PoG Set 7 answers

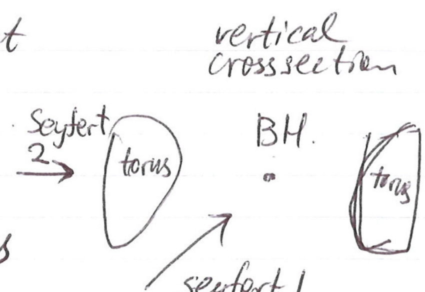
1.

AGN have bright, point-like (star-like) nucleus. In the short exposure image only nucleus is seen. In the long exposure host glaxy becomes visible too.

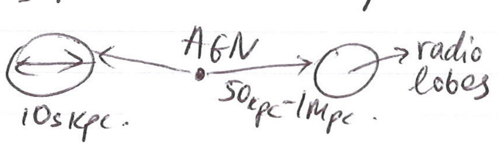
Nucleus emits across all wavelength from radio to γ-rays. This is unlike normal galaxies which emit mainly in optical/infrared.

AGN spectra is very blue and has no absorption lines. There are strong emission lines present. The emission lines come from forbidden + allowed hydrogen lines of highly ionized element. Such ionization level is likely to come from so-called "blue bump" (prominent emission part of the AGN spectrum rising from optical to UV). The emission lines are very broad. The broadening is due to Doppler effect (Doppler broadening) that results from bulk motions of plasma. The line broadening is too strong to be of thermal origin.

The difference between Seyfert 1 and Seyfert 2 type active galaxies is that in Seyfert 1 only narrow forbidden lines are present + broad hydrogen lines, while is Seyfert 2 only narrow lines (both forbidden and hydrogen) are present. This difference could be explained by the different viewing anles of the same object. The fact that Seyfert 2 have no broad lines could mean that they are obscured by dust in molecular torus. There is strong support to this in that Seyfert 2's are stronger infrared sources than Seyfert 1 suggesting that UV radiation from broad line regions is absorbed by dust and then re-radiated in infrared.



radio lobes are often present near AGN. These are 10s kpc in size and separated by distances 50kpc - 1Mpc.



radio lobes emit synchrotron spectrum $F_\nu \sim \nu^{-0.7}$ and are powered by ultra-relativistic jets.

[10 marks]

[each sub-question is worth 2 marks, 2+2+2+2+2=10 marks]

2. i) In a trailing spiral, the wave advances outward from the centre into the disc: from σ_1 expression with "-*kr*" at constant θ, $0 = \omega - k\left(\frac{\partial r}{\partial t}\right)_\theta$ i.e. $\left(\frac{\partial r}{\partial t}\right)_\theta = +\frac{\omega}{k}$.

Whereas, using, σ_1 expression with "+*kr*" wave advances inward in a leading spiral: $0 = \omega + k\left(\frac{\partial r}{\partial t}\right)_\theta$ i.e. $\left(\frac{\partial r}{\partial t}\right)_\theta = -\frac{\omega}{k}$ **[2 marks].**

ii) In a trailing spiral, the density wave front moves toward generally less dense material (outwards from the centre as it has positive phase speed) in which the speed of sound is lower (the speed of sound $u \propto \rho^{(\gamma-1)/2}$ with $\gamma > 1$) [3 marks]. It therefore tends to pile up on itself until it produces a shock front because speed of the wave exceeds the local sound speed. The leading spiral, on the other hand, is moving into a region of increasing density (inwards) and higher speed of sound. This allows the wave to "get away from itself" and reduces the effect of the perturbation [2 marks]. Since the spiral arms are dominated by hot young stars, therefore, we may conclude that only trailing waves are likely to exist. Only clouds of gas greater than a critical mass M_J could collapse to form stars. This critical mass $M_J \propto \rho^{-1/2}$. If a cloud with nearly the critical mass (or critical size) enters a shock front, this will compress the cloud, increasing its density. If the increase in density is sufficient, the cloud will now be *more* than the critical mass and will collapse in the free-fall (roughly star-formation) time [2 marks]. Shock waves thus are capable of causing gas clouds to collapse to form stars in times of the order of 10^6 yr. Since the orbital period of the material about the centre of the galaxy is some 10^8 years, this means that stars form within a few degrees of the shock front ($10^6/10^8=0.01$ – this fraction of full 360^o is about few degrees). The massive O and B stars, which distinguish the arms, stay on the main sequence for only about 10^6 years so that we should expect the arms themselves to be a few degrees wide, as indeed observed [2 marks]. [3+2+2+2=**9 marks**]

3. The out-flowing photons exert a force on the in-falling matter. If the flux of photons is large enough, this force will exceed the gravitational attraction of the central mass and accretion cannot take place. **[4 marks]**