanish astronomers place on having experience abroad. Special attention is paid to scientific papers published as a result of joint research projects carried out with colleagues from centers abroad as a result of



these study trips. Section 6 describes the situation of Astronomy professionals within the Spanish job market, the different positions available and the time taken to find a job after graduation. Section 7 examines Astronomy as a discipline in Spain, including the astronomers' own opinions of the social status of the discipline within Spanish society. Particular attention is paid to how Spanish astronomers view the status of Astronomy in Spain in comparison with that of other European countries.

1. Introduction

During the Middle Ages the Iberian Peninsula was one of the world's most privileged places for the conservation, transmission and development of classical Astronomy. Of particular note were Azarquiel, the eleventh-century astronomer from the Moorish kingdom of Al-Andalus, and – among the Christians to the north – King Alphonse X 'The Wise' (1221–1284). Toledo was originally the point of origin for longitudinal meridians – it was later superseded by Hierro in the Canary Islands and, more recently, Greenwich.

The oldest Spanish astronomical institutions still in existence are the direct result of the country's astronomical heritage. The San Fernando Observatory, today the *Real Instituto y Observatorio de la Armada* (Royal Navy Institute and Observatory), was founded in 1751. Its *Efemérides* have been published since 1791, making them the world's third oldest. The *Observatorio Astronómico Nacional* (National Astronomical Observatory; OAN) was founded in 1786 as the Observatory of Madrid. Today it is located in Alcalá de Henares, where it has been modernized to enable advanced research to be carried out, particularly in the field of radio astronomy. The Astronomy departments at the universities of Madrid and Barcelona also date back to the eighteenth and nineteenth centuries.

The discipline was given further impetus at the turn of the century by the creation of two Jesuit-run observatories – the Cartuja (Carthusian) Observatory in Granada (1902) and the Ebro Observatory in Tortosa (1904) – together with the Fabra Observatory in Barcelona (1904). An Astronomy department was subsequently created at the University of Zaragoza, followed in more recent times by that of the University of Santiago (1945), as a continuation of the observing work done by Ramón María Aller in Lalín, dating back to 1917, which led to the installation of the astronomical observatory that today bears his name.

The activities of these centers were interrupted by the Spanish Civil War (1936–1939), although all have survived to this day and have since been substantially modernized. Astronomy in Spain is currently undergoing a *renaissance*, the origins of which can be traced back to the 1960s, when Spain signed international agreements with several other European countries (e.g., the UK, Germany, the Netherlands and certain countries in Scandinavia). The subsequent installation of major observing facilities in the Iberian Peninsula (Almería and Granada), the Canary Islands (La Palma and Tenerife) and elsewhere undoubtedly acted as the

main catalyst for the spectacular development of Astronomy in Spain over the last 30 years.

Almost in parallel with these international agreements, the *Instituto de Astrofísica de Canarias* (Canary Islands Astrophysics Institute; IAC) was set up in Tenerife in 1975 (following astronomical work associated with the University of La Laguna dating back to 1959). Today the IAC is Spain's largest astronomical research center, coordinating a large number of European observing resources, most notably the Roque de los Muchachos Observatory (ORM, 1979) on the island of La Palma. This observatory is where William Herschell's 4.2-meter telescope is now located – the property of the Royal Greenwich Observatory (RGO, UK). The IAC is currently in the process of building a large 10-meter optical telescope.

1975 also saw the creation of the *Instituto de Astrofísica de Andalucía* (Andalusian Astrophysics Institute; IAA) in Granada, under the auspices of the *Consejo Superior de Investigaciones Científicas* (Spanish Scientific Research Council; CSIC). This institute – together with the IAC, one of Spain's leading astronomical research institutions – also has its roots in earlier efforts; the Cartuja Observatory and the University of Granada had been developing on research projects since 1966. The IAA is responsible for the management of Sierra Nevada Observatory (OSN) in Granada.

Major observing facilities installed in Spain by institutions from other countries include the *Centro Astronómico Hispano Alemán* (Hispano-German Astronomical Center; CAHA) in the Province of Almería, set up in 1972, which has several telescopes, the largest of with a 3.5-meter diameter. In 1977 the European Space Agency (ESA) installed the VILSPA station in the Province of Madrid in order to track the International Ultraviolet Explorer (IUE). This center has made an invaluable contribution to the growth of Astronomy in Spain. Also dating from the 1970s is the *Institut de Radio Astronomie Millimétrique* (Millimeter Radio Astronomy Institute; IRAM; 1982), a joint venture by Germany, France and Spain. IRAM's 30-meter antenna located on the Veleta peak in the Sierra Nevada (Granada) is the second largest of its kind working at millimeter wavelengths.

The 1970s also saw the creation of the first Astrophysics chairs – first at the University of La Laguna (1972) and, a decade later, at Granada (1982). 1972 was also the year when the scientific groups of the *Comisión Nacional de Investigación del Espacio* (National Space Research Commission; CONIE) were formed, later incorporating all the purely astronomical endeavors of the *Instituto Nacional de Técnica Aeroespacial* (National Aerospace Technology Institute; INTA; 1945). The *Instituto de Astronomía y Geodesia* (Astronomy and Geodesy Institute) was founded in Madrid in 1982, taking over from the *Instituto de Mecánica y Astronomía* (Mechanics and Astronomy Institute), which dated back to 1966. The most recent center to be inaugurated is the *Centro Astronómico de Yebes* (Yebes Astronomical Center; CAY), opened in 1997 under the auspices of the OAN.

Other recent initiatives include the Astronomy departments of the universities of Cantabria (1988) and Valencia (1991), plus a number of smaller research groups

based at other universities; the inclusion of Astronomy among subjects for research at the CSIC's *Centre d'Estudis Avansats de Blanes* (Blanes Advanced Studies Center; CEAB; 1988); the INTA's *Laboratorio de Astrofísica Espacial y Física Fundamental* (Space Astrophysics and Pure Physics Laboratory; LAEFF; 1991); the *Instituto de Física de Cantabria* (Cantabrian Physics Institute; IFC; 1995), jointly run by the CSIC and the University of Cantabria; and the *Institut d'Estudis Espacials de Catalunya* (Catalan Space Studies Institute; IEEC; 1996), jointly run by the *Fundación Catalana per a la Recerca* (Catalan Research Foundation), the CSIC and three universities – the Autonomous University of Barcelona, Barcelona University and Barcelona Polytechnic.

It is also worth mentioning here the involvement of Spanish research groups in the construction of scientific instruments for use on board space missions, such as the ISO and SOHO projects (in both of which the IAC played a major role), and the Cassini-Huygens, Mars-96 (IAA) and INTEGRAL (University of Valencia and the INTA, through the LAEFF) missions. INTA has also been closely involved with the launch of scientific mini-satellites with onboard astronomical experiments, such as LEGRI and EURD.

The boom in Astronomy in Spain over the last few decades has led to the development of an astronomical community that is on a par with that of other European countries, not only in the number of professionals it employs, but also in its scientific performance and the diversity of the specialties it focuses on. Since the early 1970s, the number of professional astronomers operating in Spain has undergone a twentyfold increase – today around 300 PhDs are actively involved in research programs. The *Sociedad Española de Astronomía* (Spanish Astronomical Society; SEA) was formed in 1992 to provide a forum for debate among professionals, promote the development of Astronomy, make information of general interest available, and enable the sector to be democratically represented in its dealings with public bodies and private institutions both in Spain and abroad.

One of the first initiatives of the SEA was to commission a sociological study of Spanish astronomers (both members and non-members of the Society), in order to determine the current situation of the country's Astronomy professionals. There seemed to be little doubt that a study of a sector that had seen a twentyfold increase in numbers in only 20 years would reveal information that would prove invaluable for the future development of Astronomy in Spain. The idea was to provide data that would serve as food for thought both for Astronomy professionals and for the Spanish authorities, as well as a offering point of reference for other countries whose circumstances are comparable with those of Spain. With these goals, the SEA commissioned a team from the Department of Sociology at the University of Granada to devise and carry out the study (see J. Iglesias de Ussel, A. Trinidad, and D. Ruíz, 1996, in *Sociología de una Profesión: Los Astrónomos en España*, ed. Facultad de Ciencias Políticas y Sociología, Universidad de Granada). Data were gathered by means of a questionnaire mailed to people that the SEA had previously targeted as working in the field of Astronomy in Spain. Of the 443 ques-

tionnaires mailed out, 35% were returned – an acceptable figure, with a sampling error margin of $\pm 5\%$ and a level of significance of 95%.

As a complement to this sociological study, the SEA plans to commission in the near future a study of the evolution of productivity in the field of astronomical research in Spain. Revealing the extent to which the resources assigned to astronomical research by the Spanish authorities have led to the publication of research papers in specialist journals, or the quantitative and qualitative analysis of Spanish participation in international conferences, organizations or committees will – in tandem with this sociological study – undoubtedly provide us with an overall understanding of the current status of the Spanish astronomical community in a worldwide context.

In this paper we present the most significant results and conclusions resulting from the sociological study carried out by Iglesias de Ussel, Trinidad and Ruíz (1996).

2. Socio-demographic Profile of Spanish Astronomers

As a profession, Astronomy in Spain mainly involves young people: the average age of astronomers is 34; six out of ten astronomers are under 35, and 90% of them are between 25 and 45. This shows that most Spanish astronomers were born in the 1960s – in other words, they are ‘baby boomers’.

Distribution by sex reveals a clear majority of males (78%). Although only 22% of Spanish astronomers are female, this figure is more than twice the European average for the profession (10.5%; see Virginia Trimble 1996, *European Astronomical Society Newsletter*, 13) and, more important, there has been a steady trend towards the training and recruiting of women in recent years.

There are several reasons that the astronomers cited to explain why they chose this discipline, but one stands out above the others: most Spanish astronomers chose their profession because of a personal sense of vocation, rather than for any other reason or because they were influenced by friends or family members. The high vocational element in the profession also became evident in the answers provided to the question as to whether they would choose the same career again, with 85% of respondents answering positively. Such a high vocational element is substantially higher than that found among other Spanish professional groups (see Margarita Latiesa 1992, in *Deserción Universitaria*, ed. Centro de Investigaciones Sociológicas, Madrid).

It is also noteworthy that the decision to become a professional astronomer was generally taken at a very early age; 40% of respondents made the decision at high school (at an age of about 16), a third of them decided while they were studying for their college degree, while only 27% took the decision when they graduated or later. In such a relatively novel discipline as astronomical research in Spain, this

result suggests that the publicity given to Astronomy has strongly attracted students to choose it as a profession.

Most of the astronomers were born in urban rather than rural environments – Barcelona and Madrid were the birthplaces of almost a third of all Spanish astronomers. Three other cities – Granada, Cadiz and Valencia – were also significantly represented, with similar numbers coming from each of the three. The remainder of the population is distributed, with barely significant percentages, among a number of other cities and towns. The vast majority (96%) of Spanish astronomers were born in Spain, with the remaining 4% largely being of Latin American origin.

Half of the Spanish astronomers are married at present. Although overall the group is a young one, only a third of the total remain single. The most relevant marital-status result, however, is the fact that 9% of Spanish astronomers live with partners in long-term relationships without being married. This contrasts sharply with the corresponding data available for the Spanish population as a whole (1%).

Since most Spanish astronomers are married, it will be worthwhile to look at some of the most relevant data concerning their spouses. As is the case for the astronomers themselves, half of the spouses were born in provincial capital cities, although more spouses than astronomers were born in villages or towns that are not provincial capitals.

Most of the astronomers' spouses have college degrees, and this seems to be closely linked to the level of occupation: 77% of the astronomers reported that their spouses currently have jobs, and the type of jobs they do generally require a college education. In general, the spouses had a similar educational and professional level to that of the astronomers. The married astronomers followed the general Spanish trend with regard to the number of children, with a dramatic fall in the birth rate in recent years. More than half the astronomers (55%) have no children, although this figure could also be related to other factors such as the relatively young average age of the respondents and the lack of professional stability and employment opportunities in this sector.

Data for 'passing on' the profession (i.e., to what extent the astronomers would be happy for their children to follow in their professional footsteps) showed that more than half the respondents (52%) were undecided on this matter. However, many of them (39%) said that they would like their children to grow up to be astronomers. This group was much larger than that claiming that they would not like their children to be astronomers (9%). The large number of undecided respondents is probably due to the simple fact that they have never given much thought to the question, rather than reflecting any real indifference.

Finally, Spanish astronomers spend most of their time – nine hours a day, on average – on astronomical work. The little free time they have is spent watching television, reading for pleasure and doing housework; the respondents generally said they devoted about an hour a day to each of these three activities.

3. Education and College Degree Study Programs

Most Spanish astronomers (9 out of 10) majored in Physics at college, with 50% of graduates having studied at the universities of Madrid or Barcelona. Most of the remainder of the graduates studied at Granada, Valencia, Zaragoza or La Laguna – hardly surprising, given that these same cities are where astronomical research institutions have sprung up in recent decades.

80% of the respondents with college degrees graduated within the scheduled period (i.e., after five years of study). This unusually high result suggests that those who went on to become professional astronomers made a considerable effort to be responsible and hardworking while studying for their college degrees. The college grades obtained by the astronomers bear out this hypothesis, indicating a high level of intellectual performance.

Success at job-seeking is a valid way of evaluating the study programs of college degree courses. The astronomers were asked to evaluate their college study program (on a scale from 1–10) according to following seven parameters: (i) relevance to the professional environment, (ii) subjects covered, (iii) relevance to professional requirements, (iv) length of the degree course, (v) nature of study program (vi) theoretical-practical ratio, and (vii) specific relevance of the study program to Astronomy.

The evaluation that the astronomers gave their college study programs was generally positive. 90% of gave scores of 5–10. The most frequent scores were 6 and 7 (given by six out of ten respondents) – in other words, most astronomers gave their college study programs a ‘pass’ grade. It is interesting to note that the evaluation of college study programs by graduates in general has improved markedly over the last few years. According to the universities studied, the highest score was given by graduates from Zaragoza, followed by those from La Laguna.

It is worth noting that when the evaluation of college study programs is compared with the grades obtained by the respondents, we find that the astronomers who obtained the best grades tended to rate their study programs most highly.

The main reform in college study programs called for by astronomers was for certain new subjects to be included. By a long way, the most frequently mentioned subject in this regard (16%) was Numerical Methods and Techniques. In second place was Computing, followed by Statistics. This result shows that astronomers feel that what is lacking from college study programs in Spain is a greater emphasis on practical subjects, since all the necessary theory seems to be adequately covered by the current system.

4. PhD Studies

The academic training of Spanish astronomers generally continues after graduation. Most of the respondents (67%) said they already had a doctorate, while 30% were working on their PhD thesis.

Three out of four astronomers began their postgraduate studies immediately after graduation. Most respondents completed their PhD thesis within four years, followed by those who took five years (23%) or three years (21%).

Not all astronomers studying for a PhD did so at the university where they graduated. Four out of ten did their doctorate elsewhere. In order to determine the extent of astronomers' involvement with their postgraduate universities, they were asked to state what proportion of their PhD studies were actually carried out within the university. In other words, whether the university was the nucleus for their PhD or merely where the thesis was presented and the degree formalized. The replies were wide-ranging, with most replies at the two extremes. The largest group of respondents (43%) said that they did 85–100% of their PhD studies within the university. This shows that there are strong links between university faculties and PhD studies for astronomers. However, a third of the respondents said that over 90% of their doctorate activities were based not within the university, but at other research centers. The national research institutions cited most frequently by this group of respondents were the IAC, where one in three of the respondents did their PhD, and the Andalusian Astrophysics Institute (one in five). However, 24% of postgraduate research was carried out at centers abroad – among the highest ratios of studies abroad of any Spanish professional group.

Finally, the respondents with doctorates were asked to evaluate their PhD studies on a scale between 1 (minimum) and 10 (maximum), grading six different aspects of their postgraduate studies: (i) the assistance given by the thesis advisor, (ii) the quality of teaching during the preliminary doctoral courses, (iii) the usefulness of the comments made by the thesis assessment panel, (iii) theoretical and observational skills acquired, (iv) technical skills acquired, (v) general usefulness of the training received, and (vi) usefulness for subsequent job-seeking. With a couple of exceptions – e.g., the usefulness of the assessment panel's comments (54.2% gave scores of less than 5) and the relevance of the preliminary courses (51% gave scores of less than 5) – the Spanish astronomers generally gave their PhD studies a highly positive evaluation overall. The average score was 6.3, with a large number of respondents scoring between 7 and 9, showing that Spanish astronomers were largely satisfied with their PhD studies. This is perhaps further borne out by the fact that most of the astronomers with doctorates (70%) are still working in the area of research they focused on for their PhD thesis. Most of those who changed course (73%) only did so two years or more after finishing their PhD.

5. Training Abroad

Four out of ten Spanish astronomers have made foreign study trips lasting at least one full year, while six out of ten have received no training abroad. Considering that most of the respondents are currently in the early years of their careers, the percentage that have studied abroad is notably high, and far superior to that of

most other Spanish professional groups. It is also interesting to note that those who have studied abroad for a year or more have made more than one such trip, and some respondents even said they do so on a regular basis (31% have made two or more study trips abroad).

If we compare these foreign-study results with the year of graduation, we find that most of those who graduated between 1981 and 1985 have studied abroad, unlike those who graduated before or after this period. The most recent graduates are the ones with the least experience abroad, which is a somewhat surprising result, given the ever increasing number of programs designed to promote foreign study trips for students, professors and researchers alike. This result indicates that going abroad to study is a decision that is generally only taken once astronomers have finished their doctorates.

Whether or not respondents have studied abroad is closely linked to the grades they received in their college degrees. Graduates who obtained mediocre or average grades were less likely to have made such trips than those with better grades. The duration of the trips abroad was 1–2 years for half the respondents. This is unusually long when compared with other professionals in Spain (J. Martín 1982, in *Sociología de las Profesiones en España*, ed. Centro de Estudios Sociológicos, Madrid).

The countries chosen by astronomers for their first foreign-study trip were the USA (26.3%), the UK (22.4%), Germany (15.8%), France (13.2%), Italy (5.3%), the Netherlands (5.2%), Canada (2.6%), Denmark (2.6%), Mexico (2.6%), Belgium (1.3%) and Sweden (1.3%). For second and third trips the most commonly preferred destinations were the USA (30% and 25%, respectively), Germany, (25% and 25%) and the UK (15% y 25%). Generally speaking, the more trips a respondent had made abroad, the shorter the average length of each trip. Thus, the average length of first trips was 32.4 months, with 21.2 and 17 months for second and third trips, respectively. The most frequently visited centers were the Harvard Smithsonian Center for Astrophysics (USA), the Max-Planck Institute (Germany) and the universities of Oxford (UK), Stanford (USA) and Sussex (UK).

It is worthy of note that in 91% of cases the respondents published a scientific paper in collaboration with their colleagues abroad as a result of their foreign research. The intellectual involvement of Spanish astronomers with their foreign counterparts therefore seems to be intense, with the study trips being devoted to active research and not only for the purposes of study visits or the acquisition of skills. Publishing research papers in collaboration with colleagues from centers abroad depended largely on the length of the trip. Most publications resulted from trips made once the Spanish astronomers had completed their doctorates. Indeed most postdoctoral trips resulted in joint publications. However, predoctoral trips were less productive in terms of the number of resulting joint publications.

Finally, we should stress the very positive evaluation that Spanish astronomers give to the usefulness of their trips abroad. However this usefulness was limited to the acquisition of knowledge and skills, since few respondents considered these

trips to be relevant to finding a job, particularly when it comes to applying to join a university faculty or research institute.

6. Job Prospects and Professional Activities

Once their education and training is completed, all professionals hope to find a job. Spanish astronomers are generally very successful at this – or at least they have been to date.

Most Spanish astronomers say that they found paid work (i.e., research grants, short-term contracts or permanent positions) a relatively short time after graduating from college. Seven out of ten respondents took less than a year to find a job, 15% took one year, and 8% took two years. Those who graduated between 1970 and 1975 found jobs the most quickly, with nine out of ten accepting job offers within a year of graduating. In contrast, those who took two years or more to find work tended to be the most recent graduates – i.e., receiving their degrees after 1991.

Almost all active Spanish astronomers (93%) work in universities or other public-sector research institutions, with virtually a 50–50 split between the two types of center. However, only around half the respondents held permanent positions (university faculty member or staff researcher). The permanence of positions was somewhat higher at universities than at other centers. Non-permanent positions at universities are largely those of assistant professor (14%) and postdoctoral research fellow (18%), whereas the proportion of postdoctoral research fellows at non-university centers – where there are no teaching responsibilities – was, as expected, much greater.

Most of the respondents (six out of ten) have been professional astronomers for less than ten years. Of these, 35% have been working in the sector for five years or less. 25% of the total have been professional astronomers for 6–10 years. However, a significant proportion (20%) of Spanish astronomers have been working in the field for 16 years or more. Indeed, half of these have more than 20 years' experience.

7. Astronomy as a Discipline

The prestige of a profession is directly equated with its general desirability – in other words, the more people want to take up a certain profession, the greater the social status of that profession. In this sense, the highest proportion of astronomers (38%) believe that the prestige of Astronomy is little or none. They are followed by those who think it is adequate (31%). This symmetry disappears, however, if we examine the extremes of the range of replies. While 25% of astronomers consider that the discipline enjoys a lot or rather a lot of social status, very few felt that it enjoyed none at all.

When it came to the level of quality or status that each astronomer felt he or she had compared with other Spanish astronomers, most respondents were able to state their position within the Spanish scientific community. The largest group of astronomers (34%) placed themselves at a roughly intermediate level, followed by those who ranked themselves below this level (26%). 60% of astronomers therefore believed themselves to be at intermediate level or lower within their profession. Only 15% of respondents included themselves among the top 20% of Spanish astronomers, with 8% believing that they were at the very top of their profession. In general, therefore, the self-classification of the astronomers roughly reflected the true state of affairs.

It is interesting to note the correlation between these self-evaluations and study trips abroad. Three times as many astronomers with experience abroad ranked themselves as being above average level as did those with no such experience. Twice as many of the respondents who ranked themselves below the average level have made no foreign trips as those have done so. This result once again shows – albeit indirectly – the importance that the astronomers themselves place on making trips abroad. When asked to compare the status of Astronomy in Spain with that of other countries, most astronomers believe Spanish astronomy to be on a par with the rest of Europe. Indeed, those who ranked Spain on a similar level were the majority for all criteria used: how well-run workplaces are (52.2%), efficient use of resources (62.7%), academic training and experience of center managers (57.5%), collaboration between colleagues from the same center (55.1%), support from colleagues from other centers (53%), quality of facilities (46.1%), productivity of staff at centers (65.9%), and average level of professionals in the sector (71.6%). However, in sharp contrast, in criteria such as financial resources available and the interest shown by Spanish authorities in Astronomy, most respondents felt that the Spain lags behind the rest of Europe.

Finally, we should highlight the fact that the evaluation of the managers of Spanish centers was one of the most negative values. Although the majority (57.5%) considered them to be as well prepared as managers of other European centers, very few (0.6%) felt that they were better prepared than the European average, while 41.9% believed them to be less well prepared. It is worth noting that gender was a significant factor in this result: all the respondents who thought that Spanish managers were better than the European average were women, and most of the female respondents felt that Spanish managers were on a par with the rest of Europe. Foreign trips also played a role in the responses. Those with experience abroad generally felt the level to be similar to that of other countries, whereas most of the astronomers who have never worked abroad felt Spanish managers to be inferior to their European counterparts. This clearly indicates that Astronomy as practiced in other countries is idealized by those with no first-hand experience of the real situation abroad.

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