Head count: statistics about women in astronomy

Where are the women astronomers? Catherine Cesarsky and Helen Walker take a first look at the numbers across the world and find considerable variation.

One of the aims of the International Year of Astronomy (IYA2009) Cornerstone Project "She is an Astronomer" was to get statistics about female astronomers. This has proved difficult because there are few statistics overall, and remarkably few gathered in a consistent fashion! The challenge was to find the numbers, and then to compare them, so this is a study in the making. In some countries the number of women in astronomy is changing very rapidly, so comparing one place with another can be difficult if the data are taken a few years apart. The International Astronomical Union (IAU) is an international organization with participation from 68 countries, so it is a good set of data to use as a basis for comparison with figures from individual countries.

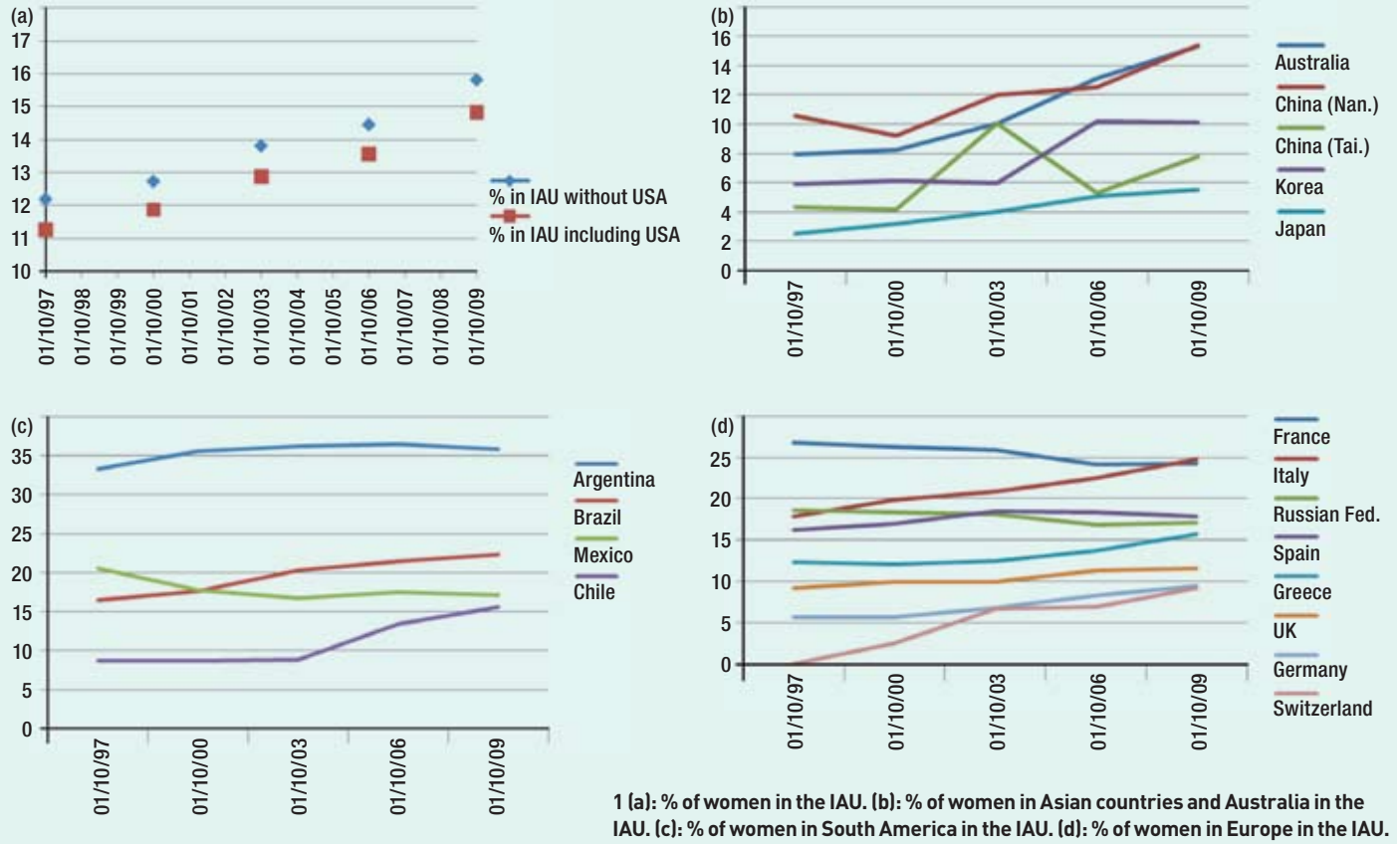
First let us decide what we regard as an "astronomer", since even this varies from country to country. Let us take the definition that a person is an astronomer once they have completed their PhD and they join the "population" of astronomers at that point. In many countries, to become a member of the IAU the person must have proven themselves, so it is usually the top levels of the population of astronomers that is given membership (whatever "proven" and "top levels" mean). If women have difficulties with recognition, retention and promotion, they will be a higher percentage of the population of astronomers than of the IAU.

IAU statistics

Some numbers are easy to get, because there was a General Assembly of the IAU in Rio de Janeiro in August 2009. The local organizing committee (thanks to Norma Tavares) counted 667 women among the 2109 people attending the IAU. This puts women at 31.6% of the people attending the IAU. We know that very few sessions had 31.6% of their talks given by women and only one of the ten plenary reviews and invited discourses was given by a woman (10%). Every three years the IAU has new members elected, and in 2009 the number exceeded 10 000 members. The number of women is increasing – in 2003 it was 12.1%, in 2006 it rose to 12.9%, and it now stands at 13.6%, an increase of 0.7% per triennium. So the percentage of invited speakers at the IAU roughly reflects the percentage of female members in the IAU. Table 1 shows the percentage of female members of the IAU per country, for those countries with more than around 40 members in 2009. Argentina has the highest percentage of women by far, whereas the UK and USA have fairly low percentages. Only seven countries have more than 20% female members in the IAU.

The percentage of women in the IAU has been tracked for more than a decade, and these figures, from IAU bulletins (1998 and 2001), and the IAU Women in Astronomy Working Group (http://astronomy.swin.edu.au/IAU-WG)

PERCENTAGES OF WOMEN IN THE IAU, BY COUNTRY



1 (a): % of women in the IAU. (b): % of women in Asian countries and Australia in the IAU. (c): % of women in South America in the IAU. (d): % of women in Europe in the IAU.

are shown in table 2. Figure 1a shows how the percentage has changed from triennium to triennium, with and without the USA (since they have such a large number of astronomers in the IAU). They are 22% of the women in the IAU, and this percentage has remained fairly constant in the period considered, from 1997 to 2009. The percentages in figure 1a are higher than those quoted in the preceding paragraph, because all the countries are included in the first percentages, i.e. the percentage of women in the IAU (in 2009) from all countries is 13.6%, as compared to 15.8% for those countries with more than 40 members, showing there are many small contributors and they have a very high percentage of men.

The IAU Women in Astronomy Working Group (WIA WG) put the 2003 version of table 1 (arranged by country) on their website and in 2004/2005 invited people to send in information about the situation in their country. Six years later only three countries had attempted the questionnaire (http://astronomy.swin.edu.au/IAU-WG); there are errors and holes, so maybe the way the questions were phrased was too complicated. But it is a complicated problem, so let us consider more simply the percentage of women in the IAU compared to the percentage of female astronomers in the country – these are not necessarily the same. We need to be careful because the situation is changing rapidly in some places. For example, in Mexico the current percentage of women in the IAU is 17.5%, whereas the percentage in the population (according to the WIA WG survey) is 20%, but that was in 2004/5 and the percentage in the IAU at that time was nearer 20% (see figure 1c)! Denmark has 10% in the IAU and 10% in the population, a number which has remained fairly constant, although since the 2004/5 survey showed only one woman with a permanent post, the definition of "top level" may have a more generous interpretation than in some other countries. Australia shows a figure of 15% female membership in the IAU for 2009, compared to 10% in the population (according to the survey); this is surprising at first glance but it may be an effect of a rapidly changing situation, since in earlier years the IAU membership was much nearer 10% (see figure 1b).

Table 1: % of women, and total members, in IAU, 2009

country	no. of members	% of total in IAU	% of women members from country
Argentina	134	1.3	35.8
Ukraine	188	1.9	27.1
Italy	568	5.6	24.7
Bulgaria	57	0.6	24.6
France	700	6.9	24.3
Portugal	43	0.4	23.3
Brazil	172	1.7	22.7
Hungary	48	0.5	20.8
Ireland	44	0.4	20.5
Austria	49	0.5	18.4
Spain	303	3.0	17.8
Mexico	111	1.1	17.1
Russian Fed.	368	3.6	17.1
Finland	67	0.7	16.4
Greece	108	1.1	15.7
Chile	90	0.9	15.6
Belgium	117	1.2	15.4
China (Nanjing)	409	4.0	15.4
Australia	262	2.6	15.3
South Africa	71	0.7	14.1
Sweden	111	1.1	13.5
Poland	149	1.5	13.4
Canada	245	2.4	12.2
USA	2594	25.5	12.1
Czech Rep.	92	0.9	12.0
UK	524	5.2	11.6
Netherlands	208	2.1	11.5
Egypt	56	0.6	10.7
Korea	109	1.1	10.1
Denmark	63	0.6	9.5
Germany	532	5.2	9.4
Switzerland	76	0.8	9.2
Israel	75	0.7	8.0
China (Taipei)	51	0.5	7.8
India	222	2.2	7.7
Japan	598	5.9	5.5

From http://www.iau.org/administration/membership/individual/distribution

Asia

According to the IAU membership in 2009, 5.5% of Japanese members were women (33 women). Yuko Motizuki sent more up-to-date statistics showing that the total population of women in astronomy, including postdoctoral researchers, is 12%, since there are now 200 female members in the Astronomical Society of Japan. This number has risen from zero in the early 1960s, with a steep increase in the last decade, so this is a situation which is changing rapidly. The large changes in percentages for China (Taipei) in figure 1b reflect the problems of small numbers, since Taipei had 30 members in the IAU in 2003, so one woman more or less made a big difference. The other Asian country to supply information is China (see table 3), which now in 2009 has 15.4% female membership in the IAU, significantly higher than the figure in 2006 (12.4%). NAOC in table 3 stands for National Astronomical Observatories, Chinese Academy of Science.

Here we do see selection effects with the comparison between populations of astronomers and the percentage in the IAU. A higher percentage of women are on contracts in the NAOC than have permanent positions, showing women have the more exposed jobs. Yanchun Liang reports that women in China are found at every level, but the ratio is lower at the highest levels, for example there are 7 women among the 70 professors (10%) in the NAOC and currently none of the five vice-directors is female. However, the Director of the Nanjing Institute of Astronomical Optics and Technology (NIAOT) is female (Prof. Xiaoqun Cui, who is very active in meetings) and the Director of the Urumqi Observatory of NAOC-CAS is female (Prof. Na Wang). The most famous female astronomer in China (Prof. Shuhua Ye) is a CAS Academician. The picture is improving rapidly.

Table 2: % of women in IAU, 1997–2009

country	01/10/1997	01/10/2000	01/10/2003	01/10/2006	01/10/2009
Argentina	33.3	35.6	36.2	36.4	35.8
Ukraine	16.8	17.9	19.4	24.3	27.1
Italy	17.8	19.9	20.9	22.5	24.7
Bulgaria	30.0	32.6	28.6	21.3	24.6
France	26.8	26.3	25.9	24.1	24.3
Portugal	11.8	12.5	22.9	20.5	23.3
Brazil	16.5	17.6	20.3	21.5	22.3
Hungary	14.6	17.8	20.5	21.3	20.8
Ireland	12.1	17.6	14.3	14.6	20.5
Austria	6.5	9.4	11.4	11.4	18.4
Spain	16.2	17.0	18.5	18.3	17.8
Mexico	20.5	17.8	16.7	17.5	17.1
Russian Fed.	18.6	18.3	18.1	16.8	17.1
Finland	8.1	14.0	13.2	14.5	16.4
Greece	12.4	12.1	12.5	13.7	15.7
Chile	8.7	8.7	8.8	13.4	15.6
Belgium	12.5	11.9	12.4	13.3	15.4
China (Nanjing)	10.6	9.2	12.0	12.5	15.4
Australia	7.9	8.2	10.0	13.1	15.3
South Africa	4.3	7.3	10.7	11.5	14.1
Sweden	4.2	12.0	13.2	13.2	13.5
Poland	12.8	10.7	10.3	11.4	13.4
Canada	6.0	6.5	9.7	10.4	12.2
USA	8.9	9.7	10.5	11.2	12.1
Czech Rep.	7.0	8.0	8.0	11.5	12.0
UK	9.2	10.0	10.0	11.3	11.6
Netherlands	6.0	9.9	9.0	9.1	11.5
Egypt	7.7	7.7	10.5	10.7	10.7
Korea	5.9	6.1	6.0	10.2	10.1
Denmark	7.7	7.7	12.3	9.8	9.5
Germany	5.7	5.7	6.8	8.3	9.4
Switzerland	0.0	2.5	6.7	6.9	9.2
Israel	2.2	2.1	4.8	4.6	8.0
China (Taipei)	4.3	4.2	10.0	5.3	7.8
India	4.0	5.1	5.9	7.0	7.7
Japan	2.5	3.2	4.0	5.1	5.5

Latin America

The women seem to be doing well in Latin America. In Argentina, 36.7% of their IAU members are female (in 2009), and this compares well with the percentage of the 175 tenured researchers and professors (34.9%). The male–female ratio of graduate students and young researchers is 50–50. At the most senior level, with the distinguished and emeritus researchers, 2 out of 14 are female (14.2%). Gloria Dubner (recently appointed a Director at Instituto de Astronomía y Física del Espacio [IAFE] in Buenos Aires) provided these figures. Marta Rovira is the President of the Argentina National Council of Scientific and Technological Research (CONICET), and she is now a vice president of the IAU. There has been an important advance in CONICET recently: the maximum age limit for access to fellowships and permanent positions has been relaxed for women whose careers were put on hold because of maternity (while everything, of course, is based on the quality of the applicants).

Venezuela has a small number of members in the IAU (19 members in 2009) but they are 26% female, and although the numbers are small, this shows a similar high percentage for researchers and professors with 15 men and 7 women (32%), and doctorate and masters students (9 men and 6 women giving 40% female). In Mexico, in 2006 it was 17.5% women in the IAU, which compares with 20% of tenured researchers and 20% non-tenured posts (short-term contracts and post-docs) being female. There is a much higher percentage of women among the students (doctorate and masters) of 39%, showing the field is expanding. When everyone is included, the percentage of women in astronomy in Mexico is 28.3%. Numbers were difficult to obtain for Brazil, but the IAU members are 22.3% female in 2009, and the membership of the Sociedade Astronomica Brasileira (with 479 members) is 25% female.

Europe

The European Commission has been active in the last 10 years with an enormous effort to bring women into scientific careers, in a similar manner to what is happening in the USA. There was the Helsinki conference in 1998, the European Union (EU) action plan in 1999 "Women in Sciences", and the action plan in 2001 "Science & Society" (http://ec.europa.eu/research/science-society/index.cfm). The Helsinki group has remained in place to monitor progress and build synergies. In 2006 around 40% of scientists with a PhD in EU programmes were female (the survey covered science, mathematics and computing). In 2005, a set of rules for hiring was created, paying a lot of attention to flexible working conditions, childcare support, and gender-balanced representation at all levels. Special groups have been set up, such as Women in Industrial Research (WIR) and European Platform of Women Scientists (EPWS). Strangely, when compared to European politics (and women are well-represented in the European parliament) it appears that in countries where there are a lot of female astronomers, there are few female politicians and vice versa.

The EU uses a number called the Gender Advantage, using scientists at levels from post-doc to the most senior levels, and table 4 shows how much more work is needed in Europe.

Gender Advantage = % men at top level relative to men at all levels, divided by % women at top level relative to women at all levels. If the Gender Advantage is >1, it shows women are not promoted as often as men.

The IAU membership of France is 24.3% female. For a long time, France had the highest percentage of women of all the large IAU countries. However, it may not stay in this favourable position: the percentage has been slightly decreasing over time, and other countries are catching up, particularly Italy.

Danielle Alloin reported figures for France, for "Sciences of the Universe", which comprises astronomy and geophysics. For the past 20 years the situation has been stable, with 26% of the astronomers/geophysicists at CNRS being female. However, at the most senior levels the number is 21% female. The Gender Advantage

Table 3: Statistics of women in astronomy in China

organization	women/total	%
members of Chinese Astronomical Society	422/2131	19.8
members of Beijing Astronomical Society for NAOC	95/312	30.4
NAOC staff with permanent position	84/300	28.0
NAOC staff with contract	60/155	38.7
Peking Uni., Dept of Astron. + Kalvi Inst. for Astron. & Astrophys.	3/15	20.0
Beijing Normal University, Dept of Astronomy	8/40	20.0
Nanjing University, Dept of Astronomy	2/20	10.0

Table 4: European gender advantage ratios

gender adv.	country
1.0–1.2	Belgium, Italy, Sweden
1.3–1.5	France
1.6–1.8	Denmark, Norway
1.9–2.1	Austria, Netherlands, Finland, Germany, UK
2.4	Switzerland

Table 5: % of female staff at INAF

scientific staff	2002	2005	2007	2007 (univ.)
senior	10.9	11.3	19.1	~4
associate	15.7	19.3	17.5	~6
researcher	20.6	28.2	32.6	~22

Table 6: % of women in astronomy in USA

	1992 (STScI)	1999 (STScI)	1999 (CSWA)	2003 (CSWA)
post-docs	17%	20%	17%	22%
assistant prof.	17%	17%	15%	20%
associate prof.	10%	15%	18%	20%
full professor	5%	8%	5%	9%

at the mid and junior levels is 1.5. Only 10% of laboratory heads are female, but women do make up 24% of the hiring/evaluation committees. In French universities 16% of the astronomy/geophysics professors are female and women make up 38% of the mid-level and junior grades. The recognition of women's work in France is low, with none of the six CNRS astronomy/geophysics gold medals awarded to women (in 50 years), 14% of the silver medals (in six years) and 25% of the bronze medals (in six years). In the French Academy of Sciences, only 10% of the astronomy/geophysics members, and only 16% of the recipients of the Academy prizes in from 2003 and 2006, are female.

Spain has 17.8% female membership in the IAU, and although statistics were hard to find, Spain's figures in "Sciences of the Universe", including biology, give 25% female. The situation has been changing in Italy, which now has 24.7% female membership in the IAU. In 2002 the percentage of women in astronomy was 18.5%, in 2005 it was 24%, and in 2007 it was 27%. The Istituto Nazionale di Astrofisica (INAF), according to Ginevra Trincheri, has 2 women out of 5 members on the executive board (40%), 5 women out of 12 members of the scientific council (42%), and 3 women out of 19 institute directors (16%). The major problem is that 40% of the people on soft money are female. The percentages over the years (table 5) are difficult to compare because in 2005 there was a merger with CNR institutes and in 2007 there was a major "job requalification" where, for example, the number of women at the most senior level almost doubled (from 7 to 13), and the next level dropped from 31 to 28. The percentages for universities in 2007 refer only to astrophysical science.

The Russian Federation has about 17.1% female membership of the IAU, but no female astronomers in the National Academy of Science. The percentage of women in the community is about 30%. Greece (from Mary Kontizas) has 15.7% women in the IAU, but only 12.9% of the permanent staff are female, with no female full professors. This shows that (as with Australia) when the numbers are low (12 women were included in the statistics), a significant number of women on fixed-term contracts are recognized as senior astronomers.

The situation in the UK, which has 11.6% female membership in the IAU, is bad. The sciences of the universe figures show the percentage of female astronomers drops from 22% at the junior levels (starting post-doc) to 12% at mid-level, 10% of lecturers and 4% of professors. No laboratory heads are female. These numbers are very similar to the figures produced by the Royal Astronomical Society (Walker 2009 *A&G* **50** 3.25). Francesca Primas looked at ESO Faculty members in 2005, and found that although 18.7% of the staff were female, only around 3.4% of the top-level staff were women, and around 16% of the mid-level. The Gender Advantage ranged from 6.4 to 1.2. These numbers are not good, and efforts are being made to improve them.

USA

The American Astronomical Society Committee on the Status of Women in Astronomy (CSWA) has been tracking the ratio of men and women in astronomy for more than a decade (http://www.grammai.org/astrowomen/stats). In 2009 the USA had 12.1% of its IAU membership as female, which is surprisingly low, and in 2003, when a recent survey was made, it was 10.5%. In the June 2004 issue of their magazine *Status*, Jennifer Hoffman and Meg Urry state that around 9% of the professors are female, 20% of the associate professors and around 20% of the post-docs. The report showed that while numbers (and percentages) were increasing, the women were progressing to senior ranks at a slower pace than men, which is reflected by the "recognition" as an IAU member being so low. Their statistics over the decade showed a very slow rise (table 6), based on the statistics shown in *Status*.

Conclusion

Gathering statistics over many years is important. As can be seen from some of the numbers, a snapshot does not give enough information. No country has an equal percentage of women in the IAU as it does in its population of astronomers (although Greece may come close), so we could say the Gender Advantage is always in favour of the men. Statistics help us as scientists to understand the situation, and they need to be gathered regularly to monitor the trends. The very slow increase in the percentage of women at senior levels and in the IAU shows that active encouragement and monitoring of "equal opportunity" is needed. One such example is the resolution approved recently by the IAU (http://www.sheisanastronomer.org/index.php/press/iau-resolution/130-iau-resolution), urging astronomers to support and encourage female astronomers in their community, break down barriers and ensure that men and women are given equal opportunities. ●

Catherine Cesarsky, CEA Saclay, France.
Helen Walker, STFC Rutherford Appleton Laboratory, UK.