

## RUBY PAYNE-SCOTT

*The Science Show* on RN, where we must celebrate a very special anniversary. Did you know that it was 75 years ago this month, on 3rd October, a team at CSIRO Radio Physics pioneered radio astronomy? It was done at Collaroy Plateau, that's by the northern beaches of Sydney, and at Dover Heights near Bondi, and in Hobart where Grote Reber built a telescope you can still see on campus. The Sydney team was led by Joe Pawsey, whose beginnings seem most unlikely for an astronomical superstar, as his son Hastings remembers.

**Hastings Pawsey:** He was initially home-schooled, and they lived on a very small farm in the western district of Victoria, and I'm not sure the reason for this but his mother and father home-schooled him until he was nine years old. And at nine years he went to a small village one-teacher school, and there he was known then to ask the teacher some rather challenging questions, not for any reason of wanting to make a statement for himself against the teacher, he just had that inherent desire to understand more than what he was hearing.

So after his couple of years at primary school, he moved to Camperdown High School and he had two years there. From those two years he moved to Melbourne and went to Wesley College where he completed his education. He was very fortunate to travel over to England and Europe with a group that was well known then called the Young Australia League. Their purpose was to show people from Australia a bit more about the world because we realised the isolation then was possibly going to hold us back. So he had a wonderful trip. He saw remnants of the First World War damage in both England and in Europe, and probably I suspect that was the beginning of his hatred towards war as such.

But after Wesley he moved to Melbourne University where he got his first degree in science and followed straight on with his master's degree and his thesis then was about the transmission of radio waves through the sky. And of course the radio waves back in the late '20s was only those that were being transmitted effectively by radio stations in their early days.

So after he finished his master's degree, he was able to obtain a scholarship to go to Cambridge under what was and is still called an 1851 Scholarship. 1851 was the year that Albert, the husband of Queen Victoria, initiated and set up and drove the 1851 exhibition in London to show the world at that stage what they were capable of doing. It was a first really world expo. And the money left over from that project was used to pay for people to come from the dominions, that was the term rather than the 'colonies', and so Dad was able to travel over to England in 1931 and start his life in Cambridge to complete his PhD. And he completed that in 1934, and immediately was employed by EMI on the subject of their transmission of the first really semi-commercial TV in London. Dad's role there was, again, a researcher and he was involved heavily with the design of the aerial that transmitted the signal of a TV, and also the interlinking cables between the aerial that went down to the transmitter in the machine. Alexandra Palace, it's still there now. He was known to climb the tower like a mini Eiffel Tower. He had a wonderful time there.

**Robyn Williams:** Hastings Pawsey, talking about his father Joe, on 3rd October in Sydney, to mark the 75th anniversary of the experiment with the sun at Collaroy. So we've mentioned

Pawsey. In an earlier *Science Show* we talked about John Bolton who did the extragalactic pioneering at Dover Heights, and then went on to create the Parkes Telescope. And there was Paul Wild, later chief of CSIRO.

But there was another name, another superstar, bypassed by history: Ruby Payne-Scott. And here's astronomer Miller Goss this month, on why we should conjure with that name.

**Miller Goss:** Ruby Payne-Scott was a science graduate, a physics graduate. She was the first woman radio astronomer in the world. She was an expert in electrical engineering, she knew how to calibrate, that is she could take the results of what the radar antenna was receiving from the Sun and turn it into real units that had very important consequences. On 28th May, 2012, she would have celebrated her 100th birthday, and it's a good fortune for all of us Google Australia decided to celebrate her centenary anniversary with a Google doodle. Every one of the images there is related to the work that she did on radar during the war, and the first radio astronomy that she did in 1945.

Now, there's something else that happened, perhaps more important. When she died in 1981, she didn't get a very important obituary in any of the Australian newspapers or anywhere in the world. The *New York Times* decided several years ago to start a series called Overlooked, to write obituaries in the *New York Times* of important women that were not given obituaries when she died. 37 years after the death of Ruby in Sydney, she received an obituary in the *New York Times* on 29th August 2018, written by a reporter, Rebecca Halleck, that many of us that were involved in the story got to know very well. And the story begins in the *New York Times* on that day; Payne-Scott helped establish the field of radio astronomy by using radio waves to detect solar bursts when she was forced to resign after she got married.

**Robyn Williams:** Got married? There's a sin for you. Miller Goss on a world beating pioneer.

And so for the rest of *The Science Show*, the story of that incredible woman, presented by Pauline Newman.

**Richard McGee:** She was one of the best physicists that Australia has ever produced.

**Claire Hooker:** She just walked into life and said what she thought and demanded what she wanted from it. An out-there, large gestured, loud-mouthed, excitable person.

**Miller Goss:** She really was an early advocate for women's rights in the workplace, well before her time.

**Carolyn Little:** She was a communist during the war, and this is at the time she was doing her top secret radar research.

**Claire Hooker:** She got to find out all this stuff about the universe that no one ever thought of before.

**Richard McGee:** People loved working with Ruby because she was so clever.

**Danebank student:** Who was Ruby Payne-Scott? Ruby Payne-Scott, radio astronomer, mother, teacher, was born on 28th May 1912, in Grafton, New South Wales, where her father

was an accountant. Her talents and interests as a young person were undoubtedly exceptional and to get a good education, she moved to Sydney to live with her aunt while completing high school. She was a distinguished student and in 1929, enrolled at the University of Sydney where she won two scholarships. She graduated with honours in physics and mathematics.

**Pauline Newman:** A student from Danebank School, Hurstville, south of Sydney, celebrating the life and achievements of Ruby Payne-Scott, who was once a teacher at the school.

But Ruby's working life encompassed much more than school teaching. Ruby Payne-Scott was one of the founders of radio astronomy, and the first woman to ever listen to the heavens.

[Audio: Parkes recording]

The roar of millions of stars and galaxies recorded by the Parkes Radio Telescope. Quasars, and pulsars with their regular beat are just two exotic examples of the many amazing discoveries about the universe made in this way.

Ruby studied the Sun. She did this at a time when sex discrimination was the norm and a woman's place was most certainly in the home, not at the telescope. And it's only now that astronomers and historians have begun to assess her contribution to science and to the fight for women's rights and equality.

Ruby was just the third woman to graduate in physics from the University of Sydney at a time, in the early decades of the 20th century, when women weren't wanted in the discipline. Claire Hooker, a science historian, describes the formidable barriers that bright girls such as Ruby were forced to jump, if they wanted to learn about the physical world.

**Claire Hooker:** Before the 1960s, almost no girls' schools in New South Wales would have offered physics as a subject. So if Ruby encountered physics at high school, it could only have been as an adjunct to mathematics perhaps, if she was lucky. Aside from that I can't imagine how she would have come across it except as big items in the news. In those days, physics was the most prestigious science. Relativity and Einstein made big news, people were excited about new understandings of the universe and, in practical terms, physics was behind all kinds of new instruments, munitions and weapons and bombs, to aeroplanes, wireless, silent movies.

**Pauline Newman:** So how did Ruby do at university?

**Claire Hooker:** She did very, very well. She was a bright little star. I can only imagine that at high school she must have stuck out like a sore thumb. She was good at doing that.

**Pauline Newman:** But her achievements didn't seem to thrill her parents back in country New South Wales, and Ruby grew apart from them after she started school in Sydney. Here's Ruby's daughter, the artist Fiona Hall.

**Fiona Hall:** It didn't sound like she was going to get much parental support, I must say. We do know that at some point when Mum went home for holidays during her university years and she took quite a lot of books home with her to study, her brother who must have been

terribly envious of the opportunity that she had, took all of her books and sold them, and Mum would have been absolutely furious, and sadly never forgave him. I feel a bit sad saying this, but she really felt that she had escaped something that wasn't working for her from when she was very young; it was a path that she had to make entirely herself.

**Pauline Newman:** But it wasn't clear where Ruby's path could lead. Claire Hooker:

**Claire Hooker:** One reason for why women did not do physics in those days is because they couldn't see a reason to. Where would you expect to work? You could possibly get a job teaching, but if no girls' schools are teaching physics then you can't even get a job doing that, which was the major employer of women with science degrees at that time. Companies almost never hired women, and Ruby graduated in the Depression when there were no jobs for anyone, and where giving a job to a woman over a man who might have to support a family would have been unthinkable. So it is a testimony to the excellence of her scholastic achievements that when she graduated she was immediately hired as a physicist on the university's very new cancer research project.

**Pauline Newman:** When the cancer research project closed down in 1935, Ruby's luck ran out.

**Claire Hooker:** There was no other job for a woman physicist, as she had well been warned, and Ruby did a teaching degree and she took a job at a school in South Australia. At that point in her life, Ruby may well have been the story of many other brilliant women of her era, she may have disappeared into teaching and we may not have heard anything of her again. But I guess she loved physics and was looking for a way back in, and she applied to Australian Wireless Amalgamated, AWA, an enormous company in those days that ran all the wireless services in Australia and it was the major hirer of physicists at that time. Ruby was the very first woman they hired in a research capacity. Ruby they hired as a librarian but she quickly turned the word 'librarian' into a whole lot more. She started editing their journal, she started to get involved in doing some of the research work in their standards laboratory, and pretty soon her fulltime 'librarian' job was a full-time physicist's research job.

**Robert Menzies:** Fellow Australians, it is my melancholy duty to inform you that, in consequence of a persistence by Germany in her invasion of Poland, Great Britain has declared war upon her and that, as a result, Australia is also at war.

**Pauline Newman:** When the Second World War began in 1939, Britain passed Australia the secrets of radar to help protect its cities from enemy bombs. The CSIR, the Australian Council for Scientific and Industrial Research and the forerunner of the CSIRO, recruited 60 of the country's best physicists to develop radar and make it as accurate as possible.

**Claire Hooker:** Radar was incredibly important top-secret research in 1939. A special attaché was sent from Australia to England and came back with the secrets of radar research, the briefcase literally padlocked to his arm, and the CSIRO agreed to set up a radio physics research division which would be largely devoted to radar. It was called Radio Physics, two words, in order to throw off any enemy spies who might think it was a cover for radar research. However, an advertisement was put out recruiting physicists.

**Reading:**

5 Thurley Street, Ashfield.

4th June 1941.

Dr Martin, Director Radio Physics Laboratory, Sydney University.

Dear Dr Martin,

I should like an opportunity to discuss with you the possibility of my joining the staff of the Radio Physics Laboratory. Mr McCready, who is a member of your staff, has known me at the university and at AWA and could be referred to for further information.

Yours sincerely, Ruby Payne-Scott.

**Claire Hooker:** Again, she was lucky. Two men dropped out and she and another woman, Joan Freeman, were hired and thus got the break of their careers. They were the first two women in Australia to have actual careers in physics and it was because wartime exigencies required that talented young women be hired.

**Pauline Newman:** And she was hired as a physicist this time, not as a librarian?

**Claire Hooker:** She was hired as a physicist. The CSIRO had been hiring women since it was organised in the late 1920s, but it also almost entirely hired women as typistes, (with an 'es' on the end) or as librarians. And again, these women would be doing scientific work but their jobs would be classified as 'women's jobs'. And I mean that seriously, because in war the Women's Employment Board was set up to give women working in men's jobs equal pay. And women who were doing scientific work for the CSIRO but who were classified as librarians or as typists or a laboratory assistant were deemed to be doing women's work and so not eligible for the equal pay. But Ruby wasn't. She was hired in a man's job and so she was eligible for equal pay and got it during the war. Interestingly enough, when she was hired, Taffy Bowen, the head of the division then, after about three months wrote a kind of memorandum on probationary employees saying 'Well, she's a bit loud and we don't think she's quite what we want, but we'll let her continue and see how she works out.' And of course, she worked out great.

**Pauline Newman:** Many years later, Joan Freeman wrote her autobiography, *A Passion for Physics*. Here's what she says about Ruby.

**Excerpt from *A Passion for Physics*:** She was tall, solidly built, with straight fair hair, a strong-minded, no-nonsense disposition and a shrill voice which she could use very effectively in an argument. But at the same time she had a sincere, kindly and generous nature to which I instinctively warmed.

**Miller Goss:** There were in fact three women in Sydney working on radar research, and all three of their lives are quite intertwined.

**Pauline Newman:** Miller Goss, who in the 1970s was a young astronomer working for CSIRO at the Parkes Radio Telescope when he kept hearing stories about the achievements and abilities of Ruby Payne-Scott, who'd left the organisation nearly two decades earlier. Miller became intrigued by her story, and a few years ago, taking time out from his job as a senior astronomer in the US, decided to find out more about Ruby's career.

**Miller Goss:** There was Joan Freeman who became an eminent and very successful nuclear physicist whose career was in Britain later on. And there was also a Rachel Makinson, who was British and had come to Australia to marry an Australian physicist, who became a very

famous CSIRO researcher in textile physics working on the properties of wool. In general, they supported each other because they knew it was such a difficult environment for a woman to work.

**Pauline Newman:** It was a tightly-knit group. Policemen guarded the door to the radio physics laboratory and the scientists weren't allowed to talk to outsiders about their work. Using improvised equipment, bits and pieces of wire and sticky tape, they designed radar that thwarted air raids on Darwin and was crucial in helping to drive the Japanese from the Pacific.

In this 'Boys Own' atmosphere, Ruby, Joan and Rachel fitted in and had a lot of fun. But they had to deal with discrimination, not by their colleagues, but by administrators and petty bureaucrats. And it wasn't just unequal pay; trivial restrictions abounded.

**Miller Goss:** They were told they were not allowed to smoke; the men could smoke but the women were not allowed to. So Ruby went along to the interview smoking a cigarette just to show that she thought this was nonsense, that this was completely unfair.

**Pauline Newman:** Then there was the dress code.

**Miller Goss:** The women were told that during the war that they were not allowed to wear shorts and of course the men were during the summer as there was no air conditioning. So again she was brought in for an interview, she and Joan Freeman. They said, 'You're not allowed to wear shorts, you have to wear a dress or a skirt.' Ruby said, 'Well, this is absurd. We're climbing up on ladders, up on aials every day. I'm not going up on a ladder with a skirt on. The shorts are much better attire for us.' But in fact, in a serious way she really was an early advocate for women's rights in the work place, well before her time. Equal rights for women were hardly heard of in the 1940s.

**Pauline Newman:** Ruby's boss during the war was a distinguished physicist called Joe Pawsey and the two worked closely together. Joe soon realised that Ruby was immensely talented both as a mathematical and as a practical, hands-on physicist. Joe Pawsey was a brilliant team leader who had a positive influence on all who worked with him. Claire Hooker:

**Claire Hooker:** Joe may have been the reason why both Ruby and Joan Freeman felt so very comfortable there, because Joe was quite unusual, everyone has remarked on this, on creating a highly equitable team structure where everybody mucked in and did all the bad jobs together. And they were working on the proverbial string and ceiling wax. They had no budget and they had no materials because in wartime almost all materials became immediately hard to get hold of, so they had to be incredibly innovative in making good use of whatever was around. And everything used to break all the time, so you had to be really handy with your wrench and your screwdriver and had to know how to fix wingnuts and you had to know how to tighten up cables. So everyone shared those bad jobs and they bonded a lot, and Joan and Ruby both flourished there, even though they could not have been more different in styles of characteristics of their personality. Ruby, as we know, was an extremely outspoken person, she was not one to suffer fools gladly, I'm sure she would have gotten her own way under any circumstances whatsoever. Joan Freeman was very quiet and gentle and soft spoken and all those female characteristics that you can imagine making her easy to

overlook and push around but instead she felt herself extremely supported. Both of them commented that they were considered just one of the boys.

**Pauline Newman:** You're listening to a special edition of *The Science Show* on Radio National, about the life of pioneering radio physicist, Ruby Payne-Scott.

Wartime Britain, and radar was the first line of defence against the constant threat of German air raids. The army recruited a civilian physicist, James Hey, to investigate reports of enemy jamming activity. One day in 1942, there was intense radio disruption but the expected air raid didn't arrive. Hey was puzzled, then guessed that the disturbances didn't come from across the North Sea but from the Sun. The Royal Greenwich Observatory confirmed the appearance of a large sunspot.

Radio engineers around the world were intrigued. In Australia, Joe Pawsey heard about the extra-terrestrial noise, and, in April 1944, decided to take a look for himself.

**Claire Hooker:** Joe thought that this was worth investigating kind of after hours, and he grabbed Ruby and one night they just put a few aerials together, radio antenna, and essentially stuck them out the window of the physics building at the University of Sydney, climbed onto the roof and pointed them at the sky, wondering what's up there. As it turned out, they didn't find very much. They were using the wrong kind of length of aerial and length of measurement

**Pauline Newman:** Though the simple experiment failed, the ideas behind it blazed the trail of radio astronomy in Australia. The following year, the war ended.

**Claire Hooker:** And at that point in time, the Radio Physics division, which had been set up just to do work on radar, faced a real crisis. They had all of these highly trained young physicists but the radar research program was going to be shut down on the grounds that no one was really going to need it. So the team put in a bid to the CSIRO president to get funding to remain a radio physics research division that would be concentrated in a couple of different research areas. One was rain making, there was a lot of research on seeding clouds. The other was radio astronomy.

**Pauline Newman:** It was incredibly speculative. Back in the '30s, Karl Jansky of Bell Laboratories in the US noticed that a sort of cosmic hiss interfered with radio reception, and seemed to come from the centre of the galaxy. Though the discovery made the front page of the *New York Times*, it was overlooked by most astronomers. But not by Grote Reber, a radio ham from Illinois who later moved to Tasmania. Reber built a 10-metre dish in his backyard and in 1944 made the first radio maps of the sky.

So when the CSIR team put in their radio astronomy proposal, the subject was still very much in its infancy. Mainstream astronomers, which in those days meant optical astronomers, still weren't interested.

**Claire Hooker:** To its eternal credit, the CSIRO agreed to fund this division and this research project, and that meant that Australia became an international leader in a completely new field, which is almost unprecedented in its scientific history. There was only one other team working and that was in England and they were hampered by various other research difficulties. So Australia really was the number one spot in the world to do that kind of

research. It was immensely exciting. So once they'd started, every day they found something new.

**Pauline Newman:** Joe Pawsey headed the astronomy group and immediately hired Ruby as a permanent, full-time research assistant, some months after she was married in September 1944. It was an appointment that broke all the rules, as Joan Freeman recalled.

**Excerpt from *A Passion for Physics*:** There was one case involving sex discrimination which Ruby went to extraordinary lengths to circumvent. It was in 1944 that she let it be known that she was living with a man, Bill Hall, to whom she was not married. Nowadays, little would be thought of such a situation, but in the 1940s, 'living in sin' as it was called, was looked on askance. However Ruby, who had always kept her private life very much to herself, carried on as usual, unperturbed. It was not until two years later that the truth came out. She had been married to Bill all along, but did not want the fact to be known officially because of the long-standing rule in government establishments that married women could not be employed on a permanent basis.

**Claire Hooker:** The CSIRO is of course a Commonwealth department and Commonwealth employer rules required that any women resign on the date of her marriage. Married women could only be employed on a temporary basis and then only if you could provide a sufficient excuse to show that no man could be hired to do the job, and that that this particular married woman had special expertise that meant that it was okay to hire her, and you would have to form that justification every single year. So she was gazetted as a full-time employee with superannuation benefits and so on, after she should legally have been deemed to have resigned.

**Excerpt from *A Passion for Physics*:** Ruby had hoped by her deception to evade what she considered to be an outrageous and discriminatory law. All her Radio Physics friends, having developed a strong affection for Ruby as well as a respect for her scientific abilities, greeted the story with hilarity and sympathised with her attitude.

**Pauline Newman:** Ruby had met her husband Bill Hall at the City of Sydney Bushwalking Club to which they both belonged. They loved being close to nature, and bushwalking was their passion. They'd don huge backpacks and set out for a weekend camping expedition in the mountains. Here's Bill and Ruby's daughter Fiona Hall:

**Fiona Hall:** It was a very happy marriage and they both had very green politics as well. Dad never had much of an education but he really admired Mum, and I don't think the fact that she went on to have what is now being perceived as quite a sort of illustrious career ever bothered him. In fact, he was really supportive of that and highly respectful and probably extremely proud of that, I would say.

**Pauline Newman:** Bill and Ruby moved to the suburb of Oatley, about 30mins train journey south of Sydney and built a house with extra-large doors so they could take their bed outside to sleep in the open. Ruby's best friend, Betty Hall lived a few streets away.

**Betty Hall:** I was very fond of them both and always found Ruby in particular very kind. She was never intellectually snobbish. Obviously she was better-read than I was and knew a lot of things that I didn't know but she never made me feel my ignorance.



**Pauline Newman:** Did you know that that she'd been this extremely competent scientist?

**Betty Hall:** No, I hadn't a clue. I knew Bill worked at the PMG and I knew that she worked at CSIRO as a scientist but I don't think any of us had any idea of this. We knew that Ruby used to go off and check various lots of instruments and we used to laugh about it but we had no idea what she was doing.

**Pauline Newman:** Betty and Ruby met up regularly for bushwalking.

**Betty Hall:** I do remember that we were on a train trip up to Kosciusko, I think. We used to go on a Friday night after work and you'd just sleep anywhere you could on a crowded train. And on this occasion Ruby had got herself up into a luggage rack and these sailors were on the train and they were all happy and enjoying themselves. And of course Ruby's fair hair attracted them and they kept calling her blondie and trying to get her to come out of the luggage rack to them but she took it all in good part, in good humour. Nothing like that would have phased her.

**Pauline Newman:** Was she known as a sort of tough woman?

**Betty Hall:** I think we were all tough women in those days. Ruby wasn't considered particularly tough, but she was considered a very good cook. A bush cook.

**Pauline Newman:** Meanwhile, Monday to Friday, life at the CSIR was just as exciting. At the end of the war, Ruby Payne-Scott and the radio astronomy group began research at Dover Heights near Sydney, the observatory that was used between 1946 and 1955. Claire Hooker and Miller Goss:

**Claire Hooker:** There was all of this left-over radar equipment from the war and the army was literally dismantling radar outposts, they had radar outposts along the cliff tops along Australia to send signals out to sea and detect enemy ships and submarines if they were coming in, that sort of thing. And they were literally just going to pull them down and just let it sink to the bottom of the ocean. So Ruby and her colleagues in the radio research division had in some cases 24 hours to grab a truck and chuck as much radar equipment as they could possibly cram into it and drive it back to Sydney Uni and kind of hang onto it in a storage room and then set it up somewhere else where they wanted to. And the first place they set things up was at Dover Heights, just north of Bondi, near The Gap where those marvellously huge tall cliffs are that drop into the ocean. And on the edge of the cliff, they would set up a huge big radar antenna, a series of wires criss-crossed in a little hatched pattern and they looked like a big TV arial.

**Miller Goss:** Ruby was involved in the early breakthroughs in solar physics that occurred. In fact, it was very fortunate that in February 1946, one of the largest sunspot groups of the 20th century occurred on the Sun.

**Claire Hooker:** Sunspots are where there are a massive turbulent storm essentially created on the surface of the Sun, and usually when that happens you get all kinds of terrible mix-up in radio signals on Earth and it emits a series of different radio signals that tell you a lot about the kinds of gasses that are exploding or churning around underneath that. And solar flares are like an explosion that burst up through the Sun's corona, the outside bit of the Sun. That's the kind of thing she was observing and looking at.

**Miller Goss:** They pointed the old radar antennas, now a radio telescope because the war was over, they pointed these at the eastern horizon as the Sun rose over the Tasman Sea and they saw these fantastic effects of large solar flares in February 1946. They interpreted these correctly as being very energetic bursts occurring in the solar corona and this, of course, was a breakthrough and led to a revolution in solar physics that essentially had a big impact on the future of radio astronomy in Australia.

**Claire Hooker:** They used the sea as a kind of huge big mirror. The Sun as it burns emits waves on all sorts of spectra: ultraviolet rays, there's light rays and in if you go down the slow end of the spectrum, the sort of long wave length end of the spectrum you get to radio waves. And you need ways of working out whether the wave really has come from the Sun, how long is its wavelength, and one really good way to do that is to measure not one but two waves. So the wave that you get directly coming in off the Sun and then the same wave bounced off some kind of surface, because then the two waves will interact together and you'll be able to look at where the troughs and crests cancel each other out. And they used the sea as one huge mirror to measure the 'bounced off' wave.

**Miller Goss:** A very clever technique, and we've studied very carefully the paper that Ruby and her colleagues have written on this and they really anticipated much of the 20th century developments in radio astronomy that occurred.

**Reading:** Memorandum from Chief of Division, Radio Physics, 25th Feb 1946. During the past 12 months, Miss Payne-Scott has demonstrated a real ability as a research officer. Her work particularly in connection with visibility of signals and noise measurement has been quite outstanding and I will recommend that she be reclassified as research officer.

**Pauline Newman:** Back in the 1940s the temperature of the Sun's surface was known to be almost 6,000 degrees, which seemed pretty hot at the time. Joe Pawsey, and another colleague Lindsay McCready, and Ruby, worked out that the temperature of the Sun's corona is over a million degrees, which leading optical astronomers at the time found incredible. Then they went on to measure the temperature of the solar flares that burst through the corona, and their results were even more amazing. Here's Dick McGee, a distinguished astronomer, now retired, who joined the CSIRO in 1951.

**Richard McGee:** Ruby observed that these types of outbursts of radiation from the Sun came from a particular position on the Sun's surface, and they found that the temperatures that they were observing in the Sun were something like 10 million degrees, and this was an extraordinary situation.

**Pauline Newman:** And that wasn't all.

**Richard McGee:** Ruby was the person who had the mathematical ability and she did all the mathematics. She deduced the magnetic fields associated with sunspots, and she established that disturbances moved outward from the Sun with speeds of the order of 1,000 kms per second. And she deduced that auroras occurred on the Earth after intense outbursts from the Sun, evidence that the particles moved out from the Sun and became involved in the Earth's magnetic field. This was a most important discovery, established by Ruby before 1950.

**Pauline Newman:** It's just really amazing that she isn't better known.

**Richard McGee:** It's extraordinary really, but she was a woman. I hope she's going to be appreciated now anyway.

**Pauline Newman:** Ruby Payne-Scott was working at a time when radio astronomy was in its infancy. There were no dedicated journals on the subject and she published mostly in Australian periodicals that didn't have a wide circulation. So when she left radio astronomy, her contribution to physics was somewhat overlooked. But back in the 1940s, she was greatly admired both by British astronomers and her Australian colleagues. Here's Miller Goss:

**Miller Goss:** They had a fortnightly meeting of the radio astronomers. Joe Pawsey was the director of the radio astronomy group, you could really say that Pawsey was the father of Australian radio astronomy. The first item at every meeting was, Joe Pawsey would look around the room and he would say, 'Ruby, what do you think?' She always led the meeting off, her opinion was the most important. She always was very forceful in her arguments but she was very willing to change her mind. If she was seen to be wrong, she would acknowledge this. But I suspect that she was somewhat intimidating and in some sense this was not surprising because she was about 10 years older than her contemporaries. Many of her contemporaries working in radio astronomy in 1945 were 25, 30 years old. She was in her late 30s at this point and had much more experience, and everyone really respected her.

**Richard McGee:** People loved working with Ruby because she was so clever. You had to have your facts in order or she'd really clamp down on you.

**Claire Hooker:** And no one questioned Ruby because they knew that she would be right, and she always was.

**Pauline Newman:** But like all women in the workforce, she still had to cope with inequality. Before the war, women in work, whether married or single, were assumed to be the responsibility of a husband or father and so not to need a good income of their own. They were typically paid just over half of what a man would get. After the war, employers' organisations wanted a return to the status quo. Ruby would have none of it.

**Claire Hooker:** So she asked for and received equal pay and I think she got a back payment from the Women's Employment Board to cover the shortfall of the period when she was paid inequitably.

**Pauline Newman:** So, was she unusual in as much as she argued for equal pay and she received it?

**Claire Hooker:** Yes, she was unusual. Most women tended to have the attitude of, that's a technical issue, it doesn't actually impinge on the respect that my colleagues give me, so I won't worry about it. It's a fight that has to be fought on a Commonwealth government level, it's not a fight about science. So yes, it was unusual for Ruby to be strident about it at the time when she was. But that was just her personality.

**Betty Hall:** I thought both Bill and Ruby were people who were before their time.

**Pauline Newman:** Ruby's friend, Betty Hall:

**Betty Hall:** Ruby quite forcefully educated me into Australian trade union politics. They were very interested in diet and health foods and things like that, altogether quite advanced people.

**Pauline Newman:** In the late 1940s, Ruby Payne-Scott helped form a union at the CSIRO. Her outspokenness made the security services suspicious.

**Miller Goss:** This is from the director, Sydney ASIO, they're talking about CSIRO radio physicists. They talk about Joe Pawsey and they say, Miss Ruby Payne-Scott, 'She is a queer girl. A bright student but very erratic, was a member of the University Christian Union which seems to be the forerunner of activity in leftist groups. It's thought that she is in a feminist group. I would not put anything beyond her,' is said in quotes.

**Pauline Newman:** You're listening to a special edition of *The Science Show* here on Radio National.

Ruby meanwhile still feared that she would lose her job because of her marriage. Until the regulations were changed in 1966, this was one of the most serious discrimination issues that professional women faced. Eventually Ruby felt compelled to reveal the truth.

**Miller Goss:** The records from this era are in an extremely good condition. Long letters back and forth between Ruby Payne-Scott and Clunies Ross, who was in the CSIR and later on the CSIRO Directorate.

**Reading:** Radio Physics Laboratory, Chippendale.  
20th Feb, 1950.

Dear Dr Ross,

Thank you for your enquiries on my behalf. When I spoke to you about my marriage, I was in effect asking whether the executive realises that customary demoting of women officers on their marriage to the status of temporaries does not appear to be required in the Act, and whether the executive agrees with this procedure or not. All the married women research officers I have met feel that their classification as 'temporary' puts them at a considerable psychological disadvantage in their work. Personally, I feel no legal or moral obligation to have taken any other action than I have in making my marriage known. I have never denied to anyone who has asked me the fact that I am married and it has gradually become common knowledge in the laboratory, particularly as many of the staff are my close neighbours at home. I have told you my story to demonstrate that the present procedure is ridiculous and can lead to ridiculous results.

With best wishes,  
Yours sincerely,  
Ruby Payne-Scott.

**Miller Goss:** The CSIR hierarchy took it very seriously. For an example, she lost her superannuation which was of course a severe financial penalty.

**Pauline Newman:** Her male colleagues who treated her just as a professional scientist were dismayed. Dick McGee:

**Richard McGee:** Ruby had been married for some years and she'd kept this quiet, except that everyone in the lab knew about it, and a child started to come along and she felt that she had to own up. And so they said: Okay, you have to retire. Everyone was really upset about this sort of thing because it seemed so unfair that she had to go when she was at the top of her career. It was a big blow to the prestige of the lab to lose such an important person. As the leader of the Radio Astronomy Group, Dr Pawsey said at the farewell, not only was she a great radio scientist but she was the best physicist in the lab. I was so impressed with Pawsey's speech.

**Claire Hooker:** If you were not legally able to be employed as married women except on this temporary basis, then of course no one would ever dream of such a thing as maternity leave. In that world, men were breadwinners and the basic wage is formulated on the basis that a man supports his wife and family and a woman does the job of rearing children. It was only over-educated women like Ruby who might have wanted to go back to work.

**Miller Goss:** She sent in her letter of resignation. We have a very nice letter that Sir Fred White, Chief Executive Officer of CSIRO, wrote to her as she was resigning.

17th July 1951. Dear Miss Payne-Scott. (You see it's very important that they don't call her Mrs Hall. They have not acknowledged that she is in fact married and that her real name is Ruby Hall.)

**Reading:** Dear Miss Payne-Scott,  
I have seen a letter from Dr Pawsey which tells me that, due to the imminent arrival of your baby, you will no longer be able to carry on with your research work. This event must be giving you a great deal of pleasure but I can well imagine that you regret having to leave off research, at least for the time being. Unfortunately, we cannot give married women leave without pay but I assure you that I at least would be very pleased to see you return to radio physics in due course. I hope the event goes off successfully.

Yours sincerely,  
FWG White, Chief Executive Officer.

**Claire Hooker:** I think that's as plain as you can get. There is no problem with her returning to work. Presumably she would have to have had to put up with the fact of being a temporary employee, but had she wanted to return to research, I think her colleagues made it abundantly clear that there was no problem with her coming back. But she chose not to.

**Fiona Hall:** I have started to think, well of course she would have missed her career. But I would say that she poured all her creative energies really into having children and she really sort of focused on that.

**Pauline Newman:** What sort of mother was she?

**Fiona Hall:** She was great. Growing up in the '50s as I did, it was all the rage to have, you know, birthday parties with frilly nylon party dresses and decorated cakes, and Mum was great at providing all of that, not just all those things but all sorts of other things as well. I mean, she realised when I was very small that I really loved visual things and working...well, when I was very small of course it was finger paints.

She was someone who was always curious about the world and who just assumed that everybody else would have that some curiosity if only you could tap into it. I always thought yeah, Mum knows everything, you know you ask her a question about why does the Sun come up in the morning and she could answer it. She never pushed us but she always made sure that the door was open for us to go along what could be our chosen path. And reading as well, she was great. It wasn't until I was 14 years old that she stopped reading to me at night. So she really was just a wonderful mother and of course I didn't know very much at all about what she did before I was born and it's really only now that so many pieces of the jigsaw of her life are falling into place. I suppose I knew she was pretty clever but not in the ways that I do now.

**Danebank student:** Ruby spent the next 12 years of her life caring for her family at home. In 1963 she became mathematics and science mistress at Danebank and remained here on part-time duties until 1974. The staff and students at Danebank had no idea of the brilliant career that Mrs Ruby Hall had led.

**Pauline Newman:** Carolyn Little, the science co-ordinator at Danebank, is ensuring that the school community today appreciates Ruby's achievements, both as a scientist and as a feminist. Carolyn instigated the Ruby Payne-Scott Lecture which is given each year by a top female scientist.

Ruby died in 1982, a few days before her 69th birthday. Her ashes were scattered in the garden of the home she'd built in Oatley.

**Miller Goss:** I think it's important that her story be told. People had been aware of her existence for a long time, the historians of radio astronomy, but I think highlighting her contributions and the difficult periods that she went through of trying to work as a woman should be documented.

**Carolyn Little:** She was somebody of outstanding intellect, of great vision, enthusiasm, passion, somebody without fear, somebody who would take up a cause if she believed it to be right and run with it as far as she could. The role model for all girls.

**Fiona Hall:** It's people like her that opened up doors for generations like my generation to follow, to make it a bit easier for women in the professional workplace. And I guess I'd like her to be remembered as a great mother who nurtured both of her children to allow them go on and have excellent careers as well.

**Miller Goss:** It's such a tragedy that she only worked as a radio astronomer from 1945 to 1951. Because she left this job so soon in her career, she never really was given the recognition that she certainly deserved.

**Carolyn Little:** I often think that Ruby's life was like a supernova; a great brilliant explosion that tragically died out very quickly.

**Robyn Williams:** Yes, too quickly, as ANU Vice-Chancellor Brian Schmidt too has told the Academy of Science. And I have actually asked Karen Andrews, our Minister for Science, to consider an honorary Prime Minister's science recognition for Ruby Payne-Scott. That feature was by Pauline Newman.

