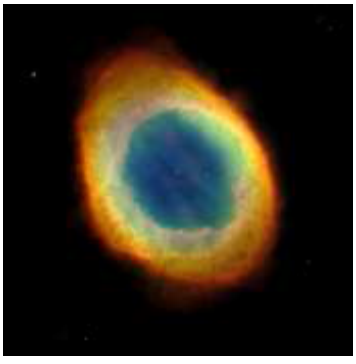
Tuesday 10th January 2017: "Ephemeral Bubbles" - Paul Jenkins (HAS)

The name planetary nebula (1) was coined by William Herschel because of the resemblance to the planetary discs of Uranus and Neptune but actually they have nothing to do with planets. They occur when a main sequence star the mass of our Sun and up to eight times as massive, dies. Any larger and the star will explode as a supernova. Since most stars are within the range of one to eight times the mass of our Sun, most stars will become planetary nebulae, including our Sun.

In the lower mass stars helium burning can happen very suddenly and a gigantic, Sun-wide thermonuclear explosion known as the helium flash can occur. Stars with a mass greater than two and a quarter times more massive than our Sun do not experience helium flashes. The outer layers of the red giant are pushed away at speeds that take them beyond the reach of the gravity of the core (which is becoming a white dwarf) resulting in a planetary nebula. These nebulae are made of extremely rarefied gasses.

The white dwarf in the centre is tremendously hot and produces a lot of UV radiation, which ionises the gases in the nebula causing them to glow. The UV radiation emitted by the white dwarf is intercepted by atoms in the nebula and converted to visible line radiation.

They also produce radio, infrared and sub-millimetre radiation as well as optical and, because the gas can reach temperatures of a million degrees, they can also radiate in the X-ray part of the spectrum. Planetary nebulae come in many forms, but the straightforward ones tend to be spherical. This means we should see a ring. M57 is the well-known Ring Nebula (The Hubble photograph 2) shows the white dwarf in the centre.



Planetary nebulae often exhibit layers that can indicate more than one expulsion event such as seen in the Cat's Eye Nebula in Draco (3). 10% of the original mass of a star is ejected so the white dwarf is smaller not just because of its contraction under gravity but also because there is less mass.

The expansion rates of the nebulae are generally 20 to 50 km per second, the temperatures are 10,000°C and the gas consists of several hundred to a million ionised atoms per cubic cm – thinner than any vacuum we can achieve on Earth. They are typically one light year across and there are around 3,000 planetary nebulae catalogued in our Galaxy but due to galactic dust, which tends to get in the way, there may be ten times that number. We can only see them for a short time – about 10,000 years, hence ephemeral bubbles and why we are privileged to be able to see the ones that are visible at the moment.

White dwarf stars are amongst some of the hottest stars in the universe with a temperature range of 25.000 to over 200,000°C. They are very luminous and radiate primarily in the UV. One of the effects of high temperatures in the core is that electrons in the hydrogen and helium separate from their atoms and become a gas in their own right – an effect called electron degeneracy.

The electrons in a degenerate state do not behave as we would expect. As the temperature of the gas is increased, instead of expanding and cooling, the pressure is unaffected. In a star, this means that when helium burning begins it spreads very rapidly throughout the core, this is unstable and results in an explosive release of energy that is known as the helium flash.

Looking at our solar system 5 billion years into the future, we will see a red giant star, no planets within the orbit of Mars and perhaps the start of the ionised outer layers of our Sun that have already been ejected – the start of the planetary nebula. In time, the nebula will have moved so far away it can no longer be lit up by the white dwarf and over billions of years the white dwarf will cool down until it becomes a black cold object that will probably be impossible to find.

Paul rounded off his talk with planetary nebulae that are local to us. He has viewed NGC 2438, which is a foreground object to M46 near Sirius, and although faint through the Society telescope, it is quite magnificent with the Hubble. (4). Others include M97, the Owl nebula, NGC 1535, Cleopatra's Eye, NGC 2022, and NGC 2392, the Eskimo Nebula. M27 and M57 are easy to find but of course, they only last 10,000 years so you had better hurry up and start viewing them.