Astronomy Assignment 3

Counting the Stars

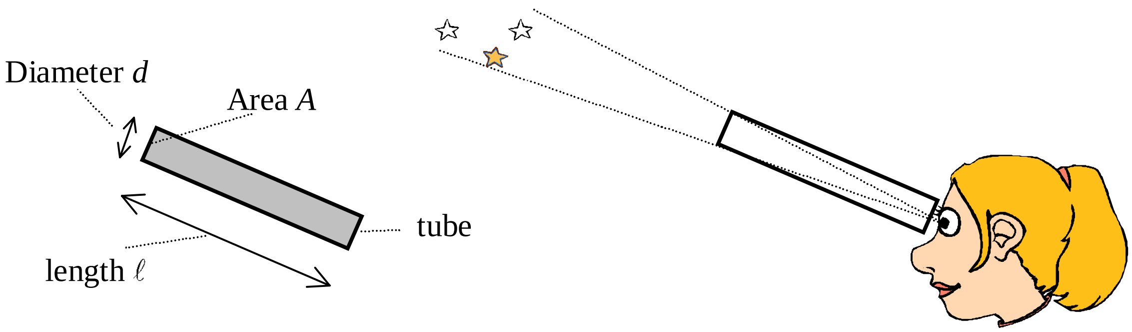
Aim

To estimate the number of stars visible in the sky and compare that with your guess.

Method

1) Write down how many stars you think can be seen on a clear moonless night, as far away from artificial lights as you can conveniently get.

2) Counting the stars exactly is not on: there are too many. You will loose track of which ones you've included and, to make matters worse, as the heavens roll by stars are rising and setting. You should obtain the count by a sampling method. This is good science.



Look at a small section of the sky through a tube and count the number of stars visible (call this count n_1).

Move the tube around to sample, say 10 different areas of the sky, chosen at random. Add up the total number (N) of star counts you have ($N = n_1 + n_2 + n_3 + ... + n_{10}$). Hence the average number of stars seen through the tube is $N/10$.

Now you must estimate what fraction of the entire sky you have sampled. If you think about it, you'll see that the tube limits the angle you can see in two dimensions, because of the limiting area at the far end of the tube. A measure of how much you can see is the area of the end of the tube (A) divided by the square of the length of the tube (ℓ^2). This quantity is known as the *solid angle* of vision. i.e.

$$\text{solid angle viewed through tube} = \frac{A}{\ell^2} \quad .$$

How much solid angle does a hemisphere of the sky subtend? That is easy. It is half the area of a sphere, divided by its radius^2. Hence

$$\text{solid angle of hemisphere of sky} = \frac{1}{2}\frac{4\pi r^2}{1}\frac{1}{r^2} = 2\pi \quad .$$

Hence the fraction of the sky you have sampled is

$$\frac{\text{solid angle viewed through tube}}{\text{solid angle of hemisphere of sky}} = \frac{A}{2\pi\ell^2}.$$

For a circular tube,

$$A = \pi d^2/4, \quad \text{where d is the tube diameter.}$$

Finally your estimate of the number of stars in the whole visible sky from 10 random samples totalling N stars is therefore

$$\boxed{\textit{Number of stars visible in sky} = \frac{N}{10}\frac{2\pi\ell^2}{1}\frac{4}{\pi d^2} = \frac{4N}{5}\left(\frac{\ell}{d}\right)^2}$$

Action

Obtain a tube of the kind used to protect small posters, say length ℓ = 340 mm, internal diameter d = 48 mm; alternatively a piece of rolled up A4 paper, folded over lengthwise has $\ell \approx$ 300 mm and $d \approx$ 65 mm. **Measure ℓ and d for your own tube**.

ℓ	*mm*
d	*mm*
N	

Pick a moonless night. Take your tube, along with friends (who can share a tube, if necessary), suitable beverage and sustenance and warm clothes and a notepad and pen, to a site as well shielded from artificial light as you can find. Record your 10 observations, **writing down the total number N of stars you counted**. Return home and write a short paragraph recording where you went, when you observed (date and approximate time), any observations such as how much of the sky you could see and how much contamination you think was present from residual light. Finally, **calculate the number of stars from the right hand side of the formula above** using your values for ℓ, d and N. Compare the answer with your guess.

Comment

You will be surprised how few stars you see through your tube. The well known constellations are based around the bright stars in the sky but there are many more faint stars than bright stars. Your random sample may never pick out a bright star.

From a really dark site, you will see that the visible stars are not distributed at random over the sky, because of the presence of the Milky Way. The Milky Way is the view edge-on through the disk of our galaxy. The Milky Way rises high in the sky. Clustering of stars makes the random sampling method less accurate for small samples. If you miss out the Milky Way in your sampling, you will underestimate the number of visible stars. If you include it a couple of times, you will overestimate the number.

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