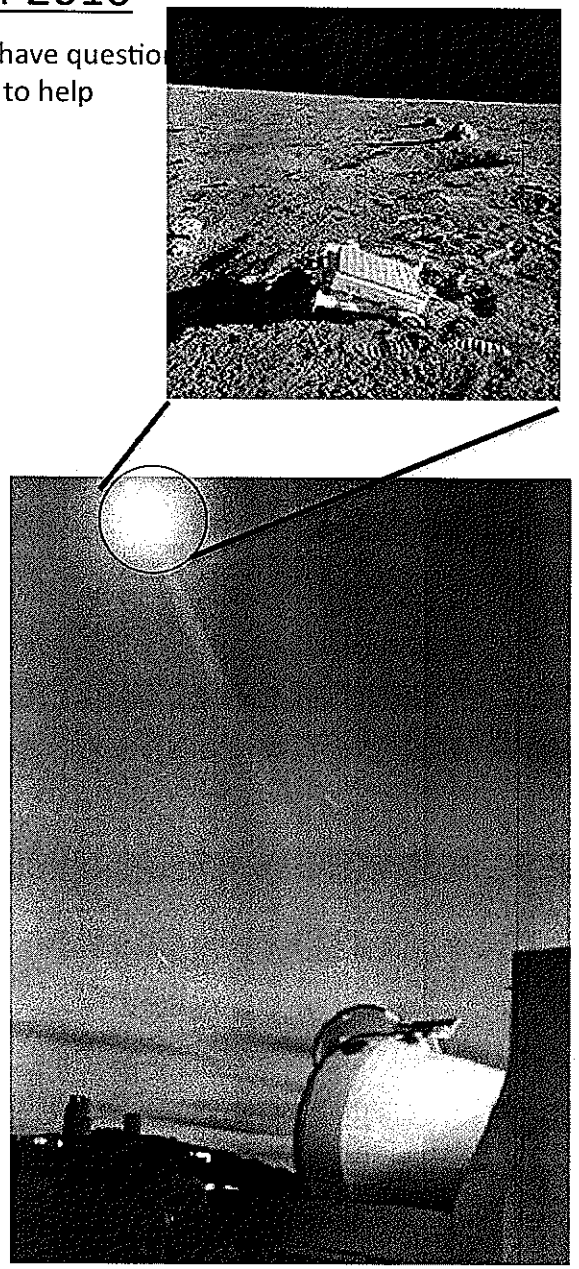
PHYS 408 Group Activities for Oct 14 2010

Please complete these exercises without opening the textbook. If you have questio
with your group mates or raise your hand and Mark or Ellen will come to help



The ongoing Lunar Laser Ranging Experiment measures the distance between Earth and Moon using laser ranging. Lasers on Earth are aimed at retro-reflectors previously planted on the Moon (Apollo 11) and via the reflected signal the distance is measured.

5-Why would we want to precisely measure the earth-moon distance?

The moon is approx .35 Gm away from earth

Find how fast moon is falling towards the earth

6-How could the distance be measured with laser ranging?

Measure time for light to travel to moon and back

$d = 0.35\,Gm \times 2 = 0.7\,Gm$

$c = 3e8\ m/s$

$\frac{\Delta d}{c} = \Delta t = 2.33\,s$

If we want to resolve distance down to mm, time resolution has to be

$\frac{1mm}{c} = 3.33 \times 10^{-12}\,s \sim 3ps$ which is possible

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The ongoing Lunar Laser Ranging Experiment measures the distance between Earth and Moon using laser ranging. Lasers on Earth are aimed at retro-reflectors previously planted on the Moon (Apollo 11) and via the reflected signal the distance is measured.

7-As an optical design engineer on the project you must model the laser beam propagation as a Gaussian Beam and you need to optimize the return signal as measured on earth. The laser (λ=532 nm, 10 Watt) is pointed to the moon through a telescope and you are offered three different telescopes with varying apertures. Via calculations of Gaussian beams, discuss the advantages and disadvantages of each.

smaller the width on the moon, harder to aim.
larger the width on the moon, less power hitting the reflector, less power back to earth.

8-If the retroreflector is 1m^2 how much total power is reflector to earth?

Gran Telescopio Canarias (10.4 m)



$2w_0$

$z_0 = 1.6e8\ m$

$w = 5.2\sqrt{1+\left(\frac{3.5e8}{1.6e8}\right)^2}$

$= 12.5\ m$

$w_0 = \sqrt{\frac{\lambda z_0}{\pi}}$

$w = w_0\sqrt{1+\left(\frac{z}{z_0}\right)^2}$

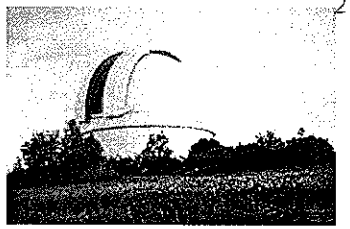
if $\left(\frac{z}{z_0}\right)^2 \gg 1$

$w = \frac{w_0}{z_0} z = \theta z$

$\theta = \frac{w_0 \lambda}{w_0^2 \pi} = \frac{\lambda}{w_0 \pi}$ $\Rightarrow$ larger w_0, smaller divergence

Note: Can't use $w = \theta z$ here ↑ because z is almost same as z_0

Hale Telescope (5.1 m)



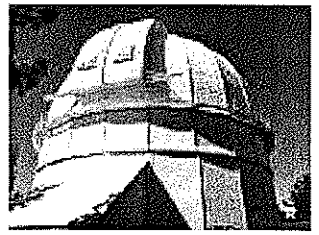
$2w_0$

$z_0 = 3.8e7\ m$

$w = 2.55\sqrt{1+\left(\frac{3.5e8}{3.8e7}\right)^2}$

$w = 23.6\ m$

Hooker telescope (2.5 m)



$2w_0$

$z_0 = 9.2e6\ m$

$w = 1.25\sqrt{1+\left(\frac{3.5e8}{9.2e6}\right)^2}$

$w = 47.6\ m$