# Introduction to Astronomy
# Summary Questions Week 9

2 December 2019

1. Much of what we know about white dwarfs is derived from their spectral lines. Name three effects that can affect the absorption lines in a white-dwarf's spectrum.

> **Solution:**
> (1) The *fast rotation* of white dwarf stars causes *Doppler broadening* of the lines;
> (2) *gravitational redshift* causes a *Doppler shift of the centre frequency*; and
> (3) some white dwarfs have been observed to have *strong magnetic fields*, which causes *line broadening through Zeeman splitting.*

2. How do observations of radio pulsars help to test and constrain theories of gravity?

> **Solution:**
> The *highly regular pulses* that we receive from radio pulsars (as a consequence of the lighthouse effect) can be *precisely timed*, which allowes very precise determination of, amongst others, the *orbital parameters* of pulsars in binary systems. Several *relativistic effects* (like energy loss due to gravitational-wave emission or periastron advance) *can consequently be measured* at otherwise unachievable levels of precision.

3. In the context of pulsar astronomy, what is a $P - \dot{P}$ diagram and why is it important? (Why is it also referred to as the "Hertzsprung-Russell diagram of pulsar astronomy"?)

> **Solution:**
> As the name indicates, the $P - \dot{P}$ diagram is *a scatter plot of the spin period ($P$) and spindown ($\dot{P}$)* of all known pulsars. It is important because it *allows categorisation* of the different sub-classes of neutron stars (millisecond pulsars, normal pulsars, young pulsars, double neutron stars, magnetars). It is also called the Hertzsprung-Russell diagram of pulsar astronomy because *the different stages of a pulsar's life are clearly identified in this diagram*: the SNR-associated young pulsars, the large island of normal pulsars, the death line and the recycled MSP island.

4. When mass is transfered in binary star systems involving a NS or BH, this is typically observed as an X-ray binary. Why do these systems primarily show up in X-rays?

> **Solution:**
> The most clearly visible part of such a binary system, is *the accretion disk*. This disk *heats up* as the matter falls towards smaller, denser, faster orbits; and eventually falls onto the neutron star or black hole. Due to the high heat, the thermal emission peaks in the X-ray range.

5. What is the lighthouse effect and what does it tell us about the nature of a pulsar's emission? (i.e. does it imply emission from pulsars is continuous or pulsed?)

**Solution:**

Even though the emission received from pulsars typically arrives in pulses, the lighthouse effect states that this is due to the *misalignment of the magnetic axis* (which defines the origin of the emission , i.e. the magnetic poles) *and the rotation axis.* Due to this misalignment, the radiation does not get emitted in the same direction all the time, but is instead *swept around in space, exactly like the beam of a lighthouse.* This is what causes the emission to be observed as pulses, even though *the actual emission from pulsars is fundamentally continuous.*