A Study of the Leaky Pipeline Phenomenon for Women in Physics Past the Postdoctoral Level, and a Critique of the AIP 2005 report on Women in Physics and Astronomy

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The author has recently examined the departmental web pages of the ‘top 50’ physics research universities, as ranked by the National Research Council (NRC). Most of the departmental web pages contained biographical data (i.e., year and institute of PhD, etc) of their faculty members. Of the approximately 1750 faculty members at the ‘top 50’ universities that were examined, approximately 100 were female, and around 1425 had available biographical data.

Based on this data, the predicted fractions of female faculty members at the ‘top 50’ universities are 0.129, 0.104, and 0.052 at the assistant, associate, and full faculty levels, respectively.

The observed fractions are 0.107, 0.109, 0.043, respectively.

The overall observed number of women faculty is about 15% less than expected, and the depletion is statistically significant.

Unfortunately, the study finds that the "leaky pipeline" is found to be alive and well for women in academic physics above the postdoctoral level, at all stages of the faculty career ladder. This result is stark contrast with the conclusion of the American Institute of Physics (AIP) 2005 report on Women in Physics and Astronomy; the AIP report concludes that women are actually more likely to be hired at the faculty level than their male peers.

In this paper, we will discuss the two key flaws in the AIP analysis that led to their faulty conclusion, then describe in detail the analysis performed by the author that corrects these flaws to get an accurate estimate of the ‘leakiness’ of the academic pipeline for women physicists past the postdoctoral level.

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Many studies have documented the "leaky pipeline" phenomenon for women in the academic hard sciences (see, for instance, references [1] and [2]). A recent report that caught the author’s interest was the American Institute of Physics 2005 report on Women in Physics and Astronomy [3]; this report is rather unique in that it concludes that the leaky pipeline phenomenon does not exist past the doctoral level. In fact, the report concludes that the observed fraction of female faculty members is actually higher than expected.

However, careful examination of the report reveals that the analysis that led to this conclusion was flawed; first, the report lumps faculty members at PhD granting universities together with faculty members at teaching colleges. At teaching colleges, the faculty are more likely to be female, yet much less likely to teach physics to physicists. Thus the AIP report gives little indication of the fraction of women at the faculty level at the universities in America that produce the majority of physics doctoral degrees. Second, the analysis performed for the report did not properly take into account the differing age distributions of male and female faculty members (the report used instead the combined age distribution of both males and females, which of course is completely dominated by the males, since they constitute over 90% of the sample). This flaw has a significant effect on the predicted fraction of female faculty (the predicted fraction goes up when the analysis is performed taking the differing age distributions properly into account).

To perform a detailed analysis that corrects both of these problems, the author began with an examination of the departmental web pages of the ‘top 50’ physics universities, as ranked by the National Research Council (NRC) [4]. These universities produce the majority of BSc’s and PhD’s in America. Most of the departmental web pages contained biographical data (ie; year and institute of PhD, etc) of their faculty members. In this study astronomers were excluded because they have a different fraction of women participating in the field than other areas of physics. Adjunct, visiting, research, and affiliated professors were also excluded. The study also excluded faculty members who had received their degree from a non-American institution.

Of 1743 faculty members at the ‘top 50’ universities that were ultimately examined, 101 were female, and a total of 1425 had available biographical data. To obtain the predicted fraction of female professors from this data, we begin with the number of PhD’s granted each year to both males and females in America [5] (see Figure 1). We then work out the probability that a male in a particular PhD graduating class will be a professor at one of the ‘top 50’ universities in 2005; we do this by dividing the year-of-PhD distribution of male professors with the distribution of the number of male PhD’s graduating each year. If the leaky pipeline does not exist, the female ‘be-a-professor-in-2005’ probability will be exactly the same as for the males in each graduating class.

In this manner, we obtain a prediction of the number of female professors we expect to see at the ‘top 50’ universities in 2005.

Figure 2 shows the actual probability versus year-of-PhD that a female physicist will be a faculty member at one of the ‘top 50’ universities in 2005. The histogram indicates the predicted distribution, obtained assuming that females have the same relative probability of being a professor in 2005 as males from the same graduating class. The actual distribution is systematically lower than the predicted distribution.

Figure 3 shows the year-of-PhD distributions of female assistant, associate, and full professors. The histograms again indicate the predicted distribution, obtained assuming that females and males from the same graduating class have the same relative probability of being a professor in 2005. Figure 4 shows the year-of-PhD distributions of all female professors. Every point in the actual distribution is lower than the predicted.

Based on this data, the predicted fractions of female faculty members at the ‘top 50’ universities are 0.129, 0.104, and 0.052 at the assistant, associate, and full faculty levels, respectively. The observed fractions are 0.107, 0.109, 0.043, respectively.

It is interesting to note that the fraction of female associate professors is actually higher than predicted. However, Figure 4 shows an overall depletion of professors for years-of-PhD 1984 and onwards. It thus appears that the excess may well be due to women languishing longer at the associate professorship level than their male peers (ie; the excess probably reflects a ‘clog’ in the academic pipeline at the associate professor level).

The overall observed number of women faculty is about 15% less than expected, and the depletion is statistically significant at a level of 1.7 standard deviations.
I. CONCLUSION

This study finds the leaky pipeline phenomenon exists for women past the postdoctoral level at a level of around 15%. Some may wonder if this is a big enough leak to be a problem. In human terms, however, a 15% leak means that we are missing one out of six women who, in an equitable society, would have been physics faculty members. There are so few women at the faculty level in physics, that losing one out of every six is in fact a serious concern. Especially if we think about what it must take to convince someone to leave a field when, by that point in their careers, they have committed their working lives to physics, and have gone through at least a decade of higher education to get there.

Not all women who become physics faculty members have experienced gender discrimination during their careers. However, many do, and it is unfortunate that the combination of gender discrimination and a ‘glass ceiling’ phenomenon in the field is preventing more women from becoming physics faculty members.

The author is an experimental particle physicist, and has observed over the years the serious obstacles that her female colleagues have had to face as they try to advance in the field. There is indeed widespread discrimination against many women in physics, and women with children seem to be particularly vulnerable; for instance, the author is personally acquainted with three female physicists who, after having children, had to work for free or a substantially reduced rate compared to their peers, simply to remain in the field. The only other choice available to them was to simply drop out of the academic pipeline all together. Conversely, the author knows literally hundreds of male physicists past the doctoral level, but is not aware of a single male who has had their pay cut off or substantially reduced for any reason.

Given some of the chilling incidents of discrimination against females that the author has personally observed to transpire within physics academia, it is somewhat surprising that the relative leak of females in the academic pipeline past the postdoctoral level is only 15%. A male colleague once mentioned to the author that he felt very sorry for many of his female colleagues in physics because he felt the message that they were persistently given was that ‘Yes! the good news is that you can succeed in physics as a female! (you just need to be prepared to chew your own leg off to do so)’.

Tragically, some of the women who have ultimately made it to the faculty level likely did have to ‘chew their own leg off’ to get there. Even more tragically, their stories are almost never told because they (quite rightly) fear repercussions to their career if they speak out. The chilly climate that removes one out of every six female potential physics faculty members needs to be changed if participation of women in physics is to be increased at all levels.
FIG. 1: Number of physics PhD graduates produced in America each year.

[1] Berryman, S.E. (1983) *Who Will Do Science? Minority and Female Attainment of Science and Mathematics Degrees. Trends and Causes.* New York: Rockefeller Foundation.

[2] National Science Foundation (NSF) (2004) *Women, Minorities, and Persons with Disabilities in Science and Engineering,* NSF04-317. [http://www.nsf.gov/statistics/wmpd](http://www.nsf.gov/statistics/wmpd)

[3] American Institute of Physics 2005 report *Women in Physics and Astronomy,* [http://www.aip.org/statistics/trends/reports/women05.pdf](http://www.aip.org/statistics/trends/reports/women05.pdf)

[4] National Research Council 1995 report *Research-Doctorate Programs in the United States: Continuity and Change,* [http://www.nap.edu/readingroom/books/researchdoc](http://www.nap.edu/readingroom/books/researchdoc)

[5] [http://www.aip.org/statistics](http://www.aip.org/statistics)
FIG. 2: Probability that a female who graduated in a particular year will be a physics professor in 2005 at one of the ‘top 50’ American physics universities. Points are the actual distribution, and the histogram indicates the predicted distribution, obtained assuming that females and males from the same graduating class have the same relative probability of being a professor in 2005.
FIG. 3: Year-of-PhD of female professors in 2005 (points), for assistant, associate and full professors. The histograms indicate the predicted year-of-PhD distributions, obtained assuming that females and males from the same graduating class have the same relative probability of being a professor in 2005.
FIG. 4: Year-of-PhD of all female professors in 2005 (points). The histogram indicates the predicted year-of-PhD distribution, obtained assuming that females and males from the same graduating class have the same relative probability of being a professor in 2005.