Introduction to Astronomy
Summary Questions Week 10

9 December 2019

1. What is optical depth and what does it mean that a medium is "optically thick"?

Solution:

The optical depth τ quantifies the *absorption* in a medium. It is defined as the *integral of the medium's absorptivity along the light travel path.* When τ is (much) larger than 1, the medium is said to be optically thick. In this case *no (or only very limited) radiation can pass through the cloud.* Note that optical depth is often a strong function of frequency. This implies that if a cloud is optically thick at a particular wavelength (because of a particular molecular transition, for example), that the background emission will show a spectral absorption line at that frequency.

2. What is the definition of the apparent magnitude?

Solution:

The apparent magnitude is based on the flux received from a star and is defined in terms of a reference star:

$$m - m_{\text{ref}} = -2.5 \log \frac{F}{F_{\text{ref}}}$$

where log is the logarithm base 10 and F is the flux received from the star. F_{ref} is the flux of the reference star and m_{ref} is the apparent magnitude of the reference star. Traditionally, Vega was taken as reference star; and its apparent magnitude was defined as zero. This has now changed slightly, though, and the reference is now just a theoretical value.

3. What is the definition of the absolute magnitude?

Solution:

The absolute magnitude is defined as the apparent magnitude a star would have if it were placed at a distance of 10 pc. Because $F \propto d^2$, the mathematical form of this definition is easily derived from the definition of the apparent magnitude, to be:

$$M = m + 5 - 5 \log d$$

where d is the distance to the star, measured in pc.

4. What is the supposed mechanism of pulsating variable stars (such as Cepheids)?

Solution:

The mechanism is based on the fact that in the atmospheres of these stars, the opacity increases with temperature. This leads to the following cycle:

1. Internal heat increases the atmospheric opacity
2. the heated atmosphere expands
3. the expanded atmosphere now has a larger surface area to radiate heat from; and because of its expansion, it is further away from the star's centre
4. as a consequence the atmosphere cools down
5. the cooling atmosphere decreases in opacity, which stops the heating and therefore the cooling accelerates
6. the cooled-down atmosphere shrinks
7. the smaller atmosphere gets closer to the centre and has a smaller contact surface with the outside, so its cooling gets less efficient
8. the smaller, cool atmosphere starts heating up, increasing the opacity (back at point 1.)

5. Why are Cepheid variables so important in astronomy?

Solution:

Because they have a very well-defined *period-luminosity relation*, they are one of the *key building blocks of the cosmic distance ladder*. This $P - M$ lay at the basis of Hubble's discovery of cosmic expansion, amongst other things.

6. What are cataclysmic variables?

Solution:

Cataclysmic variables are binary systems in which a white dwarf *accretes matter* from a companion star. This accreted matter causes *temporary variations in brightness*, for example when the accreting matter falls onto the star, of when nuclear fusion ignites on the surface of the accreting star. Typically these types of variables are called *novae*, though there are many sub-classifications