Gravitational Lensing Bound on The Transition Redshift

Presented By

Nisha Rani

Department of Physics and Astrophysics
University of Delhi
Delhi, 110007

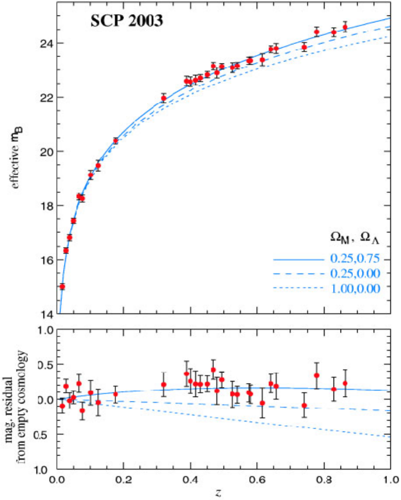
Brief Overview of the Talk

1. Evidence of accelerated expansion of Universe
2. Why kinematic approach
3. Parametrization used
4. Model Data and Methodology
    - Age Of Galaxies
    - Strong Lensing
5. Results and Conclusion
6. Future Aspects

Evidence of accelerated expansion of Universe

Results obtained by the SCP and HZSST team from the analysis of the Supernovae Ia are as follows:

- $\Omega_m = 0.25$
- $\Omega_\Lambda = 0.75$
- $q_0 = \frac{3}{2}\Omega_{mo} - 1 = -0.63$



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- This can help to narrow down the parameter space for the realistic models which describe accelerating Universe.
- This route is independent of any matter content of the Universe.
- It depends only on the assumption that at large scale, Universe is isotropic and homogeneous.

Parametrization Used

1. $q_I(z) = \frac{1}{2} + \frac{q_0}{(1+z)^2}$ (R. Nair et al. 2012)
2. $q_{II}(z) = q_1 + q_2 z$ (Lima et al. 2009)
3. $q_{III}(z) = q_3 + q_4 log(1+z)$

Model, Data and Methodology

- The theoretical age of galaxies can be calculated as follows

$$t(z,p) = \frac{1}{H_0}\int_z^{\infty} \frac{dx}{(1+x)E(x,p)}$$

$$E(x,p) = \frac{H(x,p)}{H_0}$$

Model

Corresponding Hubble parameter for this analysis are following-

$$H_I(z,p) = H_0(1+z)^{3/2} exp\left[\frac{q_0}{2}\left(\frac{z^2+2z}{(1+z)^2}\right)\right]$$

$$H_{II}(z,p) = H_0(1+z)^{(1+q1-q2)} exp(q_2 z)$$

$$H_{III}(z,p) = H_0(1+z)^{(1+q_3)} exp\left[\frac{q_4}{2}(log(1+z))^2\right]$$

Data

1. Data from the age of passively evolving galaxy.
   - Data Reference: Samushia L. et al. (2010) [arXiv: 09062734v3[astro-ph.CO]]
   - Redshift range: 0.1171 to 1.845
2. Strong lensing data.
   - Data Reference: Cao S. et al.(2012) [arXiv:1105.6226v5[astro-ph.CO]]
   - Redshift range of lens: 0.106 to 1.004
   - Redshift range of source: 0.1965 to 3.9

Method: Age of Galaxies

To constrain cosmological parameters using age of passively evolving galaxies, chisquare technique is employed

$$\chi^2 = \sum_{i=1}^{n} \frac{(t_i^{th} - t_{age}^{obs})^2}{\sigma_i^2}$$

$$\chi^2 = \sum_{i=1}^{n} \frac{(t_i^{th} - t_i^{z} - \tau)^2}{\sigma_i^2}$$

Method: Age of Galaxies

After minimization over nuisance parameter τ and H_0, chisquare becomes

$$\tilde{\tilde{\chi}}^2 = M - \frac{J^2}{C} - \frac{(GC - JE)^2}{C(CD - E^2)}$$

where

$$M = \sum_{i=1}^{n} \frac{[t_{obs}(z_i)]^2}{\sigma_i^2}, \quad J = \sum_{i=1}^{n} \frac{t_{obs}(z_i)}{\sigma_i^2}, \quad C = \sum_{i=1}^{n} \frac{1}{\sigma_i^2}$$

$$G = \sum_{i=1}^{n} \frac{\Delta(z_i) t_{obs}(z_i)}{\sigma_i^2}, \quad E = \sum_{i=1}^{n} \frac{\Delta(z_i)}{\sigma_i^2}, \quad D = \sum_{i=1}^{n} \frac{[\Delta(z_i)]^2}{\sigma_i^2}$$

$$\Delta(z_i) = \frac{t(z_i)}{H_0^{-1}}$$

Method: Age of Galaxies

Corresponding expression for the age of galaxies are following:

$$t_I(z_i, p) = H_0^{-1} \int_0^{\frac{1}{1+z}} x^{1/2} exp\left[\frac{-q_0}{2}(1-x^2)\right] dx$$

$$t_{II}(z_i, p) = H_0^{-1} \int_0^{\frac{1}{1+z}} x^{q_1-q_2} exp\left[-q_2\left(\frac{1-x}{x}\right)\right] dx$$

$$t_{III}(z_i, p) = H_0^{-1} \int_0^{\frac{1}{1+z}} \frac{x^{q_3}}{exp\left[\frac{q_4}{2}(log\ x)^2\right]} dx$$

Strong Lensing(SL)

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- Whenever the source, the lens and the observer are aligned in such a way that the observer-source direction lies inside the Einstein ring of the lens, strong gravitational lensing occurs.
- In strong lensing, cosmological model enters through the ratio of the angular diameter distances between lens and source and between observer and lens.
- This method is independent on the Hubble constant value and is also not affected by the source evolution.

Strong Lensing

To constrain cosmological parameters, chisquare technique is used again-

$$\chi^2 = \sum \frac{(d^{th} - d^{obs})^2}{\sigma_D^2}$$

Here,

$$d^{th}(z_i, p) = \frac{d_{ls}}{d_s}$$

$$d_{ls} = \frac{c}{(1+z_s)} \int_{z_l}^{z_s} \frac{dx}{H(x;p)}$$

$$d_s = \frac{c}{(1+z_s)} \int_{0}^{z_s} \frac{dx}{H(x;p)}$$

Results

Parametrization I $$q_I(z) = \frac{1}{2} + \frac{q_0}{(1+z)^2}$$

Dataset	q_0	$q(0)$	χ^2	χ^2_ν	z_t
Age	-2.58	-2.08	12.47	0.40	1.3
SL	-2.14	-1.64	66.13	1.9	1.09
Age+SL	-2.19	-1.69	78.68	1.2	1.06

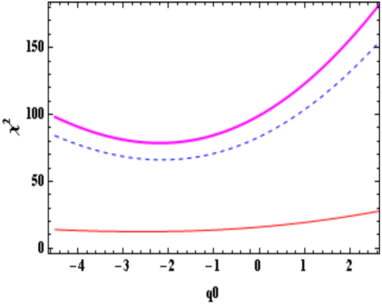

Figure: 1.1

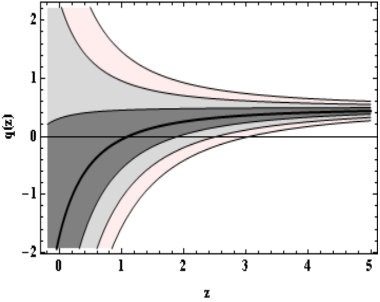

Figure: 1.2

Results

Parametrization II $\boxed{q_{II}(z) = q_1 + q_2 z}$

Dataset	q_1	q_2	$q(0)$	χ^2	χ^2_ν	z_t	FOM
Age	-1.68	1.55	-1.68	12.28	1.1	1.3	0.71
SL	-0.85	0.23	-0.85	64.71	1.9	3.7	4.62
Age+SL	-0.91	0.50	-0.91	77.47	0.65	1.8	6.3

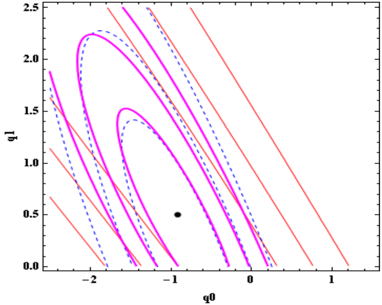

Figure: 2.1

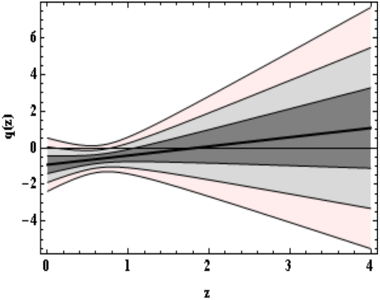

Figure: 2.2

Results

Parametrization III $q_{III}(z) = q_3 + q_4 log(1 + z)$

Dataset	q_3	q_4	$q(0)$	χ^2	χ^2_ν	z_t	FOM
Age	-1.88	2.54	-1.88	12.35	0.41	1.1	0.39
SL	-0.84	0.30	-0.84	64.76	1.9	6.6	2.58
Age+SL	-0.95	0.79	-0.95	77.56	1.2	2.3	3.7

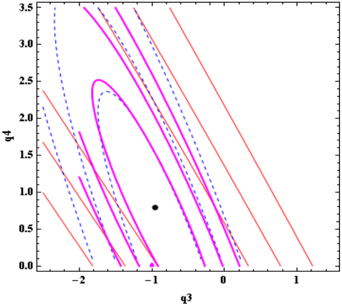

Figure: 3.1

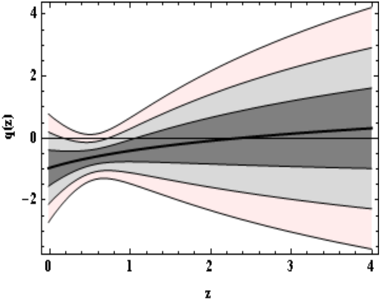

Figure: 3.2

Conclusion

1. The value of deceleration parameter at present epoch according to the recent Planck's result is -0.53.
2. Value of transition redshift coming out from the strong lensing is greater than one.
3. The dataset for the age of galaxies also gives transition redshift higher than one.
4. Strong lensing data is not very precised due to the assumptions considered while collecting data.

Future Aspects

1. Using the precised strong lensing dataset tighter constraints can be obtained.
2. Combining other datasets like data from the GRB's can minimize the cosmological parameter space.


Thank you ...