$$d = 10^9$$
 lightyears = 3×10^8 pc (where $1 \text{ ly} = 3.3 \text{ pc}$)

$$m-M = 5 \log \left(\frac{3 \times 10^8}{10}\right) = 5 \log \left(3 \times 10^7\right) = 5(\log 3 + \log 7)$$

= 5(0,5+7) = 37.5

$$M-M = 37.5$$

$$m - (-19) = 37.5$$

$$\sqrt{b}$$
 $\lambda_0 = 0.65$ microns

$$z = \frac{1}{a} - \frac{1}{0.9} - \frac{1}{0.9} = \frac{1.11 - 1}{0.11} = 0.11$$

$$z = \frac{\lambda - \lambda_0}{\lambda_0}$$

$$o.11/o + \lambda_0 = \lambda$$

OR

$$\frac{1}{0.9} = \frac{\lambda_{0.65}}{0.65} \text{ microns}$$

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m-M=42,5

$$a = \frac{1}{1+2} = \frac{1}{1+1.5} = 0.4$$

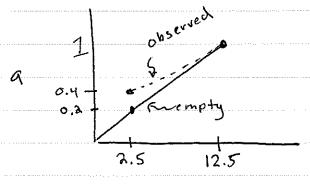
$$m-M = 5 \log \left(\frac{d}{10}\right)$$

 $42.5 = 5 \log \left(\frac{d}{10}\right)$
 $d = 3 \times 10^9 \text{ pc} = |0|^{10} \text{ lightyears}$

point "now"
$$a=1$$
 $t=12.5$ billion yrs

point "then" $a=0.4$ $t=2.5$ billion yrs

^ on 10^{10} billion yrs IN THE PAST



t (billion yrs)

universe is accelerating

we know this because at t=2.5 billion years the

expansion of the empty universe had a rate

of z=4 (a=0.2 at 2.5 billion on the empty line),

while the observed point has a slower

expansion at the same time, z=1.5. Since all

open rates must meet at "now" the observed universe

expansion must meet at "now" the observed universe

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the empty universe "now",

De we need dark energy (DE) to explain why
the observations of SNe Ia appear fainten at high z
than would be expected in a pure Rn=1
universe. This assumes that Ia's are
STANDARD CANDLES! If distance SNe Ia's
are fainten than hearby ones, than the
fact that high z Ia's appear faint
may be due merely to the fact that
they ARE faint. In that case, DE
need not be invoked to explain the
observed points.

[b] from $\Delta(m-M)$ plot at z=1 the magnitude difference between the $R_{M}=0.25$ $\Omega_{\Lambda}=0.75$ line and the $\Omega_{M}=1$ line is 0.6 magnitudes

$$0.6 = 2.5 \log \left(\frac{b_{z=1}}{b_{z=0}} \right)$$

⇒ nearby SNe are about twice as bright

as the distance SNe

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