Title: Cosmology Review-7

Date: Feb 03, 2015 11:30 AM

URL: http://pirsa.org/15020028

Abstract:

$\Omega_m = \frac{\rho_m}{\rho_c} \simeq 0.26$

$\Omega_b \simeq 0.04$

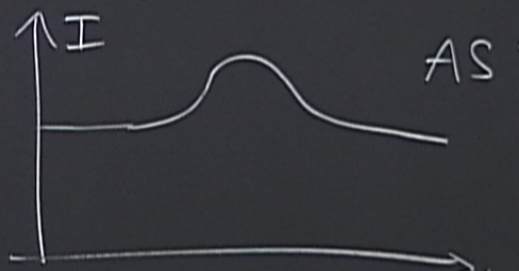
- AT THIS POINT THE ONLY EVIDENCE FOR DM IS GRAV.!

← GR WRONG

DM ← MACHOs (MAssive Compact Halo Objects) ... BU

WIMPs (Weakly Interacting Massive Particles)

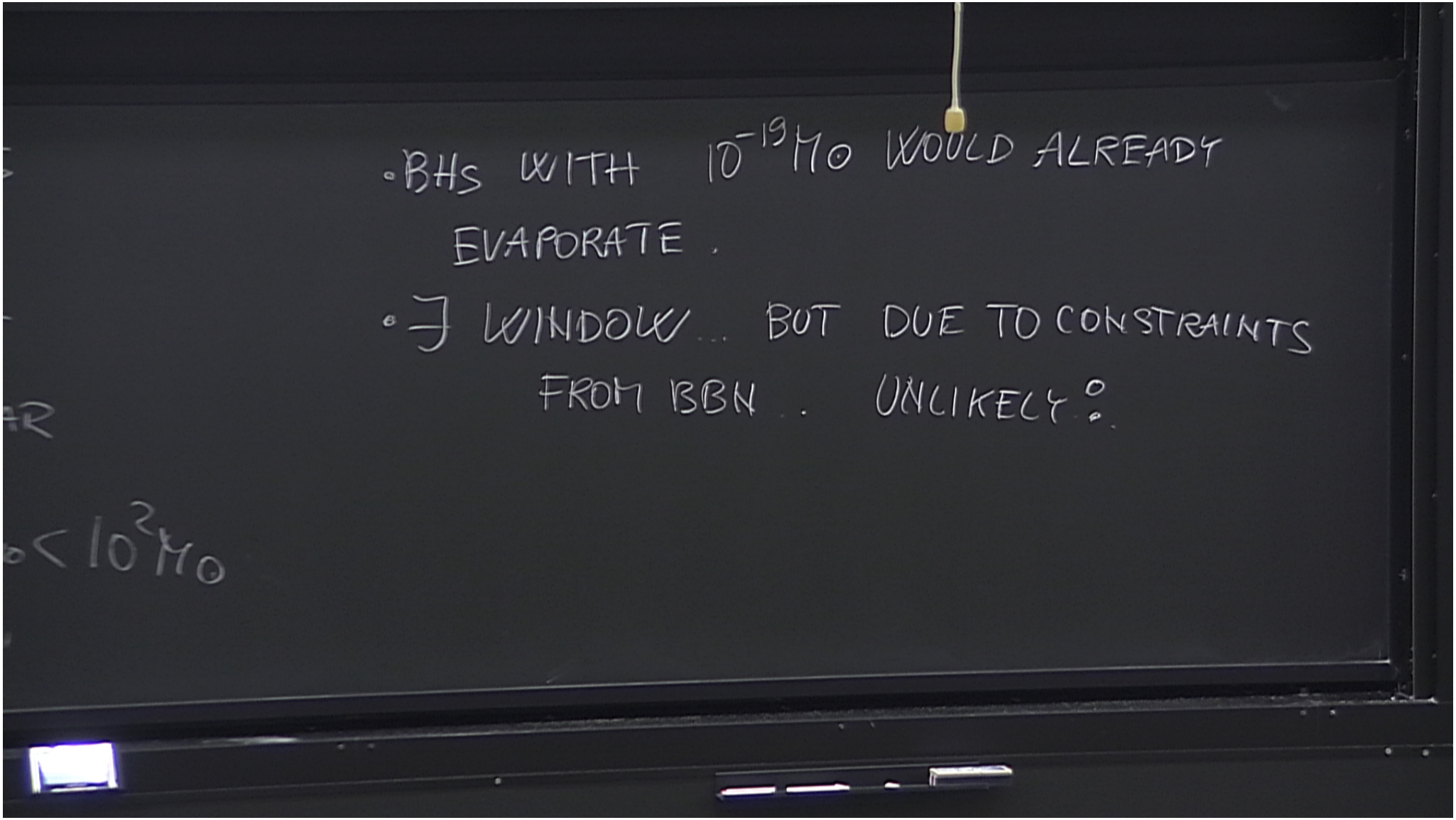
- MACHOs . COULD BE OBSERVED BY GRAV. LENSING
(SEE B. PACZYNSKI - 1986)



AS DM GOES IN FRONT OF MY FAVOURITE STAR

$\Rightarrow 10^{-8} M_\odot < M_{MACHO} < 10^{2} M_\odot$

RULED OUT.


• BHs WITH $10^{-19} M_\odot$ WOULD ALREADY EVAPORATE.
• ∃ WINDOW... BUT DUE TO CONSTRAINTS FROM BBN. UNLIKELY?
$< 10^2 M_\odot$

- NON-THERMAL RELIC E.G. AXION (SEE T4)

- HOT THERMAL RELIC - RULED OUT:
  - AT THE TIME OF FREEZE-OUT, PARTICLE χ (m_χ) STILL RELAT.
  - FROM FREEZE-OUT - TODAY

$$\left(\frac{n_\chi}{s}\right)_f = \left(\frac{n_\chi}{s}\right)_0 \Rightarrow n_{\chi,0} = s_0 \frac{n_{\chi,f}}{s_f}$$

$$s_0 = g_{s,0} \frac{2\pi^2}{45} T_0^3$$

$$n_{\chi,f} = g_\chi \frac{\zeta(3)}{\pi^2} T_f^3$$

$$s_f = g_{s,f} \frac{2\pi^2}{45} T_f^3$$

  - TODAY DM IS COLD & NON-RELATIVISTIC

$$\rho_{\chi,0} = m_\chi n_{\chi,0} \propto m_\chi T_0^3$$

- TODAY DM IS COLD & NON-RELATIVISTIC

$$\rho_{\chi,0} = m_\chi n_{\chi,0} \propto m_\chi T_0^3$$

- $$\Omega_{\chi,0} = \frac{\rho_{\chi,0}}{\rho_{c,0}} = \frac{m_\chi n_{\chi,0}}{\frac{3H_0^2}{8\pi} m_{pl}^2} \simeq$$

$g_{s,0} \simeq 3.91$

$H_0 \simeq (2.13 \times 10^{-42})\, h_{100}$ GeV

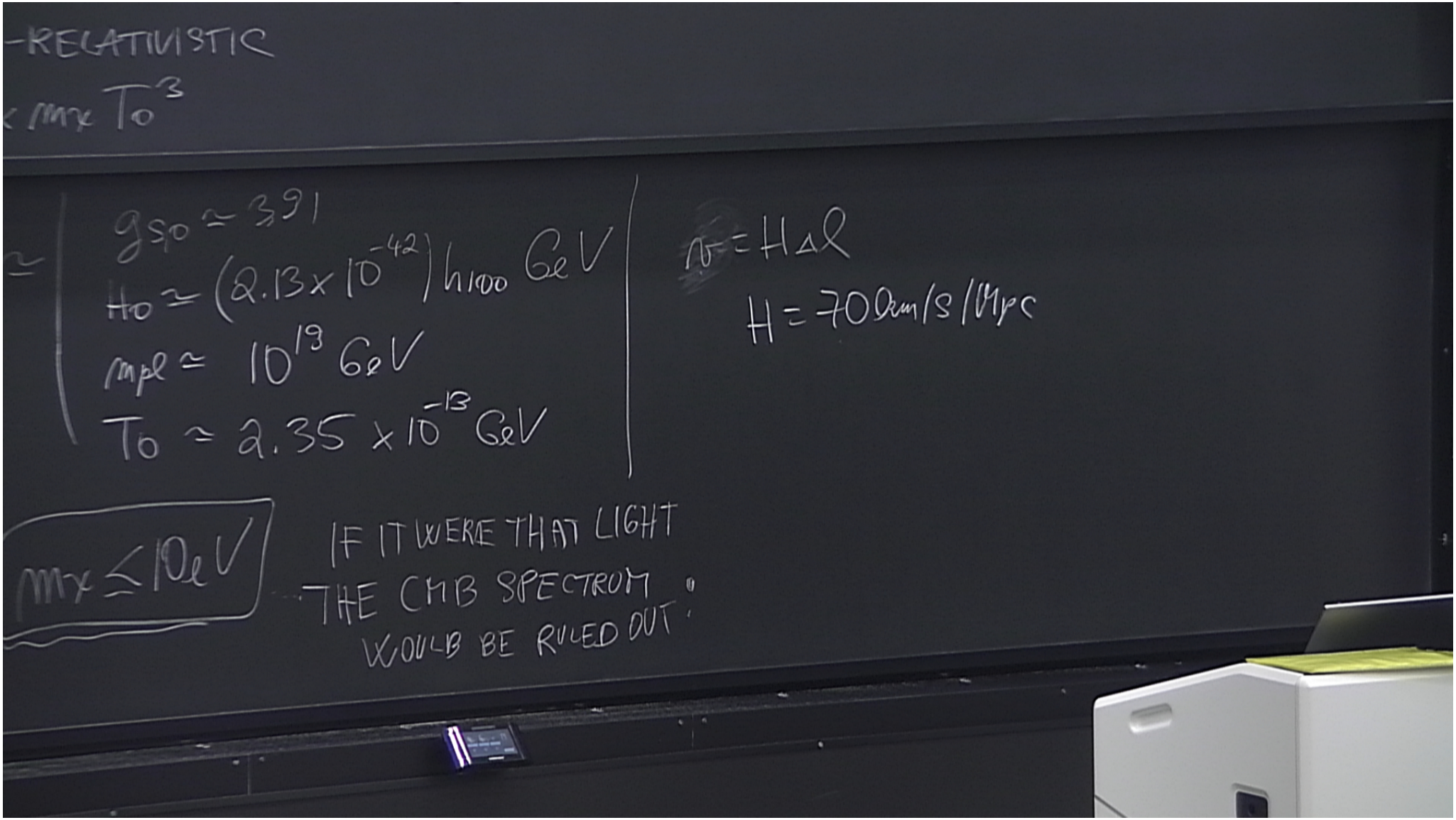
$m_{pl} \simeq 10^{19}$ GeV

$T_0 \simeq 2.35 \times 10^{-13}$ GeV

$$= \frac{g_\chi}{g_{s,f}} \frac{8 \times 10^{-2}}{h_{100}^2} \frac{m_\chi}{\text{eV}}$$

SINCE $\Omega_{\chi,0} \leq 1/4 \Rightarrow$ $\boxed{m_\chi \lesssim 10\,\text{eV}}$

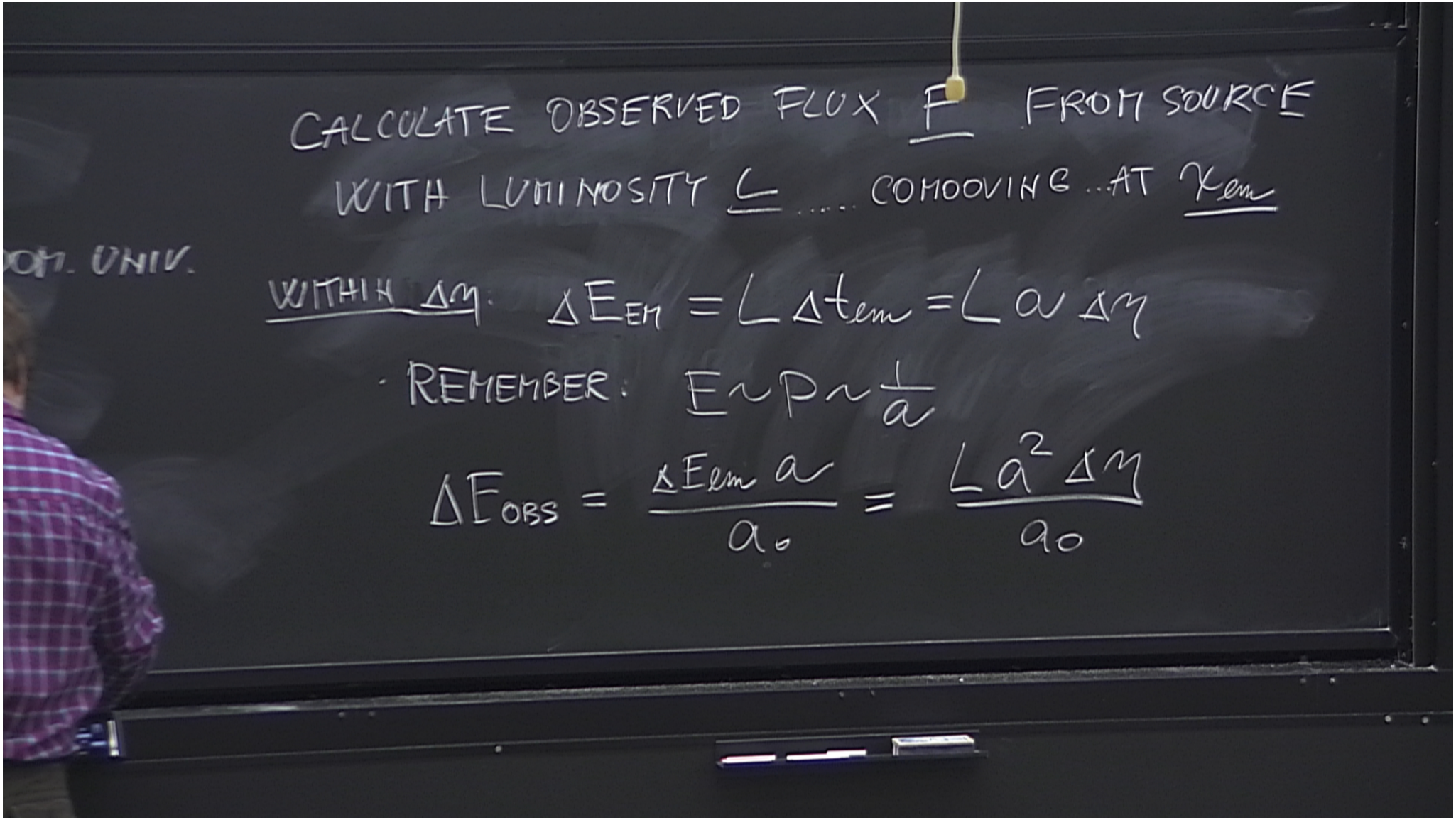
IF IT WERE THAT LIGHT THE CMB SPECTRUM WOULD BE RULED OUT.


-RELATIVISTIC
$\propto m_\chi T_0^3$
$g_{s0} \simeq 3.91$
$H_0 \simeq (2.13 \times 10^{-42})\, h_{100}$ GeV
$m_{pl} \simeq 10^{19}$ GeV
$T_0 \simeq 2.35 \times 10^{-13}$ GeV
$v = H\Delta l$
$H = 70$ km/s/Mpc
$m_\chi \lesssim 10$ eV
IF IT WERE THAT LIGHT
THE CMB SPECTRUM
WOULD BE RULED OUT!

- SUPERNOVAE Ia OBSERVATIONS (NP-2011)
  - "DISTANCE VS. REDSHIFT"
    LUMINOUS DISTANCE IS LARGER IN DE DOM. UNIV.
  - LET'S ASSUME FRW UNIVERSE

$$ds^2 = a^2(\eta)\left(-d\eta^2 + dx^2 + S_k^2(x)\,d\Omega^2\right)$$

$$dt = a\,d\eta$$


CALCULATE OBSERVED FLUX F FROM SOURCE
WITH LUMINOSITY L ..... COMOVING ..AT χ_{em}
WITHIN $\Delta\eta$: $\Delta E_{EM} = L\,\Delta t_{em} = L\,a\,\Delta\eta$
· REMEMBER: $E \sim p \sim \frac{1}{a}$
$\Delta F_{OBS} = \frac{\Delta E_{em}\, a}{a_0} = \frac{L a^2 \Delta\eta}{a_0}$

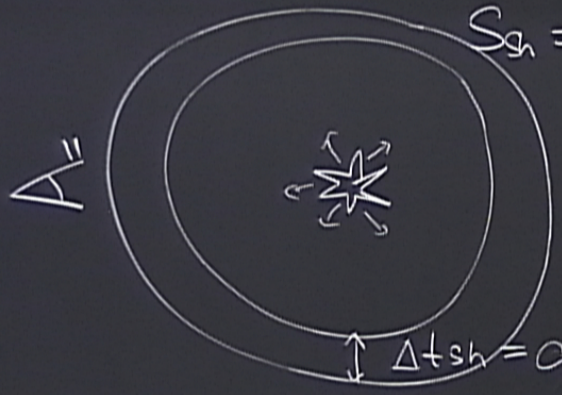
$ds = a^2(\eta)\left(-d\eta^2 + dx^2 + S_k(x)d\Omega^2\right)$

$dt = a\,d\eta$

$$\Delta E_{OBS} = \frac{\Delta E_{em}\, a}{a_0}$$

- OBSERVED FLUX

$S_{sh} = 4\pi a_0^2 S_k^2$



$$\cdot F = \frac{\Delta E_{OBS}}{S_{sh}(t_0)\,\Delta t_{sh}} = \frac{L}{4\pi}\,\frac{a^2}{a_0^4 S_k^2(r_{em})}$$

- WANT THIS AS FUNCTION OF z.
- COSMOLOGICAL REDSHIFT $\frac{a_0}{a} = \frac{a}{a_0} + 1 - 1 = z + 1$

$$\Rightarrow dz = -\frac{a_0}{a^2}\frac{da}{dt}dt = -\frac{a_0}{a} H\,dt$$

- TODAY DM IS COLD & NON-RELATIVISTIC

$$\rho_{\chi,0} = m_\chi n_{\chi,0} \propto m_\chi T_0^3$$

- NULL GEOD. $d\eta = -dx$

$$\chi_{em}(z) = -\int_{em}^{0} dx = \int_{em}^{0} d\eta = \int_{em}^{0} \frac{dt}{a} = \frac{1}{a_0}\int_0^z \frac{dz'}{H(z')}$$

WHERE $H^2 = \frac{8\pi G}{3}\rho_{TOT} = H_0^2$

$$\frac{}{} = \frac{L}{4\pi} \frac{a^2}{a_0^4 S_k^2(r_{em})} = F(z)$$

) Δt_{sh}

AS FUNCTION OF z.

GICAL REDSHIFT $\frac{a_0}{a} = \frac{\omega}{\omega_0} + 1 - 1 = z + 1$

$$dz = -\frac{a_0}{a^2}\frac{da}{dt}dt = -\frac{a_0}{a} H\, dt$$

$\left(\frac{n_f}{s}\right)_f = \left(\frac{n_f}{s}\right)_0 \Rightarrow n_{f,0} = s_0 \, s_f$

$s_f = g_{sf} \frac{2\pi^2}{1.2} T_f^3$

- NULL GEOD, $d\eta = -dx$

$$\chi_{em}(z) = -\int_{em}^{0} dx = \int_{em}^{0} d\eta = \int_{em}^{0} \frac{dt}{a} = \frac{1}{a_0} \int_0^z \frac{dz'}{H(z')}$$

WHERE $H^2 = \frac{8\pi G}{3} \rho_{TOT} = H_0^2 \left(\sum_i \Omega_i (1+z)^{3(1+w_i)} \right)$

- PEOPLE LIKE LUMINOSITY DISTANCE $d_L = \sqrt{\frac{L}{4\pi F}}$

APPARENT MAGNITUDES $m = -2.5 \log_{10} F$

THE CMB SPECTRUM WOULD BE RULED OUT

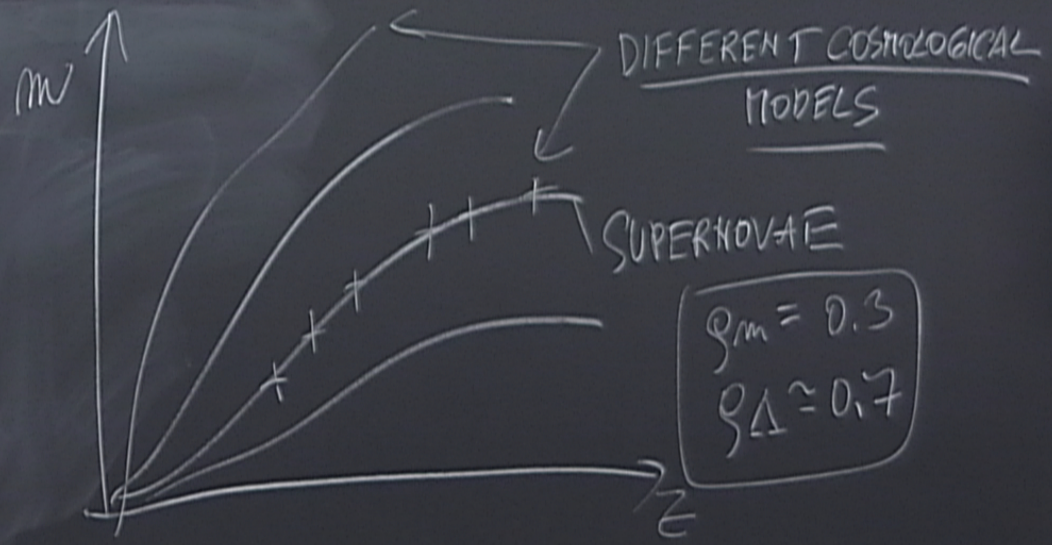
IF χ (m_χ) STILL RELAT.

$$= \frac{1}{a_0} \int_0^z \frac{dz'}{H(z')}$$

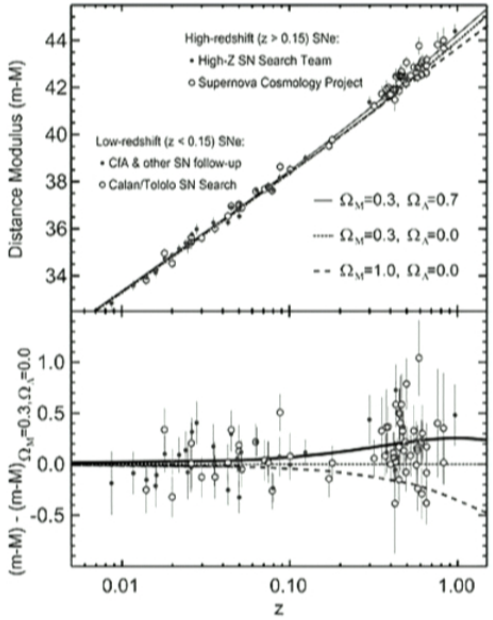
$$\left(\sum_i \Omega_i (1+z)^{3(1+w_i)} \right)$$

NCE $d_L = \sqrt{\frac{L}{4\pi F}}$

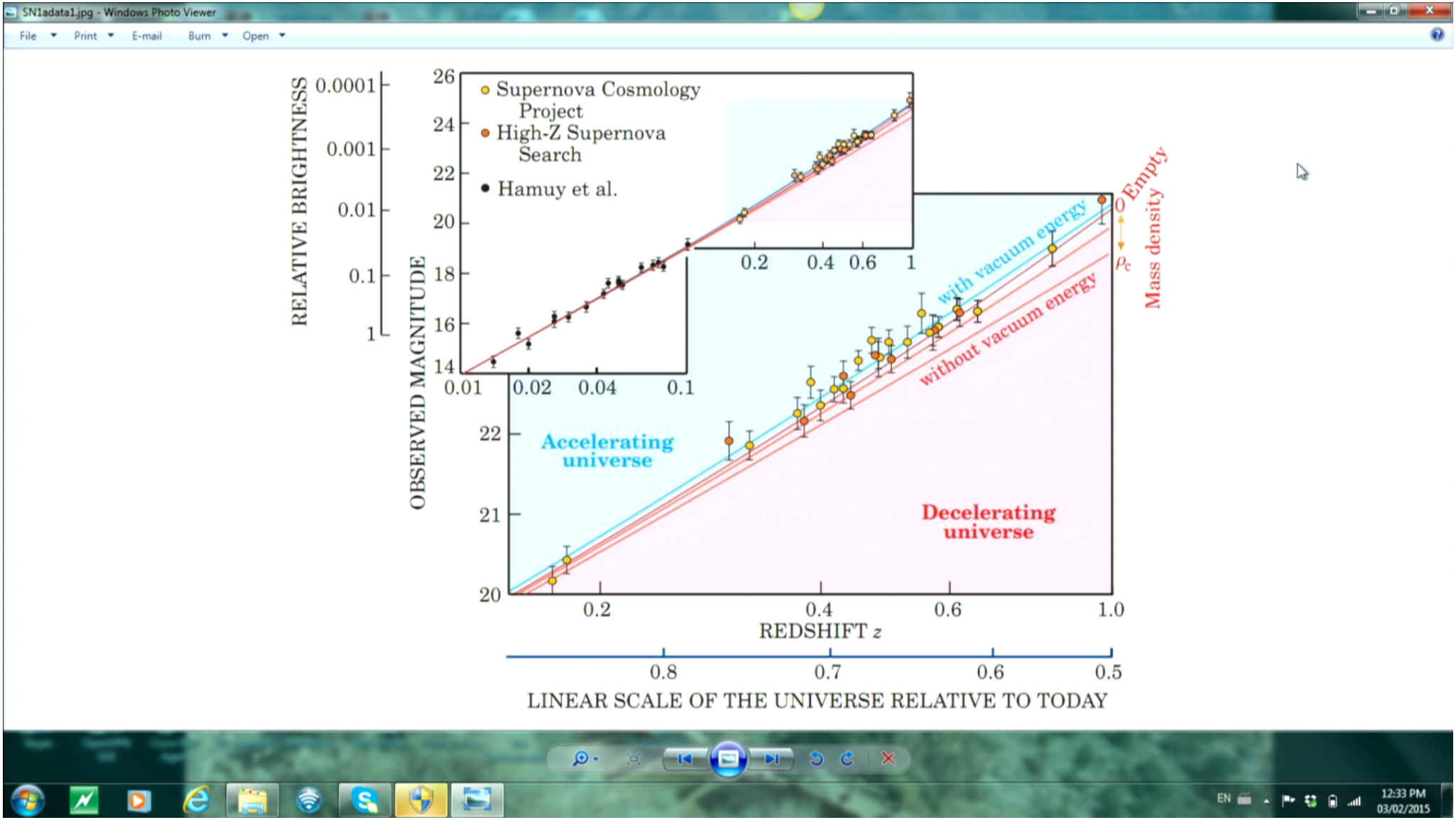
TUDES $m = -2.5 \log_{10} F$

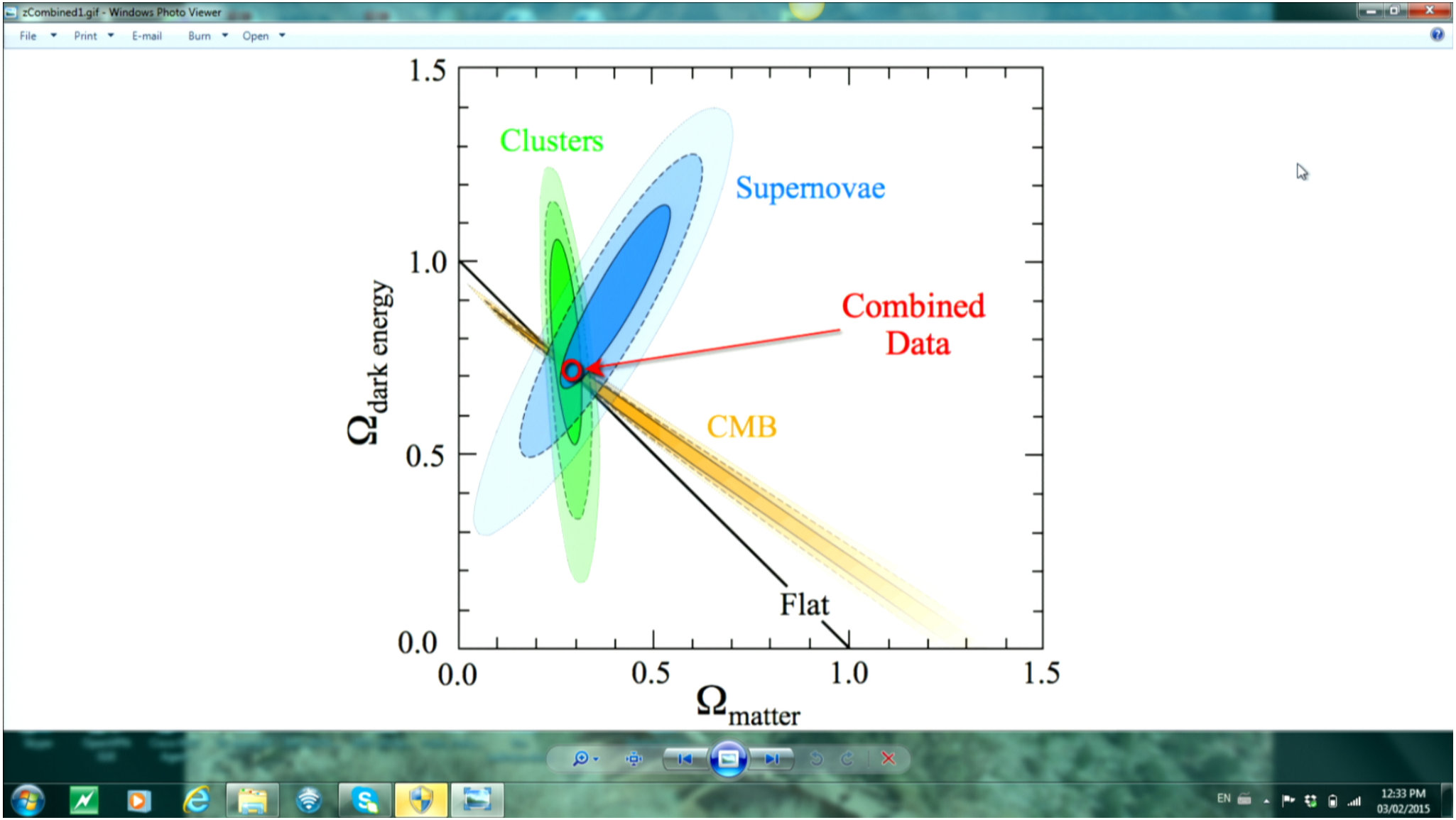


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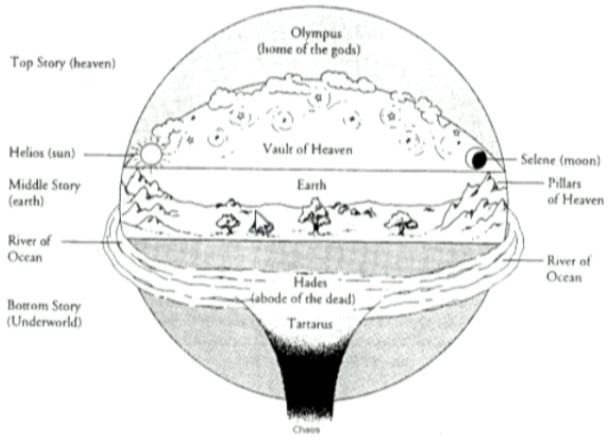


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RELATIVE BRIGHTNESS
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1
OBSERVED MAGNITUDE
Supernova Cosmology Project
High-Z Supernova Search
Hamuy et al.
Accelerating universe
Decelerating universe
with vacuum energy
without vacuum energy
Empty
Mass density
ρ_c
REDSHIFT z
LINEAR SCALE OF THE UNIVERSE RELATIVE TO TODAY
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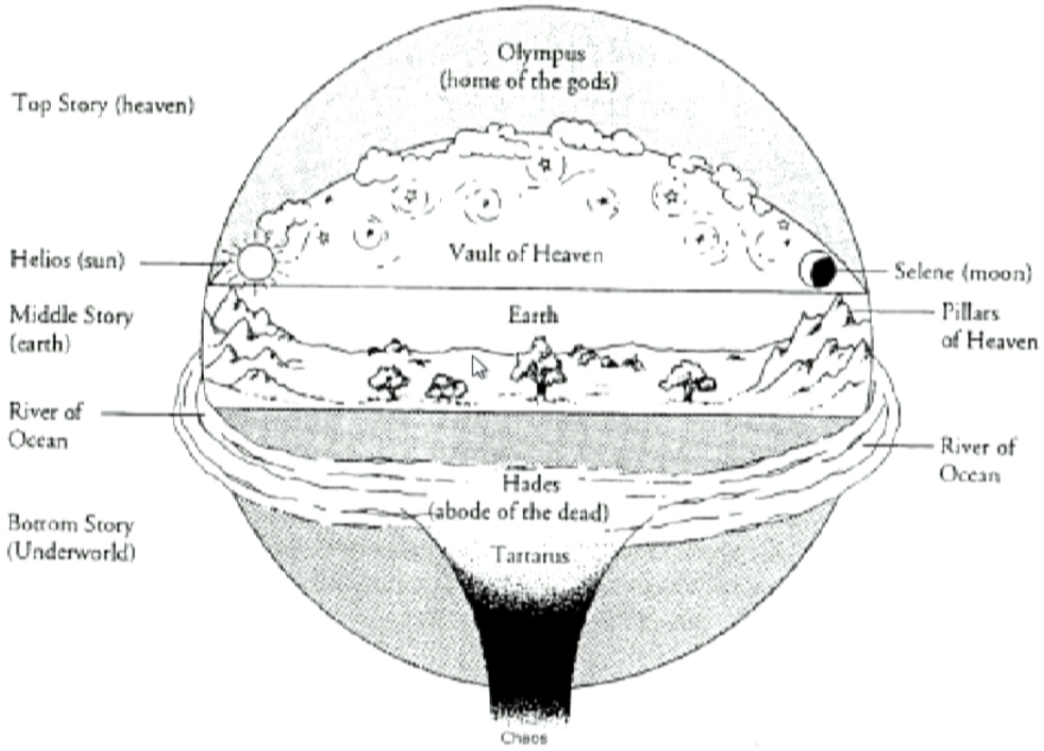

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Clusters
Supernovae
Combined Data
CMB
Flat
$\Omega_{dark\ energy}$
Ω_{matter}
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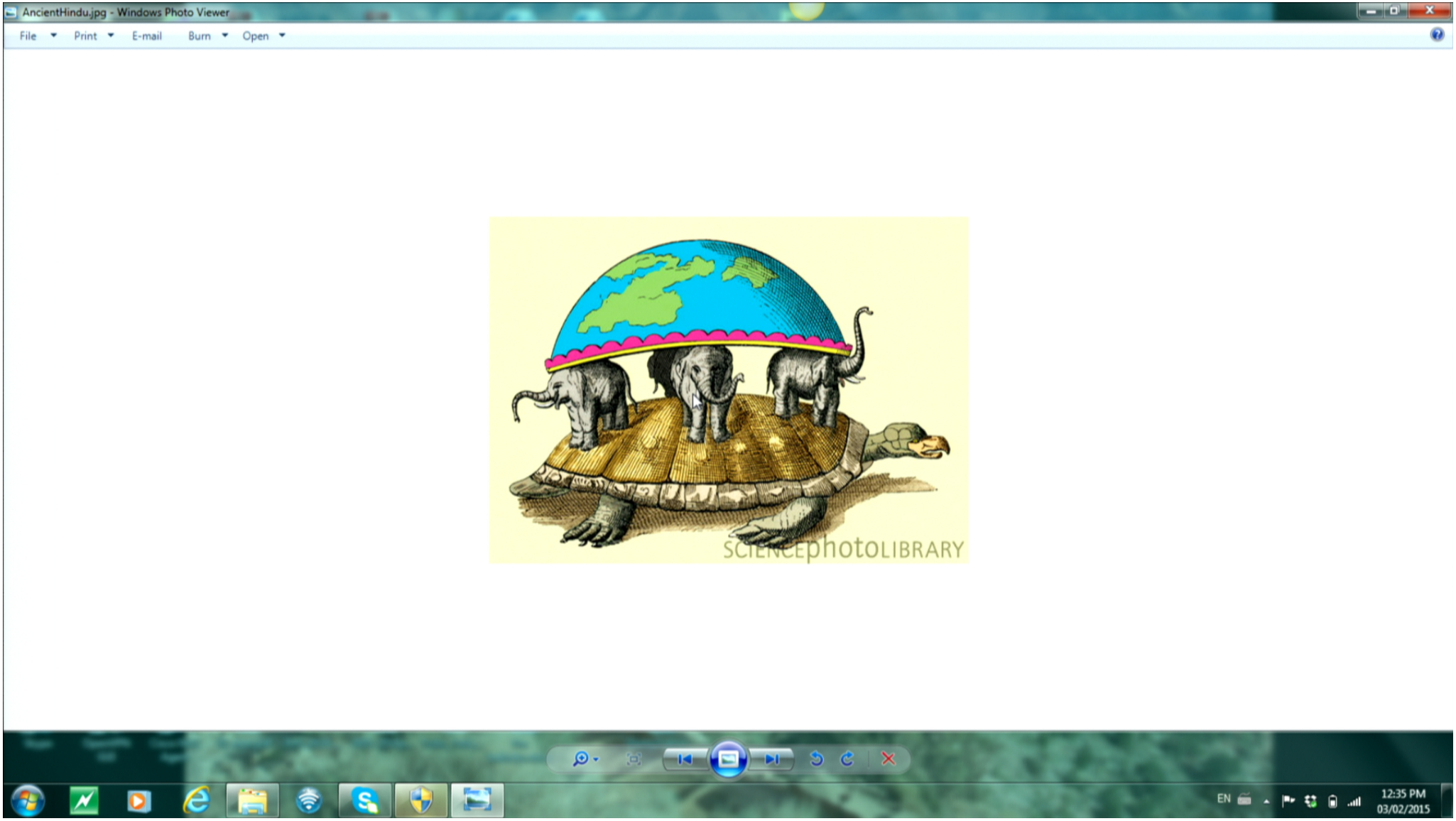


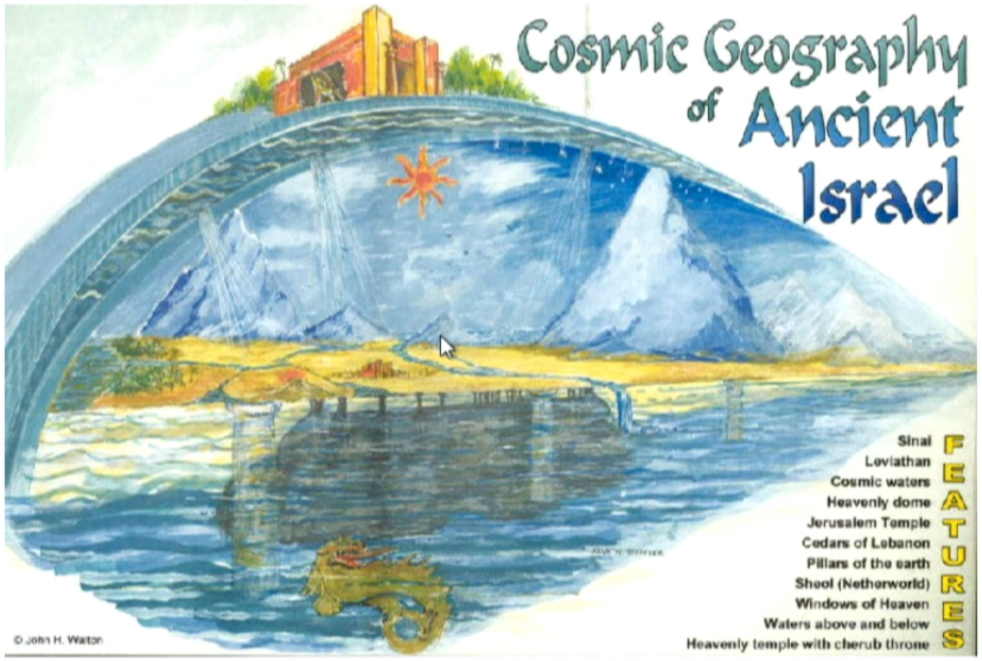
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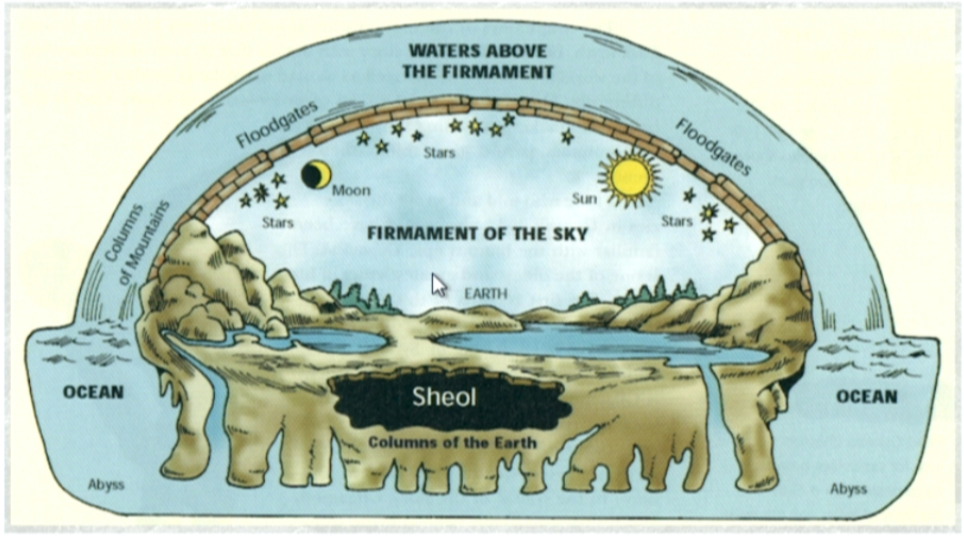


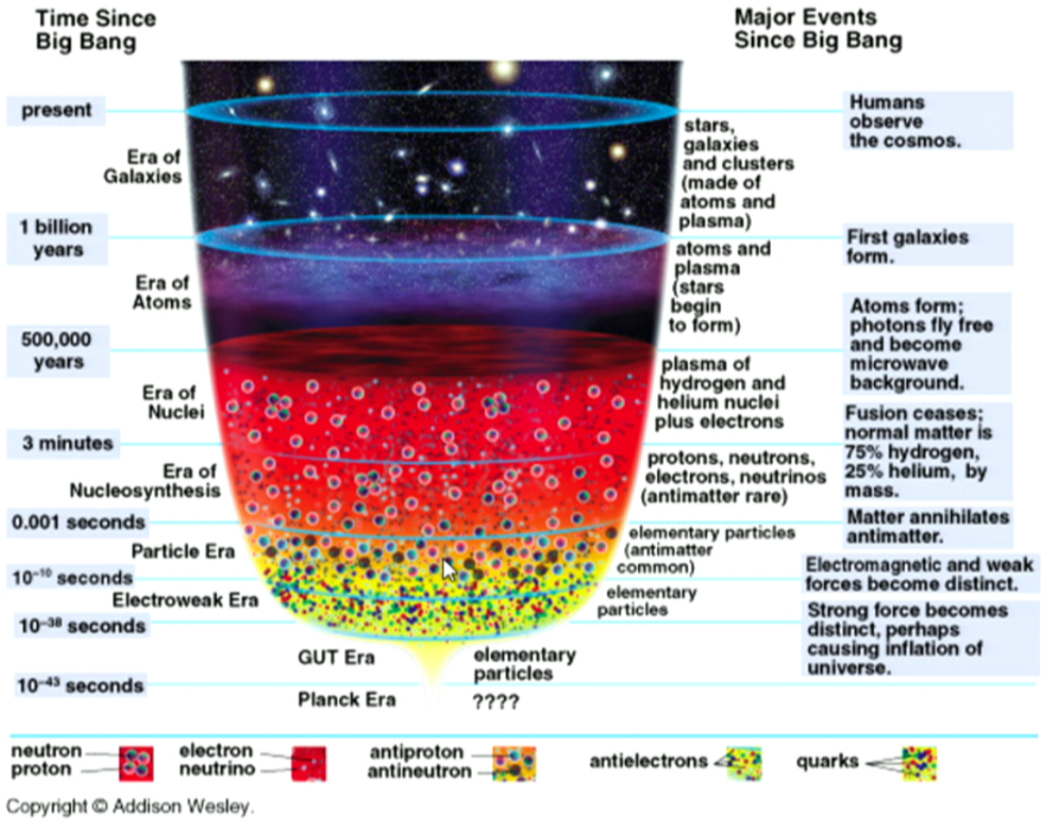
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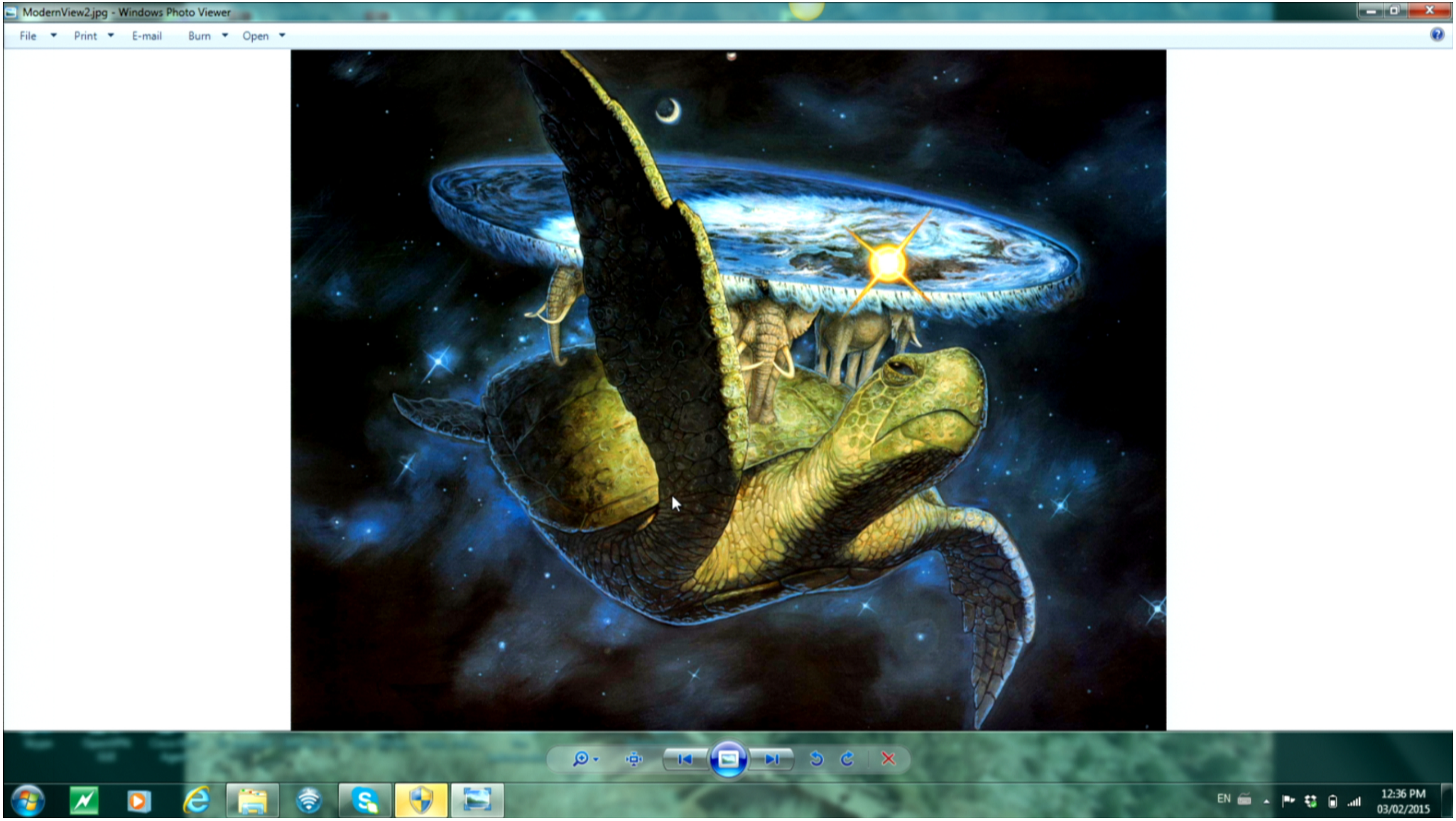

Cosmic Geography of Ancient Israel
FEATURES
Sinai
Leviathan
Cosmic waters
Heavenly dome
Jerusalem Temple
Cedars of Lebanon
Pillars of the earth
Sheol (Netherworld)
Windows of Heaven
Waters above and below
Heavenly temple with cherub throne
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WATERS ABOVE
THE FIRMAMENT
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Floodgates
Stars
Moon
Sun
Stars
Stars
Columns of Mountains
FIRMAMENT OF THE SKY
EARTH
OCEAN
Sheol
OCEAN
Columns of the Earth
Abyss
Abyss



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