Ask an Astrophysicist

The Question

(Submitted April 24, 1997)

I'm researching about some information about pulsars, I've some questions to ask.

1. Is it right that the pulsars were identified as pulsating radio sources?

2. I know that they emit x-ray and **gamma-ray**, but do they emit **ultraviolet**, radio waves, and bursts of visible light?

3. Up to how many pulses per sec. does a high-**frequency** **pulsar** emit? How about the low-frequency pulsars?

4. I know that pulsars are due to the **neutron star** rotation, but do they rotate around their axis?

5. Is it possible to find their rapid periodical changes on other bands of electromagnetic spectrum?

6. Is it thru that all pulsars are slowing down very slightly and the period of pulsation increases gradually? If it is, is that indicates a slow yet steady loss of energy due to the radiation of energy into space?

7. The old pulsars, are they strong x-ray emitters?

8. How does their **radiation** affect the nearby gas clouds? Is it by ionizing and heating them?

9. About **supernova** remnants, do they radiate for millions of years, can we measure them by our telescopes?

10. What are **nebulae**? Are they the same as supernova? What kind of **elements** are abundant in these nebulae?

11. Is it right that the most known pulsars are found in our galaxy's **disk**? Are they rare in halo of the **galaxy**, do other galaxies show the same distributions of pulsars?

12. We can't see all the supernova explosions, but the ones which are visible to us, is it because of their beam of rays is directed to us?

13. I read somewhere that neutron stars are peculiar, what is that mean?

14. **Redshift** means that the subject is going away from us, but dose the Sun gives us any redshift at all, but it's not getting away from us?

15. What kind of **mass** do the neutron **stars** have? Can they be more than 5 times the mass of the sun?

16. How can we measure the period of the neutron star's **orbiting** around their companions?

17. Do you think there might be unknown neutron star in vicinity of the solar system that we might some day reach it?

18. Is there any possibility to land on these neutron stars? Do we get crushed by their gravity if we approach them?

19. About the Large Magellanic Cloud, that famous supernova explosion, about how many pulses per sec. did that pulsar leave behind?

The Answer

You ask some interesting questions.

1. Pulsars were first discovered as radio sources.

2. Yes, pulsars have been found that emit radiation in all these bands.

3. The fastest known pulsar (PSR 1937+21) emits 641 pulses per second. Some X-ray pulsars have periods tens of minutes long.

4. Are you mixing up orbital motion and spin? It is the rotation of the neutron star about its axis that causes the pulsation.

5. Pulsars have been seen in the radio, optical, X-ray and gamma-ray bands.

6. This is true of isolated pulsars. However, if the pulsar is in a binary system, it may accrete **matter** from its companion. It is possible for this to cause the neutron star to spin faster.

7. Pulsars slow down as they get older and the amount of radiation they emit decreases. However, if the pulsar is in a binary system and is accreting matter from its companion star it can be made to spin faster. Pulsars that have been spun up this way are called "recycled pulsars" and they can be strong X-ray emitters.

8. The most obvious effect on its surroundings is caused by the supernova explosion itself. Later, the radiation emitted by the pulsar will ionize and heat nearby matter. This effect is most important in systems consisting of a neutron star orbiting another star.

9. Yes, they are visible in the optical band as well as **radio** and **X-rays**. After a few hundred

thousand years the remnant will have merged with the interstellar medium and will not be detectable any more.

10. Nebulae are clouds of gas and **dust**. Some nebulae are formed by supernova explosions. In this case the nebula is called a supernova remnant. They are mostly hydrogen and **helium**. If the material in the nebula has been processed in the interior of a star other elements up to iron will be present. Elements heavier than iron are only formed in supernova explosions.

11. Yes, most pulsars are found in the plane of the galaxy. They are also found in **globular clusters** in the halo of the galaxy. The only other galaxies in which pulsars have been detected in significant numbers are the large and small Magellanic Clouds. Because these are irregular galaxies and the Milky Way is a spiral it is difficult to compare pulsar distributions.

12. A supernova explosion is not beamed. It is visible from all directions. However, there are other reasons why it may not be seen by us. If the supernova occurs in a distant galaxy it may be too faint to be noticed. A supernova explosion on the other side of the galaxy may be hidden behind clouds of gas and dust.

13. This probably refers to the fact that neutron stars are made up of extremely dense matter. Their **gravitational** fields are so intense that the nuclei of atoms are squeezed together and **protons** combine with electrons to form neutrons. Hence the name neutron star.

You may also be thinking of 'strange stars'. These theoretical objects are similar to neutron star, except that they include particles which have 'strange quarks' in them. There are six types of quarks--Up, Down, Strange, Charm, Top, and Bottom (the physicists who name these things are somewhat lacking in gravitas). Neutrons and protons are made up of Up and Down quarks. Strange, charm, top, and bottom quarks only become important under extreme conditions because they quickly decay to up and down quarks.

14. The earth's orbit is almost circular so we are pretty much the same distance from the Sun all the time. However, when we measure **spectral lines** from the Sun we find both red- and blue-shifted lines. If you look with the right instruments, you can use this redshift to see parts of the Sun's surface moving up towards us, and other parts moving down.

15. Neutron stars tend to be formed at about 1.4 **solar masses**, but more material can fall onto them after that. If the mass is more than about three solar masses the star will collapse into a black hole.

16. We can use the **Doppler effect** to measure the orbital motion of a pulsar. This is the same effect you observe when an emergency vehicle passes you with its siren on. As it is approaching you the siren is higher pitched, and as it recedes from you it is lower-pitched. In the same way if the pulsar is coming towards us the pulses appear closer together. If it is moving away from us they appear further apart. If we plot the pulse frequency against time we find a pattern which repeats itself every orbit. From this we can measure the orbital period.

17. There has been some speculation that there might be a neutron star orbiting the Sun but there is not much evidence.

18. There is a Science Fiction book called 'Dragon's Egg' by Robert Forward, which is about a visit to a neutron star. If you were to land on a neutron star, the gravity (about 500 billion times as intense as Earth's) would immediately flatten you to a thin film an atom thick. Even if you went into orbit around a neutron star, the difference in gravity between your head and your feet would be enough to pull you apart (this difference in gravity is what causes tides). Robert Forward (who is a physicist as well as a science fiction writer) figured out how to live in orbit without being ripped apart.

19. I don't think a pulsar has been detected in the remnant of SN1987a yet. There was a report of a high frequency pulsar but it turned out to be a signal from a video camera the astronomers were using to aim their telescope.

You can find more information about pulsars at
http://heasarc.gsfc.nasa.gov/docs/science/know_l2/pulsars.html

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