

# Bryan Gaensler interview transcript

## Introduction

Music

Interviewer:

Can you tell us the different types of electromagnetic radiation and how we use them in astronomy?

Bryan Gaensler:

The light that we see with our eyes it's just a tiny slither of a much broader set of phenomena called the electromagnetic spectrum. If you take the light that we see, visual light or optical light and make the wavelength of that light a little bit shorter, it becomes a type of radiation that our eyes can't see, called ultraviolet light. Take that light and make it even shorter and you get X-rays and eventually get gamma rays. On the other extreme if you take the light that we can see and make the wavelength longer, you get infra-red radiation, and then microwave radiation, and then radio waves. So, all of these different types of radiation are really just the same thing they're just light as light we can see and light we can't see and if you put it all together it makes something called the electromagnetic spectrum.

## Useful parts of the electromagnetic spectrum

Interviewer:

What type of electromagnetic radiation is most suited for your work and why?

Bryan Gaensler:

For hundreds of years astronomers looked at the sky using normal telescopes using the same sort of light that we can see with our eyes. But we now know the sky emits radiation across the entire electromagnetic spectrum. The two types of astronomy that I find most useful are at opposite extremes, I use radio telescopes and I use X-ray telescopes. Now radio waves are very powerful in astronomy because visual light is blocked by all the dust and muck and soot and dirt in the universe but radio waves are very powerful they go through almost anything. So, if you want to see what the whole universe looks like, see all the way from the very edge of the universe to the nearby universe you really have to go for radio waves. Now X-ray astronomy is very powerful because even though the X-rays are blocked by dirt and muck, X-rays only come from the most energetic extreme objects. So, if you want to study objects that flare or burst or explode or are very hot and really the only way to get a handle on that extreme universe is by looking at the light of X-rays.

## Our knowledge of space

Interviewer:

How does the use of electromagnetic radiation help our knowledge of space?

Bryan Gaensler:

We're able to send probes to the Moon and to planets in the solar system and to the sun. But if we want to understand what other stars and galaxies look like we can't fly there and take a teaspoon of the stuff and bring it back, we need to use what information is sent out from these objects on a one

way trip to Earth and the only thing these objects send out mainly is light. So, if you want to understand the universe we need to build telescopes and collect the radiation that these objects give. The catch is that most of the universe is invisible. The universe is full of exotic stuff like dark matter and dark energy that doesn't give out any light at all. So, we can learn an awful lot about the things that do give out light, stars, planets, nebulae, galaxies but we have to remember when we draw conclusions from these that we're only learning about the bits of the universe that give off light. The bits of the universe that are invisible are much harder to understand and we have to think a lot more carefully about how to work out what's going on with them.

## Information from the EM spectrum

Interviewer:

Which parts of the electromagnetic radiation spectrum are giving us the most information on space and our surroundings?

Bryan Gaensler:

There's no real particular special type of radiation that tells us more than anything else about the universe. Modern astronomy uses the entire electromagnetic spectrum from radio waves to visual up to X-rays and gamma rays and everything in between to build up a picture. It's a bit like listening to an orchestra, if you only can hear the violins or the flutes you don't get the whole story. If you want to hear the true cosmic symphony of the universe you have to have all the instruments playing at once. And to this end modern astronomers use a whole suite of telescopes all over the world and also up in space, in orbit, and elsewhere around the solar system to piece together all the different types of objects that emit radiation and see what the universe is telling us. Quiet, calm, not very energetic objects emit in things like radio waves; medium, bubbly, hot things like the Sun emit in visual ;and the most extreme explosive things emit in X-rays and gamma rays. If you want to put the whole picture together then you need all parts of the electromagnetic spectrum at your disposal.

## Information from EM

Interviewer:

What kind of information are they giving us?

Bryan Gaensler:

Different parts of the electromagnetic spectrum tell you about different processes happening in the universe. For example, one of the ways in which radio waves are very powerful is that all of interstellar gas, quiet gas it's not doing anything on its own, is gently emitting in the light of radio waves. So, if you want to see calm, cool interstellar gas, radio waves are the way to go. It turns out that most stars emit in visual light. So if you want to see stars like the Sun, you use normal optical telescopes. If you want to see very exotic ,extreme objects like neutron stars and black holes and jets slamming into things at the speed of light, then these tend to emit in X-rays, and so you need to use X-ray telescopes to study them. So, it really depends on what sort of object it is, how hot it is, and how energetic it is, as to what type of electromagnetic radiation you choose to study it.

## Different types of telescopes

Interviewer:

How does this telescope work, and how does it differ from other telescopes here?

Bryan Gaensler:

This is a radio telescope, and so just like any telescope, it needs to collect as much light as it can. If you want to see faint objects then you have to gather up lots of light. And so you can think of any type of telescope as a light bucket, and this telescope uses its curved dish to gather up light over a large area. In order to make a picture you need to focus that light to a point so the curved surface of the dish reflects the light up to the focus where there's a detector that is able to essentially make an image of whatever the telescope is pointing at. Now, this telescope's rather special in that it has something called a focal plane array at its focus. And that means instead of looking at one place at once it actually can look at dozens of places at once. So, it's like instead of having one eye imagine if you had a whole array of eyes on your face and each one of them was looking at a slightly different position, you could actually look at multiple different people at once. And this is new technology that's been developed in Australia that makes the telescope rather different from other radio telescopes around the world.

## Problem of interference

Interviewer:

I thought the radio telescopes had to be away from other electromagnetic radiation interferences. Can they still do useful work in suburbs like in Sydney?

Bryan Gaensler:

This radio telescope here in the suburb of Sydney isn't very useful for actually doing modern radio astronomy and that's because in any big city you are totally swamped by radio signals from radio stations, from people's mobile phones, microwave ovens, cars, TV and everything else that's a part of modern society. So, if you want to be able to actually detect the very faint whispers of radio waves in space you need to put your telescope somewhere very far away from towns and cities where the radio environment is very quiet. It's very important to do that because as soon as someone starts talking on their mobile phone or a radio station's transmitting it completely drowns out the signal. This is a big problem for radioastronomy and it's very important when we build our new telescopes that we very carefully survey the area and make sure that it's completely radio quiet before we set up our equipment.

## Seeing into space

Interviewer:

How far into space can radio telescopes usefully see?

Bryan Gaensler:

Radio telescopes can see further into space than any other type of telescope. So, if you point a radio telescope out as far as you can see it will pass all the galaxies and everything else, you eventually hit this wall that looks like mist in every direction. That wall's about 13.7 billion light years away. That means that even at the speed of light it would take you 13.7 billion years to get to it. And that wall is called the Cosmic Microwave Background, and that is the glow left over from the Big Bang at the beginning of the universe. We can't actually see all the way to the Big Bang because the mist gets too thick to see, but the universe starts to clear out about three hundred thousand years after the Big Bang and that's the most distant thing we'll ever be able to see in the universe.

## Focal plane array

Interviewer:

So, how does this telescope compare with other installations overseas?

Bryan Gaensler:

This telescope's different from other radio telescopes around the world in a number of important ways. This testing ;this brand new type of technology called focal plane arrays, and that means instead of a telescope pointing at one place at a time, it can point at about a dozen different places at the same time. And, if you combine all those images, then you get a panorama of the sky. You could think of this telescope as a prototype of a fish-eye lens for radioastronomy. So instead of making a tiny, little picture of one little thumbnail of the sky, we get a beautiful broad sway, and we can see lots of things going on at once.

## Big discoveries

Interviewer:

What sort of work do you do with radio telescopes and have you made any big discoveries?

Bryan Gaensler:

A lot of the work I'm doing with radio telescopes at the moment is mapping out the magnetism of the universe. One rather exciting discovery ,that I'd made last year, is that we were looking at the thickness of the Milky Way. If you look up in a book every book tells you the Milky Way's a big, flat pancake and it's about six thousand light years thick. So, we use a special type of object called pulsars ,that allow us to work out how far away they are, to measure the thickness of the Milky Way and to our surprise we found out that everybody else, until now, had made a mistake in their calculations and the galaxy is really twelve thousand light years thick. We discovered the galaxy is twice as thick as everyone else thought it was, a total surprise, a total change in the textbooks, but it looks like our galaxy is a lot bigger than we thought it was.

## The most exciting event

Interviewer:

What's the best thing you've seen using a radio telescope?

Bryan Gaensler:

The most exciting thing that's ever happened to me in radioastronomy is something that happened just after Christmas in 2004. A tiny, little object called a neutron star with a rather romantic name of SGR1806 minus 2 zero, gave off a huge star quake. Now, this star is a long way away, it's about fifty thousand light years away, but for half a second it was brighter than every other star in the Milky Way put together and I was lucky enough to be in the box seat for this event I was able to steer a whole bunch of radio telescopes to the star right after the star quake and we saw a glowing bubble because the star blasted off its outer layers into space at half the speed of light. We were able to watch this incredible expanding bubble changing everyday getting bigger and fainter from this catastrophic explosion fifty thousand light years away.

## Controlling telescopes

Bryan Gaensler:

This is one of the remote observing stations here in Sydney and we use this to control over the

internet telescopes like this, the Australia telescope compact array which is up in Narrabri about seven hours from here. So, it's a variety of different things on the screen, some of them are about the health of the telescope, is the power on, is the wind blowing too strongly, what's the weather like. There are basic things like the time we have Greenwich mean time which is the international time that everyone uses so we don't get mixed up about time zones. And then we also have something called the sidereal time which is the time of the stars. The stars actually rise and set but they rotate across the sky at a slightly different speed than the Sun and so the stars have their own time. Here is the actual data coming in off telescopes. We don't actually take a photograph. What we do instead is, we record a whole lot of electrical voltages. So, these are the levels of the different voltages and signals coming in from all the different telescopes and they all multiply together and recorded as a string of numbers on a DVD. And it's only many weeks, or months, or sometimes even years later that you have done all the right calculations on the computer to turn this into a pretty image of a star or a galaxy. Normally, you don't steer the telescope in real time. I don't normally say 'Okay, I now want to look at that star and type'. You actually right a schedule in advance, like a recipe 'I'm going to look at this object for ten minutes, and then this object, and then this object'. And so that's all done in advance and then, at the start of the observations, I load that in and I tell it to go. And, if everything goes smoothly, I don't actually have to do anything for the whole observation. So, we have international visitors that come from all over the world here to Sydney. As I said they don't normally go to the telescope, but sitting here in front of these consoles, it's pretty much just like the real thing and you can get all the information you need sitting here, transmitting the data over the internet.

## Gazing at the stars

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Interviewer:

Thank you for coming to speak to us today, professor. I just have a few questions I'd like to ask you. Did you enjoy science at high school?

Bryan Gaensler:

I actually liked maths more than I liked science at high school. I liked it but a lot of the experiments were sort of boring, and you sort of knew what the answer had to be. And there didn't seem to be a real point. So, it wasn't until after school, and onto uni, where I realised that science was really all about figuring things out for yourself rather than just following a recipe.

Interviewer:

So have you always wanted to gaze at the stars?

Bryan Gaensler:

I've wanted to be an astronomer ever since I can remember. You know I was three or four I think when I decided I was really interested in astronomy and I've got pictures of myself at eight or nine looking through a telescope and it's pretty much the only thing I ever wanted to do.

## Inspiration to be an astronomer

Interviewer:

What inspired you to become an astronomer?

Bryan:

When I was pretty young my parents got me a book called the 'Album of Astronomy,' and I got really excited by the fact that there were so many things that we just didn't know the answers to. Normally, your mum or dad knows the answer or your teacher knows the answer, but this book said there are things out there that nobody knows the answer to and that got me really excited that astronomy was something where there was so much to discover.

Interviewer:

So what has been the most memorable part of your career so far?

Bryan:

I think the most exciting moment in your career is when you discover something and you realise that you're the first person who's ever discovered it. For example, four or five years ago I set out to make the most detailed map anybody has ever made of the magnetism of the galaxy. And so I decided to study the nearest galaxy to us, the Large Magellanic Cloud and the moment where the picture came up on the screen after all my calculations that showed that this galaxy really was magnetic, and I was seeing it in incredible detail. It's really exciting when you see something, and you know that you're the first person in the history of humanity that's ever seen this discovery or this measurement.

## Optical and radioastronomy

Interviewer:

So, what's the difference between optical astronomy and radio astronomy?

Bryan Gaensler:

They're very different in terms of the techniques you need to use. Optical astronomy just takes normal light and shines it through a lens or a mirror, and then puts it onto essentially a digital camera. With a radio telescope you have to have a giant satellite dish and you have to gather up the radio signals, and record them as a voltage onto a disk. So in optical astronomy you basically see the picture straight away in a camera. With a radio telescope you get a whole bunch of numbers and voltages and electronic information and you have to process that for a lot of time before you can make a picture. But ultimately some objects, when you finally make the picture, look the same in radio and optical and some look very different and those differences tell you what the object's made of and what it's doing.

## Australia's role in radioastronomy

Interviewer:

Compared to optical astronomy, radio astronomy is a relatively new field. How has Australia contributed to the progress?

Bryan Gaensler:

Australia has been one of the real leaders in radioastronomy. We were one of the first countries to do radio astronomy in the 1940s and some of the most important discoveries in radioastronomy, like the fact that our galaxy has a giant black hole at the centre of it, were made right here in Sydney in the early days of radioastronomy. We don't necessarily have the biggest radio telescopes in the world, but technologically our telescopes are extremely advanced and can make sorts of measurements that no other telescopes can do. So we're very much world leaders in radio astronomy and everyone around the world recognises that.

## Magnetic stars

Interviewer:

How is the existence of magnetic stars changed our understanding of the formation of galaxies, stars and our solar system?

Bryan Gaensler:

So, I've done a fair bit of work on this very strange type of object called Magnetars, which are these most magnetic stars in the universe. They're a thousand trillion times more magnetic than the Earth and so these allow us to push the extremes of our understanding of what matter is made of and how it works. You can't make magnets that strong in a laboratory and there's no other naturally occurring magnets in the universe that are that strong. So, we can actually look at the fundamental properties of matter and magnetism and electricity by studying these incredible, crazy, magnetic stars.

## Square kilometre array

Interviewer:

What is the future of the SKA in Australia if it's not chosen for the preferred site in 2010?

Bryan Gaensler:

Australians have been working for about fifteen years towards the biggest telescope ever conceived a Square Kilometre Array or SKA and there are two sites, Australia or South Africa. We're hopeful and we feel like we've got a good case for it to be put in Australia but if it's decided that this telescope goes to South Africa, Australia will still be in the box seat because we're the ones that know how to build these sort of telescopes; we know how to operate them; we know how to develop the computers that will process the data. So, even if the SKA is not built in Australia, it will really be Australians who will be taking the lead, in making the telescope happen, in processing the data and making the discoveries that come from that.

Interviewer:

The SKA's been described as the telescope of the future? Do you think it is or do you think as technology develops so will our ways of researching?

Bryan :

I think that if you want to see things that you haven't seen before then you can either adjust your technologies to make the telescope more sensitive or you can build a bigger telescope. We are getting close to the theoretically maximum sensitivity of our technologies and so it's very hard to make improvements just through thinking of cleverer ways to measure the sky. The next step forward has to be a bigger telescope. So, as simple as that seems, the SKA is the future because it will be ten or fifty or a hundred times bigger than anything we have now. The catch is that with such a big telescope the data that comes out of it is unbelievably complicated and we have to have very sophisticated computer programs to deal with that sort of data. The future is very much in building a bigger telescope than what we have now.

Music

## Current projects

Interviewer:

What project are you currently working on?

Bryan Gaensler:

Right now I'm trying to understand why the universe is magnetic and in particular what I'm trying to do is look at different types of galaxies at different stages in the universe's history, to see if galaxies that were around earlier on in the universe were more magnetic or less magnetic than galaxies that we have now. So, I have now our own home galaxy, the Milky Way, I have nearby galaxies and I have some very young galaxies that I'm looking back in time to earlier in the universe and I'm carefully trying to measure the magnetism of all these different galaxies to see how magnetism is changing as the universe, as it gets older.

Interviewer:

What are the planned outcomes of this project?

Bryan:

Well, if we can actually see magnetism changing as the universe gets older then we'll be able to understand just why galaxies are magnetic. If the magnetism is growing really fast at the time, that will tell us there are certain processes that are generating magnetism. And if the magnetism is growing very slowly, that will tell us that those fast processes aren't working and it must be more slow processes. So, it's going to be something involving how gas flows around, how galaxies rotate and how often stars explode or the swirling stirring motions that might make magnetism in the galaxy. We really don't know whether magnetism is something that grows fast, grows slowly, or gets bigger and smaller and this sort of data will allow us to put that whole picture together.

## Encouraging a career in astronomy

Interviewer:

For students currently studying science what would you do to encourage them to take a career in astronomy?

Bryan Gaensler:

Well, I think that if you want to be an astronomer you have to make sure you're doing it for the right reasons, you're not going to be particularly rich or famous but you will have an amazing, rewarding, exciting career. So, if a student wants to be an astronomer, I would say you need to be good at maths, you need to be good at physics; and you need to be good at computers; so those are the sort of things that you might want to start looking to in high school because although a lot of it is just saying 'Isn't this beautiful galaxy amazing,' or 'Isn't that star pretty?' You need to understand all the maths and the physics of how the telescope works and how the signals travel to you, in order to get to that stage.

Interviewer:

What do you see as the future of astronomy in Australia?

Bryan :

Well, hopefully the Square Kilometre Array will be built in Australia and that will put us at the forefront of astronomical research for many decades to come. There are some big questions in astronomy right now. What is dark energy? (which seems to be seventy per cent of the universe). Is there life around other stars? How were the first stars formed? And if we play our cards right then this ,and other telescopes, will be the telescopes that answer those questions. It will be Australian scientists who are the people that make the discoveries that let us answer them.

Interviewer:

Thank you Bryan for answering all those questions.

Bryan:

Thanks very much.

## Resources

These resources may be accessed via the Teaching and Learning Exchange [www.tale.edu.au](http://www.tale.edu.au)

Science Talk 2008 (features famous astronomers Fred Watson and David Malin):

[http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/scitalk08/index.htm?Signature=\(0e97044c-f84c-48b1-b84c-a8c88f008275\)](http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/scitalk08/index.htm?Signature=(0e97044c-f84c-48b1-b84c-a8c88f008275))

Fred Watson Masterclass (presents his Stargazer talk, student questions and answers, and an interview with Fred. There is also an excellent learning activity on producing a composite image from several astro-images):

<http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Cli/Download.aspx?resID=7867&v=1&preview=true>

David Malin Masterclass (how photography has made modern astronomy possible):

[http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/malin\\_masterclass/index.htm?Signature=\(69d6abeb-b425-4ea5-8f71-14f3ee2b8b85\)](http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/malin_masterclass/index.htm?Signature=(69d6abeb-b425-4ea5-8f71-14f3ee2b8b85))

Forces and fields:

[http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/Forces\\_and\\_fields\\_creative\\_commons/index.htm?Signature=\(b2d2fcec-a5f2-4fc3-8451-ca1df1a0a82e\)](http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/Forces_and_fields_creative_commons/index.htm?Signature=(b2d2fcec-a5f2-4fc3-8451-ca1df1a0a82e))

Sites2See: International Year of Astronomy 2009

[http://lrr.dlr.det.nsw.edu.au/LRRView/8150/8150\\_00.htm](http://lrr.dlr.det.nsw.edu.au/LRRView/8150/8150_00.htm)

Intel skool resources

Gravity:

[http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/skool/phys/sim/Gravity/index.htm?Signature=\(c50aee55-1b63-41ef-99c8-dc4353f69606\)](http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/skool/phys/sim/Gravity/index.htm?Signature=(c50aee55-1b63-41ef-99c8-dc4353f69606))

Gravity and the Solar System:

[http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/skool/phys/step/gravity\\_solar\\_system/index.html?Signature=\(7071c020-10b9-48c7-903c-d7082ca34d2b\)](http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/skool/phys/step/gravity_solar_system/index.html?Signature=(7071c020-10b9-48c7-903c-d7082ca34d2b))

This resource is based on outcomes from the NSW Board of Studies 7-10 Science syllabus and the Preliminary and HSC Physics Syllabuses.

## Syllabus links

- BOS Science 7 to 10 syllabus link1.

### Stage 4/5 - Prescribed Focus Areas

Students will develop knowledge and understanding of:

- \* the history of science
- \* the nature and practice of science
- \* applications and uses of science
- \* current issues, research and development.

Students learn about:

5.9.1 the big bang theory

5.9.3 components of the universe

Students learn to:

5.9.1 a) discuss current scientific thinking about the origin of the Universe

5.9.1 c) describe some of the difficulties in obtaining information about the Universe

5.9.3 a) relate some major features of the universe to theories about the formation of the universe

5.9.3 b) describe some changes that are likely to take place during the life of a star.

### Stage 6 – Prescribed Focus Areas

Students will develop knowledge and understanding of :

1. the history of physics:
2. the nature and practice of physics
3. applications and uses of physics
4. implications for society and the environment
5. current issues, research and developments in physics

A student :

- P1. outlines the historical development of major principles, concepts and ideas in physics

H1. evaluates how major advances in scientific understanding and technology have changed the direction or nature of scientific thinking

P2. applies the processes that are used to test and validate models, theories and laws of science with particular emphasis on first-hand investigations in physics

H2. analyses the ways in which models, theories and laws in physics have been tested and validated

P3. assesses the impact of particular technological advances on understanding in physics

H3. assesses the impact of particular advances in physics on the development of technologies

P4. describes applications of physics which affect society or the environment

H4. assesses the impacts of applications of physics on society and the environment

P5. describes the scientific principles employed in particular areas of research in physics

H5. identifies possible future directions of physics research

#### (8.5) The Cosmic engine

Students learn to:

- outline the discovery of the expansion of the Universe by Hubble, following its earlier prediction by Friedmann
- describe the transformation of radiation into matter which followed the 'Big Bang'
- outline how the accretion of galaxies and stars occurred through:
  - expansion and cooling of the Universe
  - subsequent loss of particle kinetic energy
  - gravitational attraction between particles
  - lumpiness of the gas cloud that then allows gravitational collapse

#### (9.7) Astrophysics (Option)

Our understanding of celestial objects depends upon observations made from Earth or from space near the Earth

- discuss why some wavebands can be more easily detected from space
- define the terms 'resolution' and 'sensitivity' of telescopes
- discuss the problems associated with ground-based astronomy in terms of resolution and absorption of radiation and atmospheric distortion
- outline methods by which the resolution and/or sensitivity of ground-based systems can be improved, including:
  - adaptive optics

- interferometry
- active optics

[Examples, given in the talk, of current applications of these technologies, further enhance students' understanding of the concepts.]

- describe the advantages of photoelectric technologies over photographic methods for photometry
- identify the general types of spectra produced by stars, emission nebulae, galaxies and quasars

Extract from Science 7 to 10 syllabus, and Preliminary and HSC Physics syllabuses July 2009, © Board of Studies<sup>2</sup>, NSW.

### Quality teaching

This resource provides opportunities to incorporate the following elements of Quality teaching in NSW public schools by:

- \* giving students an opportunity to discover the nature and practice of science (Deep knowledge, Connectedness, Metalanguage, Knowledge integration)
- \* highlighting the dynamic nature of research in astronomy (Problematic knowledge, Higher-order thinking)
- \* stimulating thought about what inspires people to become scientists (Connectedness, Problematic knowledge).

## Websites

Visit these websites for more information on the work of Professor Bryan Gaensler.

USYD School of Physics: Biography on Bryan Gaensler; links to articles about, and by Gaensler including "Why Pluto had to Go", "A Star is Burst", "When Big Stars Die", "Australian Science: Our Future"

<http://www.physics.usyd.edu.au/~bmg/>

Australian Institute of Policy & Science: Young Tall Poppy Profile of Prof. Bryan Gaensler

[http://www.aips.net.au/web\\_profile\\_gaensler.pdf](http://www.aips.net.au/web_profile_gaensler.pdf)

Science@NASA: Magnetar (star with a super strong magnetic field) discovery solves 19-year-old mystery

[http://science.nasa.gov/newhome/headlines/ast20may98\\_1.htm](http://science.nasa.gov/newhome/headlines/ast20may98_1.htm)

Cosmic Microwave Background: discovery; origin; & Big Bang theory

[http://map.gsfc.nasa.gov/universe/bb\\_tests\\_cmb.html](http://map.gsfc.nasa.gov/universe/bb_tests_cmb.html)

Australian Telescope Outreach and Education: PULSE@Parkes (real Science in real time for students); excellent info for students and teachers (see bottom tool bar);

<http://outreach.atnf.csiro.au/education/pulseatparkes/>

Australian Academy of Science: talk given by Gaensler at the Academy's 2000 Symposium, Astronomy in Australia – past and future

<http://www.science.org.au/future/gaensler.htm>