Doing Physics, Performing Gender?

A sociolinguistic approach towards understanding the persistent gender bias in physics

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Abstract: The persistent lack of women in the community of physics, from undergraduates through professionals, may reflect a systematic bias that preferentially favors males over females in physics. If this is true, such a bias may be traceable by the discourse of physics, starting with the way professional male and female physicists represent themselves at conferences. Portions of talks by eight prominent physicists, five female and three male, were analyzed for discourse markers that can be understood as orienting the speakers to stances of power or subordination, which have been associated with traditional cultural portrayals of heteronormal gender in western societies. In this sample, it was found that the male physicists preferentially orient to power through the traditional discourse markers described in the literature, however, new hybrid speech patterns are evident in the discourse of the younger women which seem to be contiguous with the discourse of "nerd" adolescents described by Bucholtz (1996, 1999).

1. Introduction and historic background:

The exclusion of women from the study and practice of physics is intertwined with the history of western civilization (Wertheim, 1995). Physicist and historian Margaret Wertheim traces this history from the public stoning of Hypatia, female mathematician of Ancient Greece in 415 C.E., to the establishment of the first official educational systems in the male-only cathedrals of Western Europe by Charlemagne at the end of the eighth century, to the exclusion of women from institutions of higher learning in the establishment of the first universities of Western Europe in the thirteenth century. Exclusion of women from physics was the official policy of institutions of higher learning, even as late as the middle of the twentieth century. For example, women could not use the cyclotron at Princeton University because the chairman of the Physics Department had a rule: no women were allowed in the building (Wertheim, 1995). While active discrimination of women was officially outlawed in the 1970's in the United States, it was not until 1992 that Harvard University granted tenure to a female physics professor for the first time (ibid). The difficulties faced by women in physics continue to be discussed in the press.

In spite of gains for women in the workforce in virtually all other areas since the 1960's, women are still outnumbered by men in physics by more than 5:1 in most institutions. A study published in 2000 by the American Institute of Physics (AIP) revealed that, although the number of women earning degrees in physics has improved during the course of the twentieth century, the percentages of women earning bachelor's degrees in physics (18.5%) and engineering (17.9%) remains significantly below the other sciences of biology (52.9%), chemistry (43.1%), and geological and atmospheric sciences (33.3%) (Ivie and Stowe, 2000). According to other studies, women in the U.S. still earn less than one-eighth of all the Ph.D.s in physics, well below the rates in other countries in Europe, South America and Asia (Tobias, 2003).

The literature on women in physics and physics education is extensive, and contains many conflicting results and opinions. Numerous studies have addressed the issue of the under-representation of women in physics (Wertheim, 1996; Zuga, 1999; Fox-Keller, 2001, 2003; Tobias, 2003; Ivy and Stowe, 2005; Blickenstaff, 2005; Zohar, 2006). Studies of curriculum reform efforts show that both pedagogy and context are important to the success of female students in physics classes. Collaborative and interactive methods such as Peer Instruction (Mazur, 1995; Crouch and Mazur, 1999) are effective in raising the level of achievement of young college women in undergraduate physics, while content reform may have a positive effect when social and natural phenomena are substituted for the conventional military and competitive contexts of traditional texts (Gosling, 2004; Tobias and Birrer, 1999; van der Veen, 2007).

Karen Zuga (1999) and Barbara Whitten (2003) claim that teaching from the feminist standpoint of women's ways of knowing in physics and engineering is effective in attracting and retaining young women in physics, yet other studies claim that it is not content that turns girls off to physics, but the competitive atmosphere of the male-dominated classroom (Zohar and Sela, 2003). Government efforts aimed at improving physics education for young women are manifest in the initiatives for reform in physics teaching that have been promoted by the National Science Foundation in recent years (see http://www.nsf.gov/pubs/2004/nsf04608/nsf04608.htm, e.g.), yet there are conflicting reports about women's success and satisfaction once they earn Ph.D.s. The leaky pipeline for women in physics (Tobias, 2003), was claimed no longer to exist in the most recent report by the American Institute of Physics (AIP) on women Ph.D.-level scientists in physics and astronomy (Ivie and Ray, 2005). At the same time, a study reported in the May, 2005 issue of *Physics Today* documents the dissatisfaction of women in physics from a broad range of ages and backgrounds (Towers, 2005).

After interviewing forty professional women in physics, Sheila Tobias, anthropologist with the Research Corporation of Tucson, Arizona, reported that the problems of women in physics cluster around three main issues: the culture of physics, which they claim remains masculine and overly competitive, often discriminating against women; work-life issues which penalize people who have working partners and children; and the perception that women are still discounted and not taken seriously by professors, employers, and colleagues (Tobias, 2003). The ongoing attention to what is perceived as the persistent gender bias in physics and physics-related disciplines suggests that this problem may be a cultural phenomenon that has a long history, and is not yielding to reform efforts that seem to have brought women into the work force in other professions.

One approach that may be useful in exposing the tenacity of the gender bias problem in physics might be to examine physics as a speech community from a sociolinguistic viewpoint, and see what clues to the persistent gender bias can be found by studying the discourse of professional physicists. Gumperz' definition of a speech community as "*any human aggregate characterized by regular and frequent interaction by means of a shared body of verbal signs, and set off from similar aggregates by significant differences in language usage*" (Gumperz, 1968. p.381) provides a starting point for our research. Besides the specialized vocabulary of physics and the language of mathematics which set physics apart as a speech community, distinct from the general public as well as other sciences, we ask: Are there secondary features of discourse and interaction which serve to maintain the cultural identity of physicist as male?

2. Gendered discourse and the construction of community identity in physics.

Physicist Evelyn Fox-Keller, in discussing the issues of sc1ience literacy for the twenty-first century writes,

> *What particular cultural norms and values has the language of gender carried into science, and how have these norms and values contributed to its shape and growth?* (Keller, 2001).

If we examine traditional, introductory high school and college physics courses, it may be that one way in which androcentricism in physics is transmitted to novice students is via introductory physics texts. Gosling (2004) studied the most widely used introductory physics texts, and found

that both in worked examples and in end-of-chapter problems, teachers and textbook authors routinely use male-oriented scenarios to illustrate principles in mechanics. How does this male orientation at the introductory level manifest in the attitudes of adult physicists later on? If there is a systematic bias in physics which preferentially favors males over females, is this manifest in hierarchical or hegemonious social behaviors of professional men and women in physics, which may be observed through language and social interactions?

3. Data and Analysis:

For the purposes of this analysis, I take the position that that gender is a socially constructed attribute, and that what might be called traditional (heteronormal) gender is interactionally established by speakers and listeners through lexicon, discourse markers, prosody, use of humor, and the use of symbols and graphics, which denote stances of greater or lesser power. Historically, more powerful stances indicate traditional, heteronormal, white Euro-American male gender, which is tacitly associated with success and competence in physics, and less powerful stances indicate traditional, heteronormal (white, Euro-American) female gender, which is tacitly associated with a lack of success or competence in physics. From this perspective, the hypothesis is that to be successful as professional physicists, females are obliged to adopt the discourse patterns of white, Euro-American males, as defined by pre-determined markers of power. If this hypothesis turns out to be false, perhaps other discourse patterns by which successful female physicists have negotiated their way into the male-dominated physics community will emerge from the data.

For this study I analyzed the talks of eight professional physicists that were recorded at prestigious invited conferences at the Kavli Institute for Theoretical Physics (KITP) at the University of California, Santa Barbara and the Center for Education and Research in Cosmology and Astrophysics (CERCA) at Case Western Reserve University, which are available on the public websites of these institutions. I studied five women and three men, ranging in age from under forty to over eighty at the time of the conferences. All are white, tenured professors in American universities. Six were born in the United States, and two in Europe, but both foreign born physicists speak fluent English, having been in the United States for more than thirty years. All are considered experts and innovators in their respective sub-fields, and two of the men are Nobel Laureates. Although the talks are available in the public domain, for the sake of this study I refer to the eight physicists by their initials only.

Women:

- F1: a soft condensed matter theorist; tenured professor, over 40.
- F2: high energy theorist; tenured professor, over 40.
- F3: string theorist; tenured professor, under 40.
- F4: complex systems theorist, geophysics and biophysics; tenured professor, over 40.
- F5: high energy particle physicist, experimentalist; tenured professor, over 40.

Men:

- M1: theorist, Nobel Laureate; tenured professor, over 70.
- M2: theorist, Nobel Laureate; tenured professor, over 80.
- M3: theorist, cosmology; tenured professor, over 60.

Six of the talks that were taken from the "Future of Physics" conference, held at the KITP in 2004. One talk (M3) was taken from the "Future of Cosmology" conference at CERCA in October, 2003. I was present at both conferences, although I did not record the talks myself, but used the recordings that were made by each institution and placed on the respective public websites by the organizers of each conference. The public lecture of M5 is the only talk for which I was not present but utilized the recorded talk exclusively, however I have heard this speaker in person on several other occasions.

3.1. Method of Analysis

Tables 1 through 3 indicate the discourse markers which I sought as I transcribed the recorded talks, and which I encoded as representing qualities of power, traditionally associated with heteronormal male gendered discourse, and subordination, traditionally associated with heteronormal female gendered discourse, as indicated in previous studies (Yates, 2001; Johnstone, 1993). After listening to these talks, I found a hybrid category emerged from the data, which falls between the extrema of power-orienting stances that have been culturally associated with gender in white, western society. These hybrid discourse markers which I have defined in Table 3 are: *coyote'd challenges and assertio*ns, *clever anthropomorphisms*, and *mild slapstick humor*, which appear only in the discourse of the female physicists in this study. After presenting the extrema of traditional discourse markers which are more apparent in the presentations of the male speakers, I will focus on these hybrid patterns found in the presentations of the female speakers. These speech patterns appear to be similar to the discourse of nerd girls which was

Table 1. Traditional gendered discourse markers from Yates (2001).

Less Powerful Stance Markers	Traditionally associated with female discourse	More Powerful Stance Markers	Traditionally associated with male discourse
Attenuated Assertions	Assertions on a topic that are prefaced with some form of distanced modality, e.g., "It might be…"	Strong Assertions	Assertions made without modalities, e.g., "It is true that," "I am sure that,"
Apologies	Retractions of position or statements employing apologetic language	Self promotion	Statements that stress the rightness or importance or social standing of the individual
Explicit Justifications	Statements that provide the justification or basis for opinions	Presuppositions	Statements that assume certain facts or opinions
Genuine Questions	Genuine open questions, seeking answers	Rhetorical Questions	Questions set up for an answer from the speaker himself
Personal Orientation	Presentation of statements and ideas from a personal position	Authoritative Orientation	Presentation of statements and ideas from a claimed, assumed, or asserted position of authority
Supports Others	Statements in support of others' ideas or opinions	Challenges Others	Statements that challenge others' ideas or opinions
		Humor/ Sarcasm	Jokes or statements used to belittle others, or minimize others' opinions
"female-normative" stories	Narratives involving community	"Male-normative" stories	Narratives involving heroism in overcoming obstacles

identified by Bucholtz (1996) among adolescents in Northern California. As I will discuss in Section 4, nerd girl discourse may provide a means for teachers to recognize and encourage adolescent girls to develop their interests in math and science-related fields.

Table 2. Conversation Analytic (CA) approach to gender indexing of discourse which relies solely on the direct references made by the speaker in the text of the discourse itself.

	Direct female gender references by speaker	Direct male gender references by speaker
	Statements in which the speaker calls attention to female gender for a reason, in which gender is relevant to the point.	Statements in which the speaker calls attention to male gender for a reason, in which gender is relevant to the point.

Table 3. Hybrid Discourse Markers

"traditional female / less powerful"	***Hybrid Discourse Markers***	*"traditional male / more powerful".*
attenuated assertions and apologies	**"Coyote'd" challenges and assertions that are neither apologetic, nor bluntly direct**	strong assertions and challenges of others
no humor or self-deprecating humor	**Mild slapstick humor, non-threatening gender jokes, laughing at self or others in a good natured way**	sarcasm, broad slapstick humor, making fun at others' expense, gender and racial jokes
"sweet" or "polite" talk ("Lakoff-like")	**Clever anthropomorphisms that are neither sexist nor overly "cute"**	sexist references to mechanical and electrical devices

3.2. Examples

3.2.1. Coyote'd challenges and assertions*:* In between attenuated assertions and apologies, which when used by a speaker call attention to his or her lower status, humble position, or the low self esteem culturally associated with women, and direct challenges and strong assertions in which speakers display the "head butting," that has been culturally associated with men, I find what I call "coyote'd challenges and assertions." I borrow the use of the noun "coyote" as a verb from a group of teachers in a wilderness program in Santa Barbara, who lead groups of students and parents in tracking expeditions to learn about animals in the wild. They use "coyote" as a verb, meaning to convince another person of a viewpoint that s/he may not initially agree to (such as getting children to cooperate) in a firm, yet non-threatening way. Like the way a coyote waits for an opportunity, then sneaks in without being noticed, this hybrid stance is not confrontational, but neither does it bear the slightest hint of apology or self-deprecation carried by an attenuated assertion. In several of the talks I transcribed, women made challenges to currently accepted theory that were quite radical, but did so in a "sideways" and less confrontational manner. I did not record any men who used this same type of hybrid discourse marker.

An example of the contrast between an attenuated assertion/apology, a coyote'd assertion, and a direct challenge is illustrated by the following three excerpts:

1) From F1: She uses a series of attenuations and apologies before she finally gets to her "challenge" in line 14, after which she immediately apologizes in line 15:

1. *And then, just beCAUSE I think that we've had hh' a long day,*
2. *I wanted to say something exTREmely controversial,*

3. *just SO y' wouldn't be bored.*
4. *And THAT..an', and again, you can sorta shoot me at dinner,*
5. *[..] and that is, this, this, uum,*
6. *I'm HAppy that Christina is here, t'speak, an' I'm I'm glad that I was-*
7. *an opportunity to ah, to ah, be a CHAIR*
8. *an' and soft condensed matter physics*
9. *I believe is one of the SUBfields where there ARE more WOmen, BUT ah,*
10. *I do-on't have the perCEPtion that ah, women are making a lot of progress in the FIELD.*
11. *{..} And in terms of the FUture, I think it's something tha-at IS part of the future of physics is wondering what the sociology is gonna be like*
12. *Now I don't wanna FOcus on this,*
13. *in, in this FIELD but I think that it's something that, at least in the t'h' time that I've BEEN here that no body has brought UP*
14. *and I think* ***it is important to the future of our FIELD that it be representative of of society at large.***
15. *Okay, having SAID that, I promised I'd be less than a minute.*

2) From F2: She uses a coyote'd challenge to the establishment to think more creatively by calling attention to her drawing of a lamp post.

1. *by us considering extra dimEN↑sions we a'a'*
2. *suddenly learned a whole bunch of new THINGS that no one had ah really thought*
3. *were possible and so <.> I think it's a good LES♫son to be learned that by looking in a new VEN↑ue or ah*
4. *if somebody HAS♫ a good idea*
5. *then everything that we're saying could change.*
6. *<....>° That's my rendition of a lamp post °* [indicating her hand drawn lamp post]

While this may seem innocuous, odd even, she is actually making a bold challenge to members of the established power base of theoretical physicists in the audience, some of whom have publicly denounced string theory and theories of higher dimensions as popular mythologies rather than substantial theoretical frameworks. Her drawing of a lamp post, to which she calls everyone's attention, is a reference to the popular folktale of the wise man who lost something of value on a dark street, but was seen to be searching exclusively in one place, simply because that is where the light was. I call this a *coyote'd challenge* because, in my opinion, she making fun of the establishment for not being willing to consider other possibilities that will lead to new insights. In another slide, depicting a topology of higher dimensions, she wrote the caption, "Copernican Revolution." This is another coyote'd challenge, in that she is implying that for society to adopt her vision of the universe as eleven dimensional requires a paradigm shift equivalent to that caused by Copernicus and Galileo in the sixteenth century in recognizing that the Earth is not the center of the Universe.

3) From M3:, he uses a strong assertion, and as direct a challenge as is possible:

1. ***The model is so UGly, it's really abhorrent.***
2. *It is POssible to do so, but <> what we SEE right now,*
3. *the SIMplest, the EAsiest models ARE just with omega equal to ONE.*
4. *<> So I do not really see many PROblems with inflationary theory.*
5. *and there are REAlly many reasons to believe*
6. *and we practice it, too.*
7. *h'h'h [laughter]*
8. *[comment from GS, another cosmologist] I agree, there are certainly many*
9. *reasons to believe, um, but I remember,*
10. *sitting in audiences with you,*
11. *with you telling us vehemently how wonderful omega equals .3 is*
12. *in the context of inflation and that –*
13. *(AL) –that – **that is a LIE**.*

It is clear that he is making a strong assertion in line 1. The model which is "so ugly" that "it's really abhorrent" to which he refers is a theoretical model of the composition of the universe that would imply the eventual re-collapse of the universe at some time in the future. When his assertion is challenged by a younger (male) member of the panel, he responds with the most direct and confrontational challenge imaginable at a professional conference: "that is a LIE."

3.2.2. C*lever anthropomorphisms*. By clever anthropomorphisms, I mean playfully ascribing human or animal qualities to non-living objects, such as atoms, for the purpose of making the unfamiliar seem more familiar. Among the women, F5 used the greatest number of clever anthropomorphisms in her public lecture, for example:

1. *And what electroMAGnetism is <> is <>*
2. *a CHARGED particle can all of a sudden SPIT <> OUT <>*
3. *a photon↓ <> and eat it again. <~3 sec pause>*
4. *Charming.*
5. *Or it can talk to aNOther <> charged particle.*
6. *There's a STRONG force*
7. *<> which is just the ability of QUARKS to spit out GLUons and*
8. *talk t' other quarks*
9.

Clearly, charged particles do not spit, eat, or talk to other charged particles. I have not heard male physicists use phrases like this, even in public talks for lay audiences, yet I do not think that the use of clever anthropomorphisms marks traditional female gender. Rather, it is more reminiscent of the type of nerd discourse described by Bucholtz (1995) in her study of adolescents in a Northern California high school. To indicate this type of mildly humorous lexical marker as neither performing traditional hegemonious femininity, nor traditional assertive masculinity, I

contrast it with "sweet" or "polite" talk as described by Lakoff (1975) to indicate the subordinate speech of women, and hegemonious sexist references of male physicists reported by Traweek (1988) and Cohn (2001) discussed in the Introduction. The term "quarks," for example, the name given to the particles that make up the proton and neutron and the other nuclear particles, I would say falls into this hybrid category of clever anthropomorphisms.[1]

3.3.3. Mild slapstick humor. I use this hybrid category to indicate a use of humor that I consider truly funny, clever, and *nerdy* in that it requires a certain level of sophistication in order to be understood and fully appreciated. In Yates' earlier study (2001) he did not ascribe a category of humor to women's discourse at all. I define *mild slapstick humor* as a hybrid category to distinguish it from the classical categorization of humor by Yates (2001), in which he ascribes to women a complete absence of humor to women. Yates ascribes the discourse marker "humor/sarcasm" to males only, with the description "jokes or statements used to belittle others, or minimize others' opinions" (ibid.).

In the talks to which I listened, I found both men and women to use mild slapstick humor, in which the speaker may or may not make direct fun of someone or something. This sort of humor is neither overly derogatory, overly sarcastic, sexist, nor racist. Even in cases in which the speaker made fun of him or herself , as well as others - both those who were present and those who were not - the spotlighted individual was somewhat glorified by virtue of being the subject of the humorous remarks, rather than insulted or demeaned.

Three examples from MF illustrate what I call mild slapstick humor:

1)

10. So <.> normally one would just put up a picture like THIS,
11. which is the elementary PARticles
12. and we would say <> the PINK <> are QUARKS <>
13. <☺☺☺ audience laughter>
14. <..> the GREEN <> are NOT↑
15. <☺☺☺ audience laughter>
16. ……[omitted two lines]
17. BLUE are things which were discovered in EUrope↓.
18. <☺☺☺ audience laughter ~5 sec>

[1]It is a meaningless, nonsensical word that was chosen by physicist Murray Gell-Mann, which he took from a sentence from James Joyce's novel Ulysses: "*Three quarks for Muster Mark."*

This is a reference to the force carriers, photons, bosons, and "gluons" that were discovered at the Center Europee Research Nuclear (CERN), the international particle accelerator in Switzerland.

2)

19. So <> actually HERE here's a picture of Gell Mann <>
20. I should-I should just point OUT here that
21. this is what a THEorist looks like↓
22. <☺☺☺ audience laughter ~2sec>
23. You see the very SOFT <> CHEEK <>
24. the nice <> HAIR <> the TIE <> the-
25. LATer I'll show you a picture of an experiMENtalist.
<☺☺☺ audience laughter>

She is poking fun of a revered physics icon – Murray Gell-Mann, the theorist who is credited with naming quarks, and at the same time hinting at a future gender-oriented joke that she will make shortly.

3)

26. Anyhow, I've done this uh with my <> CAT.
27. I've done this experiment, I've shined the
28. light in the kitchen on my cat GOOF - Ball,
29. this is – I named him after GELL - Mann <~ 5 sec of audience laughter>

This is another bit of humor directed at Gell-Mann, a play on his hyphenated name as well as a whimsical character indictment by association with a cat named Goof-Ball. The prior knowledge necessary to fully appreciate the humor in this association is that Gell-Mann is reputed to have been quite a character in his youth. When I was an undergraduate at Columbia University, one of my physics professors used to tell stories of his fishing trips with Murray Gell-Mann to Baja California.

An example of males' use of slapstick humor, from the CERCA conference, appeared earlier in the same tape from which the talk by AL was taken. The organizer of the conference began the session on Inflationary Cosmology by showing a video clip from an actual television program in which talk show host Conan O'Brien was interviewing comedian Jim Carey, who was pretending to be a theoretical cosmologist. Carey's portrayal was a clear and successful attempt to make fun of the way physicists talk, using language that sounds like gibberish to anyone outside their community of discourse. During the interview, the famous theoretical physicist Stephen Hawking

staged a call into the show. Hawking and Carey tried to out-complement each other for their respective brilliance; Hawking finally "won" the argument by resorting to the absolutely childish remark of "*No, YOU are, to infinity!*" The entire episode is extraordinarily funny for the way it makes fun of how physicists talk, as well as the caricature-like portrayal of male one-upmanship. During the playing of this video clip at the conference, Stephen Hawking was actually present in the audience, adding to the humor of the situation. The audience laughter indicated in the transcript is on the tape of the television show that was shown, not that of the conference participants, which did not get recorded.

1. *Carey: Hello?*
2. *Hawking: Hello, Jim, it's Stephen*
3. *<audience laughter>*
4. *Carey: O, Hi, Steph – it's Stephen HAWking, I can't beLIEVE this.*
5. *O'brian: Wow, that's amAzing.*
6. *-Hawking: I am well, thank you.*
7. *Carey: 'K' I-I-I-*
8. *Hawking: -I just wanted to call and tell you how happy I am↓*
9. *that you're excited about the new ekpyrotic universe theory↓.*
10. *Carey: It's amazing-*
11. *Hawking: -but don't bother trying to explain it to them.↓*
12. *-<☺ ☺ ☺>*
13. *Their PEA brains cannot grasp the idea of the world on the brane↓.*
14. *Carey: Yeah, I know♫.*
15. *Well, it's been so frustrating for me*
16. *'cause, ah, the moment I wrote it – re-READ it, I knew it was imPORtant*
17. *and I wanted t' TELL them, but, y'know pfft what can y' do♫.*
18. *Hawking: Well, I have to go↑ now↓.*
19. *Carey: 'K'*
20. *Hawking: I'm very bu↑sy↓ watching Dumb↑ and Dum↓ber.*
21. *<☺ ☺ ☺ ☺ ☺ ☺ ☺ ☺> applause*
22. *Hawking: {???} You truly are a genius.*
23. *Carey: No, YOU'RE a genius.*
24. *Hawking: -No You are.*
25. *Carey: NO♫♫ YOU are.*
26. *Hawking: No. <..> YOU ARE.*
27. *<☺ ☺ ☺ ☺ ☺>*
28. *Carey: YOU♫♫ are.*
29. *Hawking: -No, YOU are, to infinity↓*
30. *Carey: Y' got me THERE, Stephen. .*

While broader and more obvious than the examples of slapstick humor in the talk by MF, this humorous interlude injected by the program chair, into an otherwise serious conference, shares the same characteristics of making fun of self or others, who may or may not be present, requires some prior knowledge to be fully understood and appreciated, and has a tendency to glorify rather

than belittle the person who is the object of the humor. This type of slapstick humor, along with clever anthropomorphisms, is similar to the humorous discourse employed by nerd adolescents to display humor, intelligence, and a resistance to the hegemonious "cool" identity (Bucholtz, 1995).

3.3.4. Direct gender references: Several times during her talk, F5 directly referred to gender in a humorous manner. Besides accomplishing humor, these were the only instances that I found in which a speaker directly performed gender by explicit reference. The direct gender references of MF seemed to serve two purposes: by performing gender in a humorous way, she simultaneously was calling attention to the inherent hegemony in the community of physics where there are still so few women; and by referring to stages of her own life, as a girl growing up in physics, she was attempting to diffuse the popular mythology that one has to be somehow smarter than others, or specially endowed in order to do physics. The following three examples illustrate this speaker's orientation to gender, and her hidden agenda in each case.

1) Referring to the prevalent hegemony in physics, and how male dominance has come to seem normal:

30. At that TI♬ME <..> uh <>
31. the U, D, and S <> QUARKS
32. were being SEEN but not by themselves↓.
33. <..> and <> People were trying t' make SENSE of them.
34. THESE guys, CHARM, bottom, TOP, <..>
35. They weren't aROUND yet.
36. THIS guy <.> h' THESE guys were there <..>
37. THESE guys were there, but these guys were not↓.
38. THIS guy was there- they're GUYS h'h
39. <☺☺ a guy in the audience laughs>
40. Oh my <u>GOD</u>
41. <☺☺☺ audience loud laughter ~2 sec>
42. I'll just take that BACK. Anyhow- So-

2) Referring to the myth that one has to be smart to do physics:

43. ya NEver ask yourself
44. when you're watching a tv program y' never say,
45. am I smart enough? Am I SMA↑RT enough t' be WA♬tching↑ this tv program↑?
46. I dunno♬ <using pseudo male voice> am I SMART enough↑?
47. and then you just go, NO, I- I WANna watch this tv program
48. and then so you say <> OK <> forGET↑it↓.
49. <..> You don' NEED↑t' be smart t' do physics↓.
50. Ya just hafta wanna DO↑it↓.

3) Making fun of being a "girl" in physics while implying that it should be acceptable for a person to do physics while displaying female gender:

51. an' so in fact↓ I <> got into FA↑SHion↓
52. so this is ME♬<☺☺audience laughter>
53. [- before –
54. before I had CHILdren <☺☺audience laughter>
55. You SEE, I've inCORporated int' h'h <short laugh>
56. inta my CLOTHES thee- the up, down, and STRANGE↑
57. <> quark and there
58. HERE <> will be the <> the discOVery↓ <..☺☺audience laughter. picture: the discovery of the top quark is in the heel of her shoe>
59. Notice the DIF↑ference between uh'
60. THEorist is MALE <> clearly, and ↓experimentalists <> are <> female↓ <☺☺~3 sec of audience laughter >

The slide which accompanies this excerpt is shown in Figure 2.

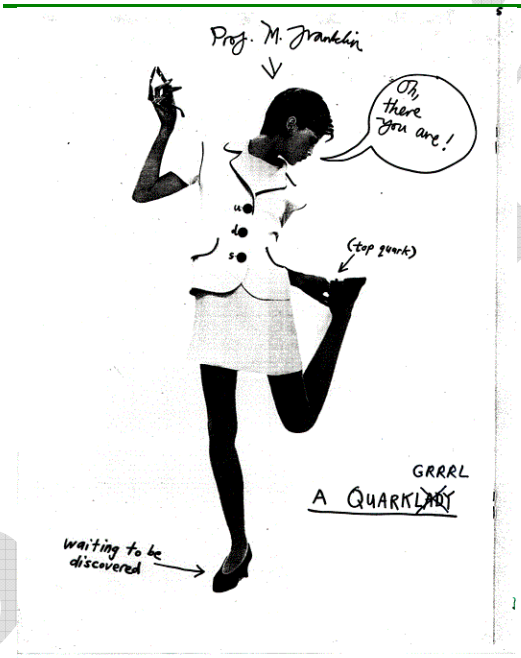

Figure 2. "Experimentalists are female." (http://online.itp.ucsb.edu/online/plecture/franklin/oh/06.html)

The blending of slapstick humor and gender orientation makes fun of traditional, hegemonious feminine identity in the way the woman is looking backwards at the heel of her shoe while simultaneously displaying pride in a manner that is also reminiscent of Bucholtz's (1995) nerd girl community. The arrow pointing to that which is "waiting to be discovered" in the toe of her shoe is a reference to the highly sought-after Theory of Everything (TOE) which is the current holy grail of the particle physics community, of which she is a member. The quest for the TOE is

also referred to by Margaret Wertheim as being a manifestation of the male orientation of the international physics community.

3.4. Summary of discourse markers

To determine the actual usage of the discourse markers in Tables 1 – 3 by each speaker, the transcription of each excerpt of talk was color coded. The number of instances of each type of discourse marker was counted, and listed in an Excel file. The total number of occurrences of each type of marker was divided by the total duration, in minutes, of each talk. In that way, a temporal density of discourse markers was used as a standard of comparison between speakers.

Only two of the women (F4 and F2) used any sort of apology, and of the two occurrences which I counted as apologies, only one statement by F2 used a direct apology:

1. *ok, so I was asked <..> to talk about what have extra dimensions taught us*↑
2. *um I was also TOLD not to use Powerpoint*↑*, so I apologize for my handwriting*↑

The up arrow at the end of a word indicates that the pitch of her voice rose on the last syllable, or last word of the phrase. I counted the statement, *"you can sorta shoot me at dinner"* as an apology, but it is not clear whether it can actually be labeled an apology, or if it is rather an extremely attenuated assertion:

16. *And then, just beCAUSE I think that we've had hh' a long day,*
17. *I wanted to say something exTREmely controversial,*
18. *just SO y' wouldn't be bored.*
19. *And THAT..an', and again, you can sorta shoot me at dinner,*

No other apology occurred in any of the talks I transcribed. Twice in the talk of M1, he corrected himself, but he did not apologize, for example:

1. *a'right, exCUSE me*
2. *<...> the PROB - uhuh*
3. *I said just the OPposite*
4. *the PROBlem with gravitating –*
5. *with gravity mediated supersymmetry breaking*
6. *is that UNlike gauge mediated supersymmetry breaking*
7. *it DOESN'T naturally account for flavor conservation in the neutral currents.*

Therefore, because I only found one example of an unambiguous apology, I combined the two categories of attenuated assertions and apologies.

The difference between strong assertions and authoritative stances in male speakers was not clear, so in the final count these two assertive categories were merged. For example, the following sample from the talk of M3, could be coded as either a strong assertion or an authoritative stance:

14. *All of these MOdels are based ON the principles of*
15. *gauge invariance with spontaneous symmetry breaking.*
16. *'khay<.> Inflation is something SImilar, it is*
17. *a PRINciple which helps us to build realistic models.*
18. *It's NOT –A- model, it's not THE model, it is a principle.*
19. *<> Now IF this principle helps us to understand some questions*
20. *that's great.*
21. *IF it canNOT <> well, so, too- too bad.*

The results are displayed in Figures 3 and 4. Figure 3 is a summary of all speakers, all categories. It is clear that women used more attenuated assertions and personal orientations ("*I think…"*) than men, but the women also employed a broader choice of discourse markers, including more powerful indices and hybrid stances, than the men did. It is interesting that both the greatest number of attenuated assertions and personal orientations among the women were used by F2, who also had a greater density of authoritative stances and coyote'd challenges than the other women. It is also surprising that, although the talk of F1, the oldest female physicist, *sounded* more apologetic, she did not, in fact, turn out to have the highest density of attenuations in her talk.

The men displayed a much narrower range in their choices of discourse markers, tending to orient to power through the predominance of strong assertions and authoritative stances. M2 (Nobel Laureate) used more presuppositions than the others, while AL (Russian theorist) used the greatest number of strong assertions, authoritative orientations, and direct challenges (including *"That's a LIE."*). In Figure 4 the more powerful, less powerful, and hybrid stances, as well as the direct gender orientations for each speaker are summed. This graph makes it possible to visibly weigh the power balances for each individual, and it is apparent that the men do tend to outweigh the women in terms of their use of discourse markers that index power stances.

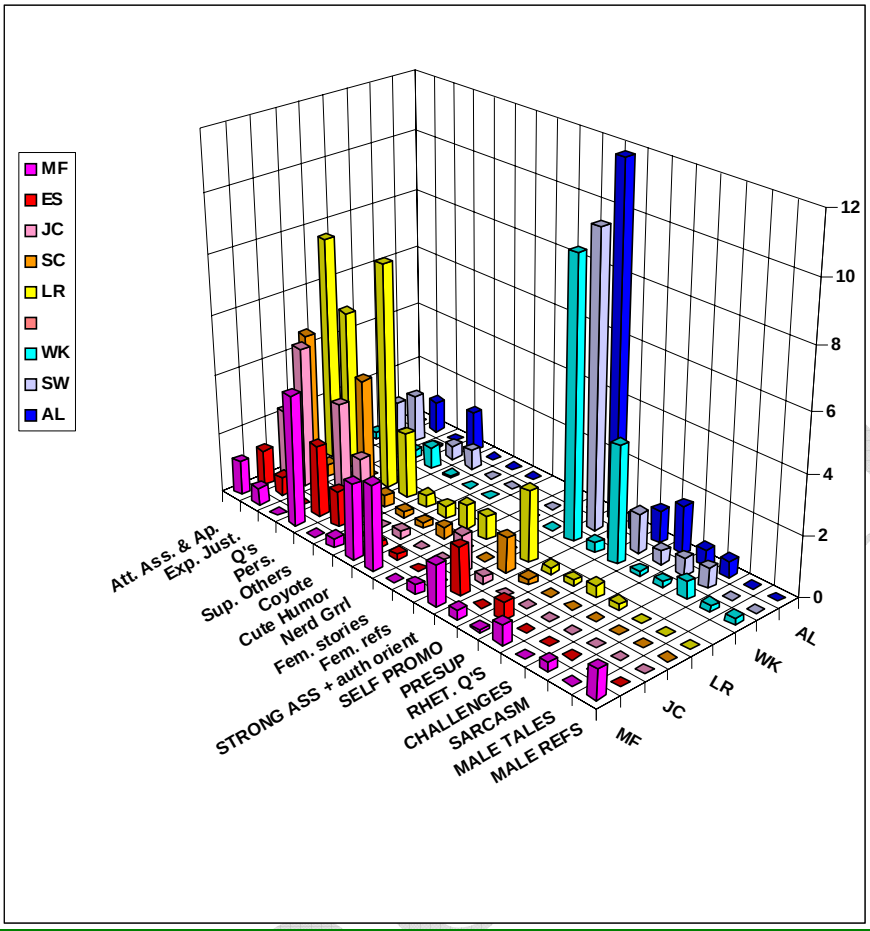

Figure 3. Total discourse markers for all speakers, all categories. Numbers on vertical axis represent "discourse marker density" "counts / minute of talk."

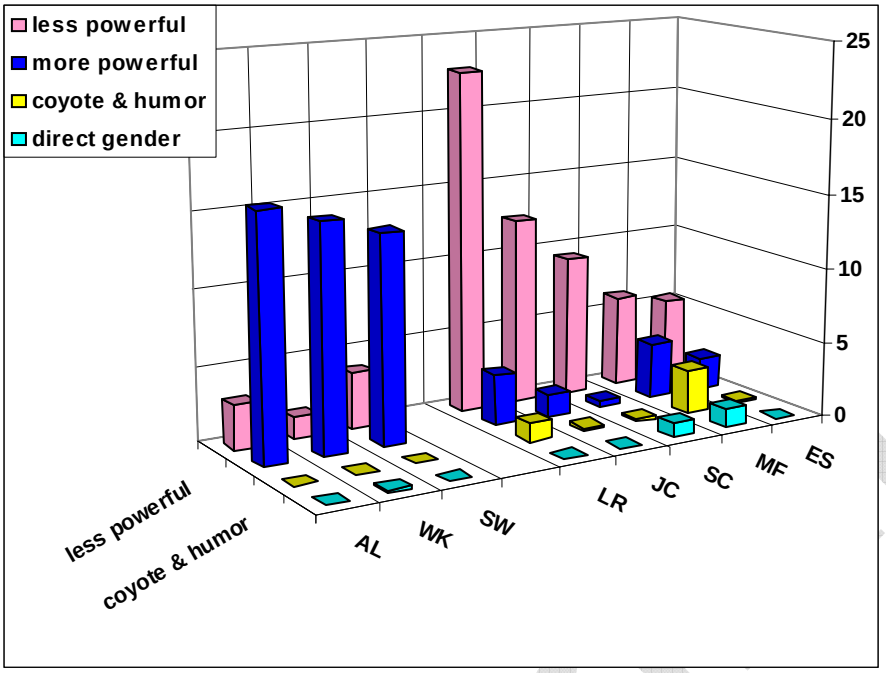

Figure 4. Total discourse markers grouped by power stance, for each speaker.

4. Analysis and Discussion.

In this limited sample of successful physicists, although the discourse of the males did outweigh that of the females in terms of lexical markers that index stances of power, the women accessed a broader repertoire of discourse markers than the men, including hybrid stances and direct gender orientations, especially the two youngest women, F3 and F5. Baron (2001) studied the presentations of men and women in academic conferences in Europe, and found differences in the formatting of criticisms and concessions, the opening sequence of remarks, and in general strategies of representing oneself as an expert. She found that, despite being well-known experts in their fields, the women nevertheless tended to use certain strategies of self-deprecation which were not found in the discourse of males.

> *The interplay between gender, status and prestige is very complex: Those women with a low hierarchical rank are even more handicapped in these ritual academic fights during conferences than men of the same professional status. Women of high status and public prestige, on the other hand, often do not receive the same verbal space as male scholars with a similar prestige. The women tend to anticipate criticisms from the audience and transform them into self-criticisms, sometimes as early as the very beginning of their talk.*

> *This is often accompanied by admissions of the limited scope of their hypotheses and promises to keep their contribution short. When criticized or when their special role within conversation, e.g. being the chairwoman, is challenged, the female scientists observed were also likely to react with concessions.*
>
> (Baron, 2001, p. 14, *in* Kotthoff and Baron (2001), Eds.)

Baron's observations of women scientists in Europe are not inconsistent with the data presented here, however the nascent hybrid stances that appear to be emerging in the discourse of the American women in this study are continuous with the emergence of nerd girl identity that was identified in adolescent speech communities in Northern California by Bucholtz (1996).

In Language Diversity and Education , David Corson (2001) of the University of Toronto writes: *"...History shows that control over discourse is the most important power to seize, if people want to escape the unwanted power of others"* (p. 157). The nerd girl identity, described by Bucholtz and depicted by F5 in the above examples, can provide a new iconic role model through which to encourage the next generation of females in physics and engineering. The nerd girl is accorded the right to be attractive, to dress in a feminine manner – or not - if she chooses, to marry and have children, without being seen as less powerful. She is recognized as a nerd girl and not a cool girl by her discourse and her stances, or, in the terms defined by Bourdieu, her hexis and habitus (referenced in Bucholtz, 1999). Rejecting the hegemony of the traditional, culturally defined female identity, nerd girls are *hybrid*s between cool girls and male scientists. Just as Maltz and Borker (1983) found a continuity between the speech socialization of children and the speech patterns of adults, similarly, the emergent hybrid markers in the discourse of younger women in physics may be the first signs of the continuity between the growing acceptance of nerd identity among American adolescents and the adults they are becoming.

Among the identifying features of nerd girls described by Bucholtz (1999) are the value they place on individuality, intelligence, knowledge, egalitarianism, and cleverness; their use of puns, humor, and sophisticated vocabulary; and the nerd identity as an emerging oppositional identity, consciously chosen as a resistance to the hegemonious cool identity of mainstream conformity. The hybrid stances defined in this study of clever anthropomorphisms and mild slapstick humor in these adult physicists are aligned with some of the humor of the adolescent nerd community reported by Bucholtz (1999). The ability to appreciate a joke also defines a person's membership in a community. F5's reference to her cat Goof-Ball and European force carriers are examples of

physics humor that defines those who laugh as insiders, as is the comedy scene between Stephen Hawking, Jim Carey, and Conan O'Brien presented at the CERCA (2003) conference. Bucholtz's study suggests that nerd identity allows adolescent girls to both achieve authority and avoid the trivialization of the traditional cultural female identity, which Lakoff (1975) described. If nerd identity is encouraged in educational settings, teachers can help overcome the gender stereotypes that perpetuate the gender inequality, which in turn may help achieve a power and hence gender balance in the adult physics community.

4.1. Narratives as discourse markers.

One remaining discourse marker from Table 1 warrants some discussion: *Narratives and personal stories.* Nigel Eadly (2001) states, *" Transforming the status quo becomes understood as a matter of challenging and changing discourses, encouraging people to tell different stories about themselves and other."* (p. 193). The types of narratives told by speakers reveal a great deal about how they view themselves and their communities, and their roles in their communities. According to Johnstone (1993) women tend to tell community-oriented stories and men tend to report stories of individual heroism. Among the talks of the eight physicists presented in this study, there were no examples of community oriented narratives in which cooperation was the key to success; rather, each of the specific narratives reported was of a personal nature, performed *within* the community of physics. Two speakers at the future of physics conference inserted personal narratives inserted into their talks, M2 and F2; a third, MF, presented her entire public lecture on particle physics as a personal narrative.

4.1.1. A heroine's tale: F2's short narrative was a personal story, told for a humorous affect that at the same time served as a rather powerful self promotion, aligning her with one of the newly crowned Nobel Laureates. She related that she actually deserved a share of the 2004 Nobel Prize because she bet one of the recipients ten dollars that he would get a Nobel Prize before a competing theory was experimentally verified. The recounting of her tale provoked laughter in the audience, but at the end of her talk, when the named Laureate took out a ten dollar bill and handed it to her in front of everyone, the audience broke out into laughter and loud applause.

7. *I'm very PLEASED that Frank reMIN↑ded me that I SHARE♫ in the Nobel Prize*
8. *because um I actually BET him he would win the Nobel Prize before the Higgs was discovered.*
9. *<☺ speaker laughs, audience laughs>,*
10. *So I get <.> Ten Dollars from the Nobel Prize*
11. *audience applauds <~ 5-6 seconds>*

The insertion of this tangential narrative, which had nothing to do with her talk (which was about the search for extra dimensions), serves to establish her as a prominent community member ('one of the guys') by her familiar association with the recent Nobel recipient. The strong approval, via laughter and applause, of the audience would indicate that she is an accepted member.

4.1.2. Heroes' tales of bravery and odd behavior*:* M2 told three narratives of iconic heroes in the history of physicists, which support Sharon Traweek's assertion in her (1988) book, Beamtimes and Lifetimes:

> *When humanity suddenly faces great danger, it is the scientist who alters the people's perception of the event, provides a solution, and thereby enables the threat to be controlled* (p. 81).

M2 begins his narratives with the following assertion, which illustrates Traweek's assertion:

1. *…there HAVE been a FEW occasions <…> <…>[4:34 long pause] WHEN this*
2. *a few hisTOrical occasions when , when there HAVE been ah treMENdous URgent threats*
3. *which ah <…> threatened everybody um scIentists, ah no more than others,*
4. *but, but scientists on those occasions have in FACT ah played LEAding roles*
5. *in, um, in FACing the challenge and in DEALing with it.*
6. *<…> um <…> I'd like to give THREE examples.*

The examples he gave were all stories of male heroes: the development of the atom bomb by Robert Oppenheimer and the Manhattan Project; the development of radar by Julian Schwinger, and the eradication of the mad cow virus by David King, Science Advisor to Tony Blair, the Prime Minister of England. I will not recount these here, as they are reported elsewhere (van der Veen and Cook-Gumperz, 2010).

4.1.3. A nerd girl's narrative*:* The public lecture by F5 was presented almost entirely from a personal standpoint, as a heroine's tale, but in a very non-traditional sense. She related the timeline of the discoveries of the six quarks to the timeline of her own life: how she got interested in physics as an adolescent, decided to study physics at university, and eventually worked on the experiment in which the sixth and final quark to have been predicted was finally discovered.[2] Her narrative is, like much of her language, a hybrid between a female personal orientation and a male hero's tale. She presented herself as a very ordinary girl who, as an adolescent, could not take her bicycle apart and put it back together again and have it work, yet who, as an adult, could help

[2] This discovery took place in April, 1995. I spent three weeks studying at Fermilab that summer, 1995, just after the discovery, when the excitement had not yet died down. That was when I met MF for the first time.

build a complicated particle detector. Her personalized story was intended to show the audience that a physicist can be the girl next door.

Unlike the traditional male hero's tale, in which the hero is somehow chosen for his special qualities, treads a lonely path, and single-handedly wins a treasure or makes a conquest, MF's personal tale is of an ordinary girl who was not born with any special qualities, who chose rather than was chosen, and who did not end up with any special prize (like a Nobel). Her narrative was intended to make physics seem more accessible and personable to her lay audience, as opposed to the typical male hero stories alluded to in the quote from Traweek's (1988) book, and borne out by the narratives of M2. Given F5's use of hybrid discourse markers already discussed, it is not unreasonable to propose that her narrative represents a hybrid between the archetypal male hero's tales told by M2, and the traditional representations of women in folklore.

5. Conclusions:

In an attempt to understand the persistent lack of women in physics from a sociolinguistic point of view, the distribution of discourse markers in the talks of eight prominent, internationally recognized, American physicists have been analyzed. A new type of discourse marker that is suggested by these data is a hybrid between the markers which index power and subordination which have been associated with typical male and female discourse, respectively. I have identified three hybrid discourse markers, which I call *coyote'd assertions, clever anthropomorphisms,* and *mild slapstick humor*. These hybrid markers, in between the less powerful lexical indices associated with traditional hegemonic heteronormal femininity, and the more powerful lexical indices associated with traditional heteronormal masculinity, are consistent with the types of speech patterns observed by Bucholtz (1996, 1999) for nerd adolescent girls.

The results of this study have implications for educating future generations of scientists and engineers. Teachers should be encouraged to recognize and validate nerd girl identity among adolescents through discourse, and seek ways to include heroine’s narratives in telling the story of physics. When coupled with curriculum reform in physics education that would include alternative, possibly interdisciplinary, contexts for teaching physics, changing discourse in physics may be the first step in reaching the goal of gender balance in the physics community.

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