# GA 3

1. Briefly describe the three main *stellar* components of a spiral galaxy. Which component is the most massive in the Milky Way? [4 marks]

   **Answer**:
   The three components are

   (a) a central spheroidal *bulge*

   (b) the *disc*

   (c) a faint, extended spheroidal *halo*

   [1 mark per correct answer]
   The Milky Way's *disc* is the most massive.[1 mark]
   The ratios are approximately, disc: 70%, bulge 30%, halo: 1%. - eagle-eyed readers will spot that these numbers do not quite add up to 100%.

2. Dust particles obscure and redden the light of distant stars

   (a) Assume spherical dust particles with radius $a = 0.1\mu$m and number density $n_d = 3.3 \times 10^{-12}$ cm$^{-3}$. Follow the reasoning in the notes to show that such particles decrease the intensity of radiation over a distance $dl$ by

   $$\frac{dI}{I} = -n_d\,(\pi\, a^2)\, dl$$

   . [2 marks]

   (b) Show that if $n_d$ and $a$ are constant, the intensity decreases by $\propto \exp((-n_d\,(\pi\, a^2)l)$ over a distance $l$. [2 marks]

   (c) Compare the wavelength of UV light ($\lambda = 300$ nm) with that of infra-red light ($\lambda = 1\mu$m). Which radiation will be affected most and why? [2 marks]

   **Answer**:

   (a) Following the reasoning in the notes, consider a cylinder (area $S$, length $dl$). The fraction of light $dI/I$ blocked by dust particles is the ratio $\sigma\, dN$ of area presented by the dust grain (where $dN$ is the number of grains in the cylinder, and $\sigma = \pi\, a^2$ their surface area) over $S$:

$$\frac{dI}{I} = -\frac{\sigma\, dN}{S}\,. \tag{1}$$

This is indeed the *fraction* of light blocked all grains combined. If $n_d$ is the number density of grains, use $dV = S\, dl$ for the volume of the cylinder to find that the total number of grains (in the cylinder) is $dN = n_d\, S\, dl$. Substitution in Eq. (1) yields

$$\frac{dI}{I} = -n_d\,(\pi a^2)\, dl\,. \tag{2}$$

(b) If $n_d$ and $a$ are constants, then also $1/l_c \equiv n_d\,(\pi a^2)$ is a constant. In that cased it is easy to solve the previous ODE, obtaining the solution $I \propto \exp(-l/l_c)$, so the intensity drops exponentially.

(c) The wavelength of IR light is long compared to the size of individual grains, so the interaction cross section will be smaller than the geometric cross section. For UV light, $\lambda < a$ and the interaction cross section will be of order the geometrical cross section. As a consequence, UV-light will be much more strongly attenuated than IR light. This phenomenon is called *reddening*: the transmitted light becomes progressively redder, as a larger fraction of the short wavelength (blue) light is absorbed compared to the longer wavelength (redder) light.