

## Excerpts from an Interview with Dr. S. Jocelyn Bell Burnell<sup>1</sup>

by David DeVorkin, May 21, 2000 at the Carnegie Institution, Washington, D.C.

**Section I: Burnell's Early Life and Educational Expectations of Her Parents** (audio available at <https://www.aip.org/history-programs/niels-bohr-library/oral-histories/audio/31792>)

**Burnell:** Our parents were obviously much more delighted when we did well at school and that was obviously valued by them. And if you hadn't done well it was going to be less enjoyable going home after school. They really saw education as being important, and important that we were stimulated and reached whatever level we could reach; that we reached our potential academically.

**DeVorkin:** Did they have specific expectations?

**Burnell:** I don't know that they had thought it through. Probably particularly not for the girls. I became conscious in later life that I had been given an education that enabled me to do all kinds of jobs, but often jobs weren't open to me. You know, so in that sense I think they hadn't thought it through and they hadn't thought what young women do when they have a university education and they get married and have children. It's issues just like that where I think they hadn't seen it through, but perhaps it's asking too much that they should have.

**DeVorkin:** Of that generation, certainly. But I'm curious as to how much gender specificity there was in your family between you, the three sisters, and the brother. Were you definitely on different tracks?

**Burnell:** Depends who you're talking of. As far as our parents were concerned, no, we were not; we were equal. But I mentioned maids and cooks and nannies. They were almost invariably Southern Irish Roman Catholics, and they came out of a society that was very strongly patriarchal. And one of the incidents from my early life is my brother came along eighteen months after me, and the nanny would go out with the baby in the pram and me toting along beside and go meet other nannies, you know, other young women like them, and they would say, "Isn't it great that Mrs. Bell has a son now?" in my hearing. And I don't quite know what happened, but somehow or other I was taken to the family doctor and the family doctor spotted this and told my parents what was going on.

**DeVorkin:** And what did they do about it?

**Burnell:** They say, "Very obviously, we value little girls as much as little boys." And I can remember that, because it didn't quite seem to ring true, or it didn't seem to me to be the whole story is perhaps a fairer way of saying it. You know, I think my brain was already saying, "Well, you may say that, but the nanny says differently," you know.

**DeVorkin:** Did you ever envy boys?

**Burnell:** Yes, frequently in my life.

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<sup>1</sup> To access the interview transcript in its entirety, see <http://www.aip.org/history-programs/niels-bohr-library/oral-histories/23363-1>.

**On sex differences and early schooling:**

**Burnell:** Now I can remember the first day of those intervening two years where I was with kids that had passed the [high school entrance] exam. Word went 'round that at two o'clock in the afternoon all the girls were to go to the domestic science room and all the boys were to go to the science lab. And I was a bit puzzled by this, but I went along in case it was some kind of special announcement or something. And it turned out that there was an assumption that all the girls, even these academic ones, would take domestic science: cookery and needlework.

**DeVorkin:** That's what domestic science is.

**Burnell:** Yes. While the boys were doing physics, chemistry, biology. And I suspected this was wrong, so after about twenty minutes in this first domestic science class I said to the teacher, "I think I'm in the wrong place." And so did two other girls, and three of us moved to the science class. But there were presumptions about our roles in society.

**DeVorkin:** Sure. But no resistance from the teacher?

**Burnell:** Not once we'd had the courage to challenge it, no. If we hadn't had the courage, it might have taken a week or two to get it sorted out. So I went to the science, and that first term we were doing astronomy and physics.

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**Burnell:** I don't remember a lot in the school other than the textbook that we would have been issued with for that particular course. There probably was a school library, but I don't remember a lot about it. My parents however were frequently buying us books, and particularly when my parents realized that I might have a scientific bent, having come top of this science exam, if I expressed an interest in a book about science it would come along pretty quickly.

**DeVorkin:** So again there was nothing but encouragement.

**Burnell:** Yes, indeed. Absolutely.

**Section II: On Burnell's Interest in Astronomy and Physics**

**DeVorkin:** Back to this scoring the highest in astronomy, tell me a little bit about what your impressions are of how this happened.

**Burnell:** I just took to the subject. It was rather more physics than astronomy, I have to say. It was just a little bit about the constellations but you might be interested to know, I got 97% on that exam and the one thing I got wrong was the speed of light. They asked us what was the speed of light and I wrote down 186,000 miles per second, which is correct. And for the first time in my life, looked at that number and thought, 'That's very big. That can't be right.' Scored out 'seconds' and wrote 'hours.'

**DeVorkin:** Wonderful. So that's the first time you realized just how big that number was. What was it that triggered that; that you saw something that just was so counter-intuitive?

**Burnell:** I guess what I'm saying is, even in that first exam I had learnt to check that my answers seemed sensible, that where I came up with a numerical value, that it was reasonable, whatever reasonable means.

**DeVorkin:** Oh this wasn't a memory thing, you had to calculate it?

**Burnell:** No, it was a memory thing, but one can remember numbers wrongly or units wrongly so I think I had already built in some kind of checking system, and it was just unfortunate that I had never sort of thought about that number before this exam.

**DeVorkin:** What was it about physics that fascinated you most, that drew you to it?

**Burnell:** Well, first of all I could clearly do it, when actually a lot of my classmates couldn't do it and that gives one a great boost. I think we tend to like the things we're good at. So, first of all I could do it. When I went away to boarding school at age 13, not only did I discover that I could do it and my classmates were struggling, I also discovered that I could explain it to my classmates and quite a few evenings in that boarding school were spent explaining to classmates how to do the problems that were physics homework. That gives one authority as well!

### **Section III: On Burnell's Early Experiences with Astronomy**

**Burnell:** Yes, but the staff [of Armaugh Observatory] there were very kind and very helpful when they learnt that I was interested, and they showed me the telescopes and they showed me this and they showed me that. And one of them made a very significant statement. He said, "If you want to be an astronomer, you have to be good at staying up at night." And as a teenager I knew I loved my bed and my sleep. And I became very depressed at that point, because I didn't reckon I could make it as an astronomer.

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**DeVorkin:** I know this is speculation, but the astronomer who said this to you, do you think he would have said that to you if you were a boy?

**Burnell:** I wonder. I hadn't thought of that. He might not have. It certainly was an era where there were very few female astronomers, and those that were, were being directed. For instance Mary Bruck, who married one of the directors of the Royal Observatory Edinburgh, she was steered into solar astronomy because you could do it in daytime. And a couple of my contemporaries who ten years later will have been observing at the Royal Greenwich Observatory at Herstmonceaux, two women were allowed to observe in pairs. A single woman was not allowed to observe; a man and a woman was not allowed to observe. And if two women observed in pairs, they weren't allowed to drive home afterwards. It was not deemed safe.

**DeVorkin:** A lot of obstacles put in your way that are supposedly for your safety, but not necessarily logical.

**Burnell:** And sometimes excluding in some sense, yes.

#### **Section IV: On Burnell's College Experience and Institutionalized Sexism**

**Burnell:** [My father] brought home Fred Hoyle's *Frontiers of Astronomy* and something by Dennis Sciama — and I can't remember the title of that book. It dealt a lot with Mach's principle. I remember struggling. And I didn't just flip through these books; I took them off to my bedroom to read. You know, and a fortnight later Dad was saying, "Where is my library books?" Sorry, "a fortnight" means two weeks. I became hooked. And that's when I decided I wanted to do astronomy. And then followed the incident at Armagh Observatory where I was told you have to be able to stay up at night. And I became quite depressed at that point, because it didn't look as if I could do astronomy.

**DeVorkin:** So that really did affect you.

**Burnell:** It did, yes.

**DeVorkin:** Did you talk to your Dad about it, or anybody?

**Burnell:** Probably, although I don't remember doing that. But a few months later I discovered there was a subject called radio astronomy which you can do in the daytime, so I decided I was going to be a radio astronomer. I must have been about fifteen, sixteen, and it was getting to the stage where you had to decide what subjects you were going to study. The British schoolchildren specialize a lot, lot sooner. By about age sixteen you are down to three subjects and you pursue those subjects at college. The careers mistress at the boarding school had not heard of radio astronomy.

**DeVorkin:** Even with Bernard Lovell being so well known?

**Burnell:** She still hadn't heard of it. So I took the initiative and I wrote to Bernard Lovell. I didn't have a proper address. It was Jodrell Bank, somewhere in Cheshire, you know. And I said, "I want to be a radio astronomer. What subjects should I do at university?" And (a) he got the letter, and (b) he replied. And he told me what I needed to know.

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**DeVorkin:** Right. So, he wrote back to you. Do you remember what he said?

**Burnell:** He said, "Do physics." He said some people come in through electrical engineering, and there are some people doing this new computing stuff, but basically physics was a good route to go. So I was still a little bit uncertain about whether I should do some astronomy or not, so I applied to universities where you could do astronomy, but I ended up doing physics, straight physics.

**DeVorkin:** So you chose Glasgow. How would you typify your experience at Glasgow?

**Burnell:** Well, it was certainly very different from what I expected. One of the things that took me by surprise is that almost all the students lived at home. They came in on the bus at nine o'clock and they went home on the bus at five o'clock. Which I hadn't expected, but actually is quite the norm in — well, certainly in Glasgow and in one or two other Scottish Universities. It was a big city. I had certainly achieved that okay. It was a big city that was beginning to decline. The ship building was going, the heavy industry was beginning to go, and it was quite, quite rough in parts — very rough in some parts. I lived in digs for the first year — sorry — in lodgings for the first year, and then was in a women's dorm

for the next two years and in the first coed dorm for my final year. Living in the women's dorm was an interesting experience. It's where I first really came across questions like, "Are you sure you want to do physics? Can you bear to do physics? How can you do physics?"

**DeVorkin:** Really?

**Burnell:** Yes.

**DeVorkin:** From your peers.

**Burnell:** Yes, from my peers. And also the attitude, "Well, you are only going to get married, so why are you bothering about doing an honors degree? Why not just do general degrees like the rest of us, a pass degree, and a three-year degree?" There wasn't a lot of ambition amongst women, other than to get married. Which caught me slightly by surprise? I met it amongst the less academic girls at my high school, but the more academic ones, the brighter ones, were going to go and get full honors degrees.

**DeVorkin:** Did you seek out other more dedicated academics among the students as your friends?

**Burnell:** Yes, except I was the only female in the honors physics class in a class of fifty.

**DeVorkin:** Would you typify that as self— selection?

**Burnell:** Yes. I think that's probably a fair comment. Yes. There were many others that could have done physics honors but didn't. It was also an inhibiting atmosphere for women. There was a tradition in that university that whenever a woman walked into a lecture hall all the guys in the room would stamp [makes noise of loud stomping and banging on desktops] their desks and whistle and catcall. Every time. So for my junior and senior years, I had to face that every time I went into a classroom. And again, the women in my dorm said, "Jocelyn, why don't you change course?" So I had to stop and think, "Do I really want to do physics badly enough that I am going to live with this?"

**DeVorkin:** This was a tradition? Was this a British tradition?

**Burnell:** It was a Glasgow tradition. I'm sure there were other schools that did it, but it wasn't throughout Britain.

**DeVorkin:** How far back does that go, do you think?

**Burnell:** That I don't know.

**DeVorkin:** I wonder where it came from. It certainly is a very derisive sort of thing.

**Burnell:** Yes. What really annoys me in retrospect is my contemporaries probably didn't in a sense realize what they were doing; it was just, you know what people did. But the faculty did nothing, and thereby condoned it. Indeed, one or two of the faculty smirked and looked as if they'd like to join in.

**DeVorkin:** But they didn't. They didn't join in.

**Burnell:** They didn't join in, no.

**DeVorkin:** Did you ever protest formally?

**Burnell:** No, I didn't. Looking back on it, I'm not quite sure why. But in part I guess it's as I got older that I got a perspective on things, that I've seen more clearly the injustices or whatever you want to call them — the thousand pinpricks. I wasn't terribly alert — I wasn't at all alert — as a feminist in those days.

**DeVorkin:** It's a very curious custom. Could it have been so ingrained that it was just something they did?

**Burnell:** Yes, absolutely. They learnt it from the class ahead of them.

**DeVorkin:** And you didn't take it personally, I take it, but it was still this identification of being a woman.

**Burnell:** Yes. . . And being the only woman, I mean it was fairly clear who it was directed at.

**Burnell:** It was teasing. Here was only one occasion where it was hostile, and that was the time I came top in a subsidiary math exam, and they were livid.

**DeVorkin:** Really?

**Burnell:** Yes. I was scared on that occasion.

**DeVorkin:** Did you ever question your resolve?

**Burnell:** I knew I wanted to be an astronomer. I knew that I had to get a degree. And probably in most sciences in Glasgow you would have faced that kind of barricade, harassment, so actually changing and doing another science wouldn't actually help.

**DeVorkin:** Did you ever go home and say you'd like to find a university where they don't do this sort of thing?

**Burnell:** Somehow I don't think that occurred to me. There weren't many people who transferred university. What I did do was to learn not to blush. You can actually control your blushing. And within a few weeks I had achieved that. And that gave the guys much less reward. But I was obviously quite nervous in class. We sat in long benches, continuous wooden benches and continuous wooden desks.

**Burnell:** Yes. Oh yes. Yes. And if I asked a question in class, it would probably be accompanied by a bit of that — particularly if my question was a good one.

**DeVorkin:** But it was always just that? When you scored highest in this exam, was it still just a—

**Burnell:** It was an amplified version of that. And more sort of booing and hissing and catcalling.

**DeVorkin:** Here many times when people hit or stomp their feet, its applause.

**Burnell:** Yes. No, this wasn't. This was barracking. This is Irish slang. I guess a combination of harassment and teasing would be the translation.

**DeVorkin:** Did this ever make you think how you were going to survive a whole life of this? Or did you think, "It can't be this way once I'm an astronomer."

**Burnell:** I'm not sure that I remember. I think I suspected that it was peculiar, or that it was local. I don't know how I came to that conclusion. Maybe I met up with some of my high school friends and asked them, you know, "In your university, do they do this?" and they said, "No." That's probably most likely what happened, so I knew that it was a local and temporary phenomena; that I wouldn't have to, at least in that form, tolerate it the whole of my life.

### **Section V: Graduate School and Marriage**

[Discussing finding the first pulsar signals.]

**Burnell:** We were thinking that there was something wrong. Of course the first thought is, 'Jocelyn's connected up this aerial wrongly, she was responsible for the wiring.' So I had an anxious time while we checked out the antenna... Tony [] and Paul [Scott] started walking down this very long laboratory saying "Now what is it that shows up in our telescope but doesn't show up in yours , what's going on?" and I was pattering along behind them trying to keep up in every sense of the word. Robin stayed by the pen recorders and we got down the far end of this very long laboratory and there was a strangled cry, "Here it is!" We went charging back up the lab; we'd miscalculated when it was due to appear! Fortunately by only five minutes. If we'd got that calculation more wrong, who knows? But that was good. Their instrument wasn't totally east— west or it was not on horizontal ground or something like that and we had just miscalculated when it would appear. It was also a transit instrument, we had miscalculated when it would go through their beam, and it was as simple as that.

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**DeVorkin:** Were you getting any kind of feelings from Hewish or from the others that you had failed when they were walking down this very long corridor?

**Burnell:** It was getting to that, yes. What was also happening around about this time, initially it was Tony Hewish and I. And then we needed some help, so we brought in somebody else. And I think the first people we roped in were Paul and Robin, who then became party to this amazing result, and of course were interested and continued to ask what was going on and offer suggestions about tests we could do and so on. And the group, so to speak, gradually grew, and more and more experienced and powerful Cambridge brains came in on this problem. It wasn't a fault with the equipment. I had to work very hard to keep up with all these bright ideas that were tumbling in. It was quite a tough time for a grad student. You could get marginalized very easily in that kind of process.

**DeVorkin:** And you certainly didn't want to be marginalized.

**Burnell:** No, I didn't want to be marginalized. I was hanging in there, but I did also have to keep an eye on a thesis which I had to produce. So I was trying to keep several balls in the air, and it was quite hard work.

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**Burnell:** What I did notice is when, after that Christmas break, I appeared in the laboratory wearing an engagement ring, many people's approach to me changed.

**DeVorkin:** In what way?

**Burnell:** Well, in those days in Britain married women didn't have careers. They might work a little bit 'til the kids came along, and then they stopped work. So this was a signal that I was exiting. And other interesting phenomenon from that time, I found that people were much more willing to congratulate me on my engagement to be married than congratulate me on making a major astrophysical discovery. So I was going, wasn't I?

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**DeVorkin:** And what about your decision to be engaged? Did you know that this was the stigma?

**Burnell:** No, I definitely had not at that stage fully appreciated the social pressures that there were on the woman — to get married, or when she was married, or when there were children.

**DeVorkin:** So that was something that you had relatively compartmentalized.

**Burnell:** I was naïve. I can remember actually thinking, "Men can have careers and marriages, so why can't women?" I assumed symmetry.

**DeVorkin:** Pretty reasonable. Today.

**Burnell:** It was totally stupid; totally stupid in those days.

**DeVorkin:** Okay, well let's go back to the point where you didn't want to be marginalized and carry on. You were continuing to observe, working on your thesis, and you discovered more of these things. What was Tony doing at this time?

**Burnell:** Well, Tony was taking quite an interest of course, particularly in the pulsars, and there were ideas coming from various directions about further observations and tests we could do.

**DeVorkin:** But they weren't called pulsars yet.

**Burnell:** No, no. They had various nicknames. The one that stuck was "little green men." Which is a phrase that was current in Britain in those days to indicate extraterrestrial civilization? And radio astronomers had at the backs of their minds that if anybody made contact with extraterrestrials it probably would be the radio astronomers.

**DeVorkin:** Speculation about what this was. How did that go? Were you still in the race? Did you feel marginalized?

**Burnell:** I had to watch it. And if I tell you about the night I found the second one, it actually illustrates quite a few things. I went down to Tony's office about four o'clock, five o'clock in the afternoon to talk to him about something, and the door was shut — which is very unusual in that department. So I knocked and he said, "Come in." I put my head around the door and he said, "Oh, come in, Jocelyn, and shut the door." So I went in and shut the door. And it was quite a high level meeting. It was Tony, it was Martin Ryle who was head of the group, and another senior radio astronomer — I can't remember who. And they were actually discussing how to announce this discovery. We didn't seriously think it was little green men, but we didn't have a natural hypothesis to put in its place. We actually had very little clue what this thing was at that stage, and we had only one of them. Well, we didn't resolve the issue that evening, and I went home to get some supper, very disgusted. You know, some silly lot of little green men had chosen my frequency and my antenna to signal to planet Earth, and here was I trying to get a Ph.D. and running out of money and time and blah blah blah.

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**Burnell:** Yes. I suspected. I knew that instinctively when the second one came.

**DeVorkin:** When the second one came?

**Burnell:** Yes. First one, no. It could have been anything. Second one, similar but not identical, a different part of the sky, this must be a new stellar population of some sort or galactic or, you know, astronomical thing. And that was lovely. That was very, very good. So on that instance I piled the charts on Tony's desk and said, "Look at this, Tony," and went off on vacation. And of course that helped the publication problem as well, because it's not little green men, there's more than one of them. You publish the first one and say, "We've found some others." And the day I came back from Christmas vacation I found another two suspects on the charts, and they were confirmed over the next few weeks.

**DeVorkin:** Finding the suspects means scrutinizing hundreds and hundreds of feet of chart paper.

**Burnell:** About three miles.

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**DeVorkin:** He already knew you were getting married and this was just generally a write-off. Did you ever consider not getting married?

**Burnell:** No, I don't think I envisaged that. A bit of me believed that I could be married and have a career and a bit of me knew fine well that women in Britain at that stage who were married didn't have careers.

**DeVorkin:** A few did. For example, Margaret Burbidge.

**Burnell:** Margaret Burbidge, yes. Her career has got hiccups in it as well.

**DeVorkin:** But I'm wondering, was she or anyone else, by this time, a role model for you?

**Burnell:** No. One of my great regrets is that there was no role model, and not even a mentor, actually. There were times when I could have done with a good mentor. So I was very much on my own. I was married to a man who expected wives to be at home. He said he didn't but he actually did!

**DeVorkin:** You certainly came to international attention when Tony Hewish got the Nobel Prize.

**Burnell:** Mmm [affirmative].

**DeVorkin:** But what was it like personally for you? Because I heard all of the controversy that we all know. How did that controversy develop? Who were the voices?

**Burnell:** I think there was fairly widespread feeling amongst my generation, sort of postdoc generation, that things had been a little bit unfair. And I can remember for instance I was one of the editors of the Observatory magazine. There were four or five editors — I think four of us at that time — and there was a question of whether we should put a note in an issue of the Observatory congratulating Martin Ryle and Tony Hewish. And I was for it, but the other three editors said, wrote, "Nobel = No Bell."

**DeVorkin:** I haven't seen that one. Is that in print?

**Burnell:** No, no. That was amongst ourselves as we were making decisions.

**DeVorkin:** My God. Nobel = No-Bell

**Burnell:** No — space — Bell. Yes.

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**DeVorkin:** How did you feel about that?

**Burnell:** Well actually, I was very pleased about the Nobel Prize. I can remember the day vividly, because something else happened that day, and if I put this in a novel nobody would believe it. ... And then on the midday news program was the announcement about the Nobel Prize. And the wife of one of the faculty heard this, and he came rushing along to my office to relay the news, I think expecting me to blow a fuse. And I didn't, because I have a strategic sense, a political sense. This was the first time that a Nobel Prize in Physics had gone to anything astro. For the first time astronomy and astrophysics had been brought within the purview of physics. And I saw that as extremely important and nice incidentally those pulsars were part of it. But I wasn't cross or anything. It did have a slight social effect in the sense that it said to me that, "Men get Nobel Prizes and women stay at home looking after babies," because I had a wee one by then. So it's had some consequences for me in my self-understanding, but I was very, very pleased that a Nobel Prize in Physics was going to astronomy.

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**DeVorkin:** That's a very important point. You have always appeared to me to be — from the media side or reading secondary reports — to be very reticent at being publicly taking anything but a positive attitude about it.

**Burnell:** Mmm [affirmative].

**DeVorkin:** And I often wondered whether that was a hundred percent sincere.

**Burnell:** I think so. Yes. Yes, I think so.

**DeVorkin:** Okay. But that there could also be an element there that you don't want to be used.

**Burnell:** Well, that's something one always has to look out for in life — I mean, forever and ever, and particularly when you get a name of some sort. People are always trying to hitch you to their cause. So that's something I've had to learn post-pulsars.

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**DeVorkin:** Your name opens doors. It is issue-related. Did you try to avoid that?

**Burnell:** I discovered quite quickly that my husband became twitchy at my successes, and I learnt to play them down, certainly at home and probably in other circumstances as well. When my marriage broke up ten years ago, I can see that my profile just went up like the side of a house, because I was free to accept rewards and to do things like broadcasts and things like that.

**DeVorkin:** And you were not free when you were married?

**Burnell:** It was more difficult. For example, I did not receive my Ph.D. in person. My husband said we couldn't afford for me to travel from the South Coast of England to Cambridge for the degree ceremony— which I didn't actually believe. I think it was more significant that he did not have a Ph.D. And I didn't have to go in person to receive the degree. I mean, it's a nice occasion, but you don't have to go. And it made an honorary degree ceremony in Cambridge a couple of years ago all the more meaningful. It is difficult, because there is still the perception that in a partnership, a marriage, the male is the leader, the dominant, and the women is often there — think of photographs — as the attractive accompaniment. Less often do you see a woman being photographed and her man standing sort of behind her right shoulder? You know, the world is not actually symmetric.

#### **For further reading:**

##### Websites:

- NASA Starchild, an educational website for young astronomers did a short audio interview with Jocelyn Bell: [http://starchild.gsfc.nasa.gov/docs/StarChild/whos\\_who\\_level2/bell.html](http://starchild.gsfc.nasa.gov/docs/StarChild/whos_who_level2/bell.html)

##### Biographies:

- Byers, Nina and Gary Williams, eds. *Out of the Shadows: Contributions of Twentieth-Century Women to Physics*. Cambridge, UK: Cambridge University Press, 2010.
- McGrayne, Sharon Bertsch. *Nobel Prize Women in Science: Their lives, struggles, and momentous discoveries*. Secaucus, N.J.: Carol Publishing Group, 1993.
- Wade, Nicholas. "Discovery of Pulsars: A Graduate Student's Story." *Science* 189 (1975) 358-364.

##### Important publications:

- Hewish, Antony, S. Jocelyn Bell, J. D. H. Pilkington, P. F. Scott, and R. A. Collins. "Observation of a rapidly pulsating radio source." *Nature* 217, no. 5130 (1968): 709-713.

([http://www.researchgate.net/profile/P\\_Scott/publication/32005350\\_Observation\\_of\\_a\\_Rapidly\\_Pulsating\\_Radio\\_Source/links/0deec51a72db0aaca3000000.pdf](http://www.researchgate.net/profile/P_Scott/publication/32005350_Observation_of_a_Rapidly_Pulsating_Radio_Source/links/0deec51a72db0aaca3000000.pdf)) (original publication on the discovery of pulsars)