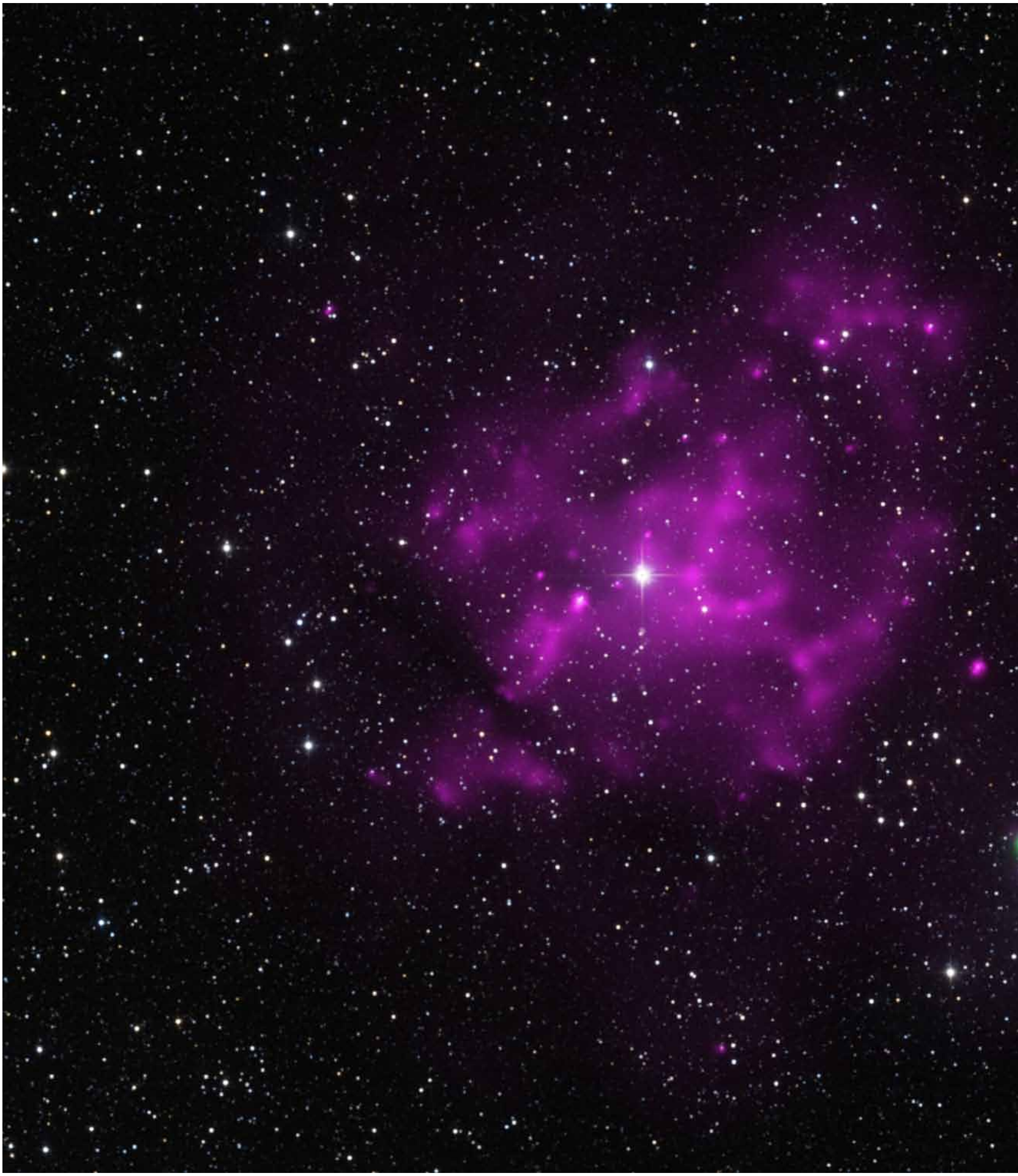


X-ray: NASA/CXC/UC Berkeley/J. Tomsick et al and ESA/XMM-Newton; Optical: DSS, 2MASS/UMass/IPAC-Caltech/NASA/NSF

Researchers using three different telescopes -- NASA's Chandra X-ray Observatory and ESA's XMM-Newton in space, and the Parkes radio telescope in Australia -- may have found the fastest moving pulsar ever seen.

The evidence for this potentially record-breaking speed comes, in part, from the features highlighted in this composite image. X-ray observations from Chandra (green) and XMM-Newton (purple) have been combined with infrared data from the 2MASS project and optical data from the Digitized Sky Survey (colored red, green and blue, but appearing in the image as white).

The large area of diffuse X-rays seen by XMM-Newton was produced when a massive star exploded as a supernova, leaving behind a debris field, or supernova remnant known as SNR MSH 11-16A. Shocks waves from the supernova have heated surrounding gas to several million degrees Kelvin, causing the remnant to glow brightly in X-rays. [Courtesy Harvard-Smithsonian Center for Astrophysics]

Dame Jocelyn Bell, Astrophysicist

BY SUSANNA KUMLIEN

As a young postgraduate Dame Jocelyn Bell Burnell discovered the first pulsar.And the second, third and fourth. Her boss and and fellow worker were awarded the Nobel, but Bell Burnell was left without. Not that she minds, she has even stated that the Nobel is slightly overrated. Instead she has won a prize almost every year and with every prize there is a party, which allows her to have more fun.

Photo: Nobelmuseet

Madame Curie, the first woman to receive the Nobel in Physics

As the Prize Committee, headed by its permanent Secretary Anders Normark, on October 9th gathers in the Session Room of the Royal Swedish Academy of Sciences to announce this year´s Nobel Prize in Physics, it will mark the 110th year since a woman received it for the first time.

In 1903, Marie Sklodowska, better known under her married name Marie Curie, received the prize together with her husband Pierre and Antoine Henri Becquerel "in recognition of the extraordinary services he has rendered by his discovery of spontaneous radioactivity". Curiously, the prize was not equally distributed among the three, but with Marie jointly sharing half the prize with her husband. She would seven years later be awarded again, this time in Chemistry "in recognition of her services to the advancement of chemistry by the discovery of the elements radium and polonium" and thereby be the only woman ever to have received a Nobel Prize twice (whereas three men have been granted the same honour).

Marie Curie´s 1903 prize also accounts for 50 percent of Nobel Prizes in Physics given to women during its entire history. The other woman to have received it, Maria Goeppert-Mayer, was in 1963 honoured "for discoveries concerning nuclear shell structure", also receiving a fourth share of the prize (sharing half of it with German physicist J. Hans D. Jensen).

Up until the 1970s the number of women who received Nobel prizes was roughly proportional to the number of women doing scientific research. That is, a small group of women winning a small number of Nobel prizes. But as the number of women in science has increased over the past 40 years, women Nobel laureates remain the exception.

Alas, among the 194 physicists in total awarded the Nobel Prize during its entire 112-year history, only two have been female. A telling figure, but it doesn´t have to imply there haven´t been women around with the necessary qualifications. People in science often refer to two specific cases in this regard: Lise Meitner, whose equations guided the experiments that led to the discovery of nuclear fission, and Jocelyn Bell, who discovered a form of neutron stars known as pulsars.

Lise Meitner, whose scientific achievements are indisputable to most physicists of today, died in 1968 and nowadays has her own award – the Lise Meitner Prize was founded in 2006 by Chalmers in Gothenburg and is annually awarded to a person having performed groundbreaking discoveries in Physics.

But Bell is alive and kicking, a well-known figure in the world of public understanding of science. In 2010 she was awarded the Royal Society Michael Faraday prize for excellence in communicating science and she has served on many boards and panels throughout Europe, including as president of both the Royal Astronomical Society and the Institute of Physics.

During her distinguished career her many awards and honours include the Oppenheimer Prize, the Michelson Medal, the Tinsley Prize and the Herschel Medal. UK and US universities have conferred honorary doctorates on her, and she holds an Honorary Fellowship in her former Cambridge College and has also won the Edinburgh Medal. She became a Fellow of the Royal Society in 2003. In 2007, when she became Dame Commander of the Order of the British Empire in recognition of her services to science in the Queen's Birthday Honours, the *Guardian* newspaper said: "The Damehood awarded to Professor Jocelyn Bell Burnell goes some way to righting one of the most notorious wrongs in science."

No wonder one of her many quotes worth considering is about the Nobel Prize "being slightly overrated".

Nevertheless, the total absence of any pompousness about her is striking as I have the privilege to meet her at a Physicists' Congress in the southern provincial town of Lund in Sweden. She comes across as unpretentious and charming, is accessible for friendly chats and as we run together from a lecture, trying to avoid getting wet in the rain, there is girlish giggle.

Jocelyn Bell is a sought-after lecturer all over the world, and she travels intensely despite her 70 years of age. By the time I reach her for an interview, she is in the Xinjiang province of China.

"Officially I am retired, but I am still active in the sense that I do a lot of lecturing and a lot of committee work. Here in China I have been speaking to school students

Jocelyn Bell

about astronomy, and to graduate students, and to professional colleagues, often about pulsars. I will also do a public lecture at Peking University later this week," she says.

"I, and some other European and US scientists, have met with the Xinjiang state chairman to encourage the state to fund a new radio telescope in Xinjiang. What I am doing here is quite like what I do all the time. Soon after I get back, I go to Ireland to speak to a student astronomical society at a university and to present the prizes at a girls' high school. There will be several committee meetings in Oxford in between!"

"My position in Oxford is as Visiting Professor – they give me a desk, computer and library access but they do not pay me. My pension is my income. In the Department I am a spare pair of hands, so if they need an extra person to give a student a viva exam I may be asked for example. Oxford Astrophysics is a great place to be; it is a large Department with a lot going on and lots of visitors passing through. I feel very privileged to be there. I also have a similar position at one of the colleges – Mansfield. This is a source of more committee meetings!"

Jocelyn Bell was part of the team that discovered the first pulsar, a spinning star rich in neutrons. In fact it was she who noticed not only the first one but also the second, third and fourth.

In the late 60s, as a postgraduate at the University of Cambridge, under the supervision of Antony Hewish, Bell helped in constructing and operating an 81.5 Megahertz radio telescope. She studied interplanetary scintillations of compact radio sources and

Photo: Marcus Macelic, KVA

Staffan Normark, Permanent Secretary of the Royal Swedish Science Academy.

was responsible for analysing the data. At the time, a phenomenon called quasars had recently been discovered and astronomers were looking for more such objects to study.

While analyzing literally miles of printed data from the telescope, Jocelyn Bell noted a few unusual signals which she termed as "scruff". These "bits of scruff" seemed to indicate radio signals too fast and too regular to come from quasars. Sources of error in the data, such as orbiting satellites, television signals and radar reflections from the moon were ruled out.

No known natural source would produce such a signal, a series of sharp pulses that came every 1.3 seconds. It seemed too fast to be coming from anything like a star. Bell and Hewish jokingly called the new source LGM-1, for "Little Green Men." Consulting some papers in Theoretical Physics, they determined that these signals must have emerged from rapidly spinning, super-dense, collapsed stars. Bell and Hewish submitted a paper to *Nature* describing the first pulsar.

The findings led to her supervisor, Antony Hewish, and her Head of Department Martin Ryle, winning the Nobel Prize in Physics in 1974. She has always taken what many people in science believe to be a snub with good grace, although she said in one interview in 2006: "And so I think at one level it said to me 'Well men win prizes and young women look after babies.'"

"There was some outrage, especially amongst my contemporaries, that I was not included, and I have been carried on a wave of sympathy, augmented by a feminist wave, and have received many, many other awards since. If you receive a Nobel Prize nobody ever gives you anything again, as they feel they cannot match the Nobel. By contrast I have had an award almost every year since then, each with its own party, and this seems to me much more fun! I was lucky enough to go to Stockholm as a guest of Joe Taylor when he received the Nobel Prize in 1993 – or was it 94? – and saw what happened there. It was an amazing week. I decided it was more fun to go as a guest than as a laureate!

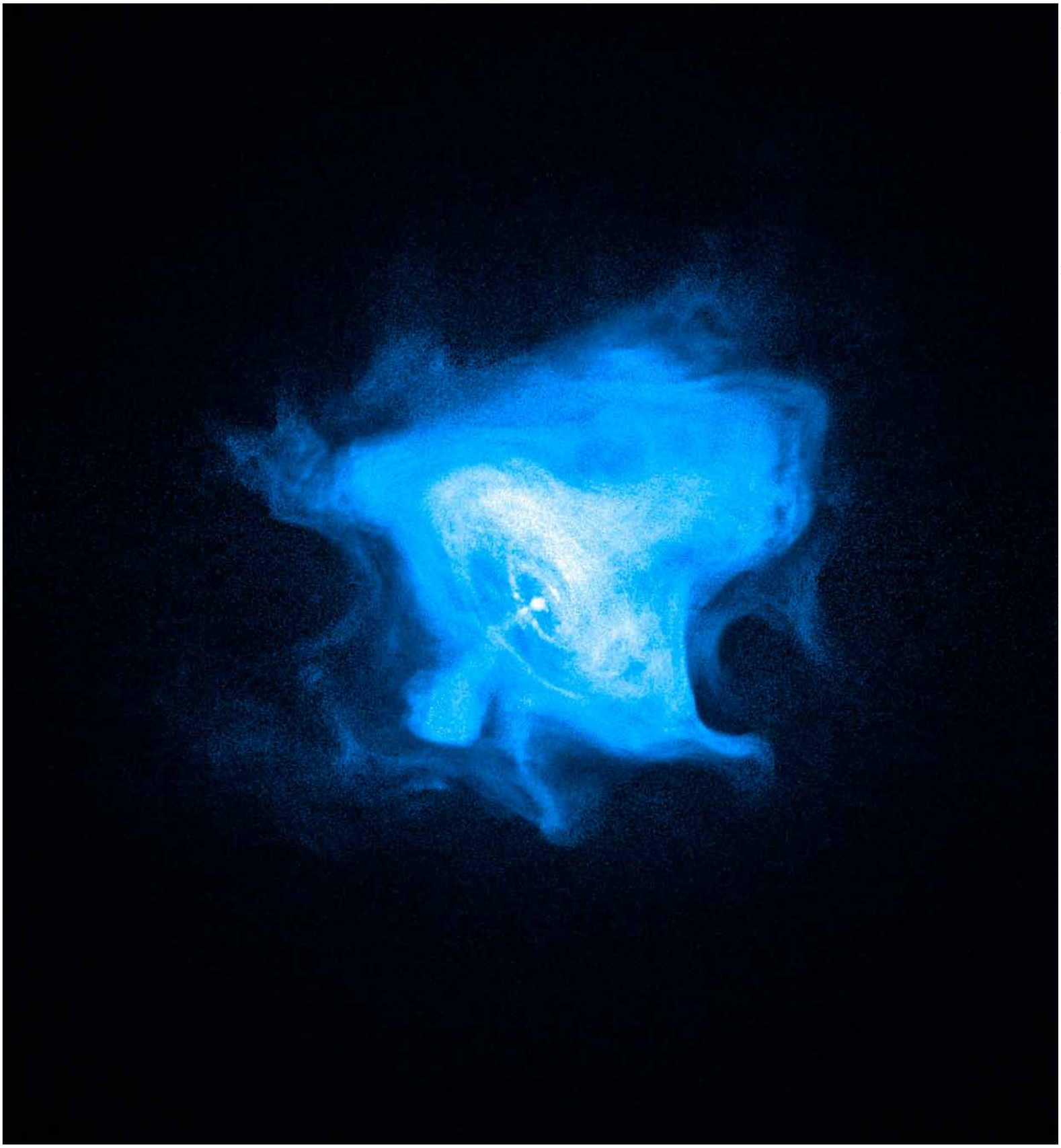
"My immediate reaction to the 1974 Nobel announcement at the time was to recognise what an important precedent this was. There is no Nobel Prize in Astronomy and this was the first time the Physics prize committee had felt anything in astronomy was worthy of the Physics prize. I was proud that it was neutron stars that had opened the Physics community's eyes to Astrophysics! And indeed it has opened a door – perhaps a dozen astronomers since then have received a Nobel Prize."

In 1968, soon after her discovery, Bell married Martin Burnell (divorced 1993). Martin was a civil servant, and his career took them to various parts of England. She worked part-time for many years while raising their son, Gavin Burnell. During that period she began studying almost every wave spectrum in astronomy and gained an extraordinary breadth of experience. At the University of Southampton, she developed and calibrated a 1-10 million electron volt gamma-ray telescope. She also held research and teaching positions in X-ray Astronomy at the Mullard Space Science Laboratory in London as well as working with infrared astronomy in Edinburgh.

"In Britain at the time married women did not usually work – it reflected badly on their husbands – it seemed then that the husband did not earn enough. Also mothers were strongly discouraged from working: we were told it was proven that if mothers worked, the children became delinquent. I think this came about because during the war women worked because men had gone to the front to fight. When the war finished and the men were coming home, the government had to get the women out of the jobs to make them free for the men, and one way they did this was to put strong emphasis on women at home as wives and mothers. I worked part-time for 18 years while our son grew up. Child-minding arrangements were difficult – there weren't any work-place nurseries! My husband worked in local government and the way you advance in that field is to move to another area to take up a bigger job. So that is why I have worked in so many places and in so many parts of the electromagnetic spectrum."

Throughout her career, Dame Jocelyn has remained fascinated by the mysterious phenomenon of pulsars. Pulsar research remains very active and full of unexpected turns even 45 years after they were discovered. "Normally, you would have expected a new field to have settled down by now," says Jocelyn Bell. "But this field is still like a teenager rather than a sedate middle-aged person!"

"Pulsars have extreme physics, so they are excellent laboratories. They have



Courtesy of the Chandra X-ray Observatory, the Harvard-Smithsonian Center for Astrophysics

In the Crab Nebula, a rapidly rotating neutron star, a pulsar, powers the dramatic activity seen by the Chandra Telescope. The inner X-ray ring is thought to be a shock wave that marks the boundary between the surrounding nebula and the flow of matter and antimatter particles from the pulsar. Energetic particles move outward to brighten the outer ring and produce an extended X-ray glow. The jets perpendicular to the ring are due to matter and antimatter particles spewing out from the poles of the pulsar. The fingers, loops and bays visible on the outer boundary of the nebula are likely caused by confinement of the high-energy particles by magnetic forces.

Jocelyn Bell´s father was an architect in Belfast. The Armagh Observatory consulted him for the maintenance of the old building as well as designing any new buildings they needed - such as the Planetarium. "In school holidays I used to go with him when he went out of the office to visit sites where his new buildings were being built and to the Observatory. I have memories of crawling through the roof rafters in the old building trying to locate a leak in the roof. I tease the Armagh astronomers that I know their roof better than they do!" says Jocelyn Bell.

extreme densities, more dense than the nucleus, and so are extending our understanding of matter at very high densities. Because they pulse very steadily they are like clocks distributed through the galaxy, and for the first time we can do experimental relativity with these "clocks". Because of their extreme gravity we can also use them to check Einstein's theory of gravity. They have very strong magnetic and electric fields, so there is important work going on trying to understand what happens when you have such fields. We can see different kinds of pulsars but we have not yet sorted out how they are related to each other."

Another accomplishment of Bell´s is no doubt pointing out the importance of women in science, and as a lecturer and the first woman to chair IOP – Institute of Physics – she´s been promoting Physics and bringing physicists together for the benefit of all.

"It has been shown that companies/businesses that have the greatest diversity in their workforce are the strongest – robust and flexible. It is believed that having people who approach a question from different backgrounds gives this. I believe the same applies to research – a diverse group will be more successful than one made of, for example, white British males."

"Prizes like the Nobel were set up when our picture of research science was that there was a top man (yes, nearly always a man) and under him were a lot of 'servants' –scientists and assistants who did what he told them to do and who were not expected to think, only to carry out orders. Today we see science as done by groups of people each making a contribution. But many of the prizes can only be awarded to a restricted number of people, and this makes problems for those of us who sit on prize-awarding committees, as we know that lots of people have helped in a significant way with the prize-winning work. You will see that now some of the professional bodies have set up prizes for groups or teams of people, as we are all aware of this issue." ■