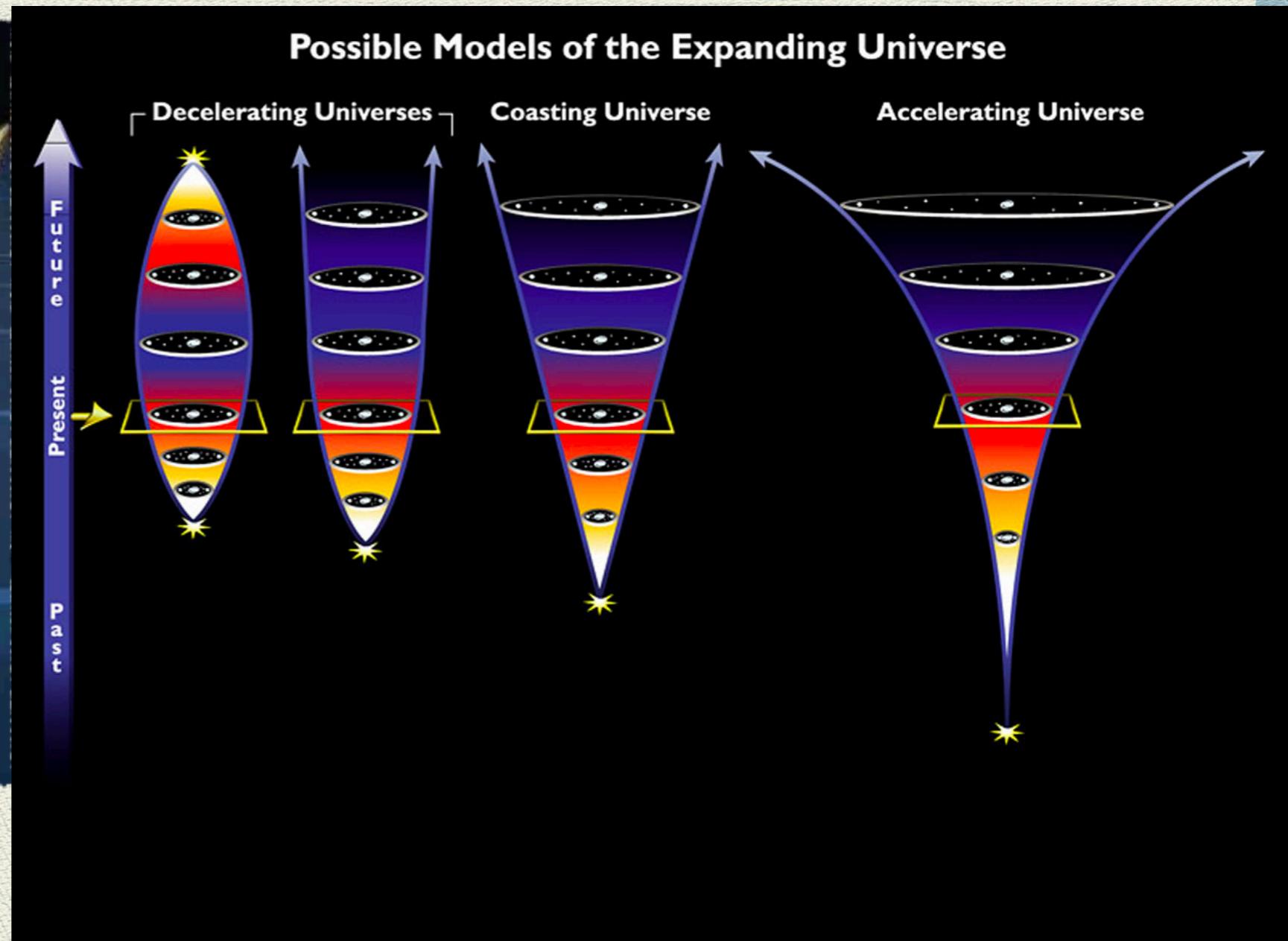
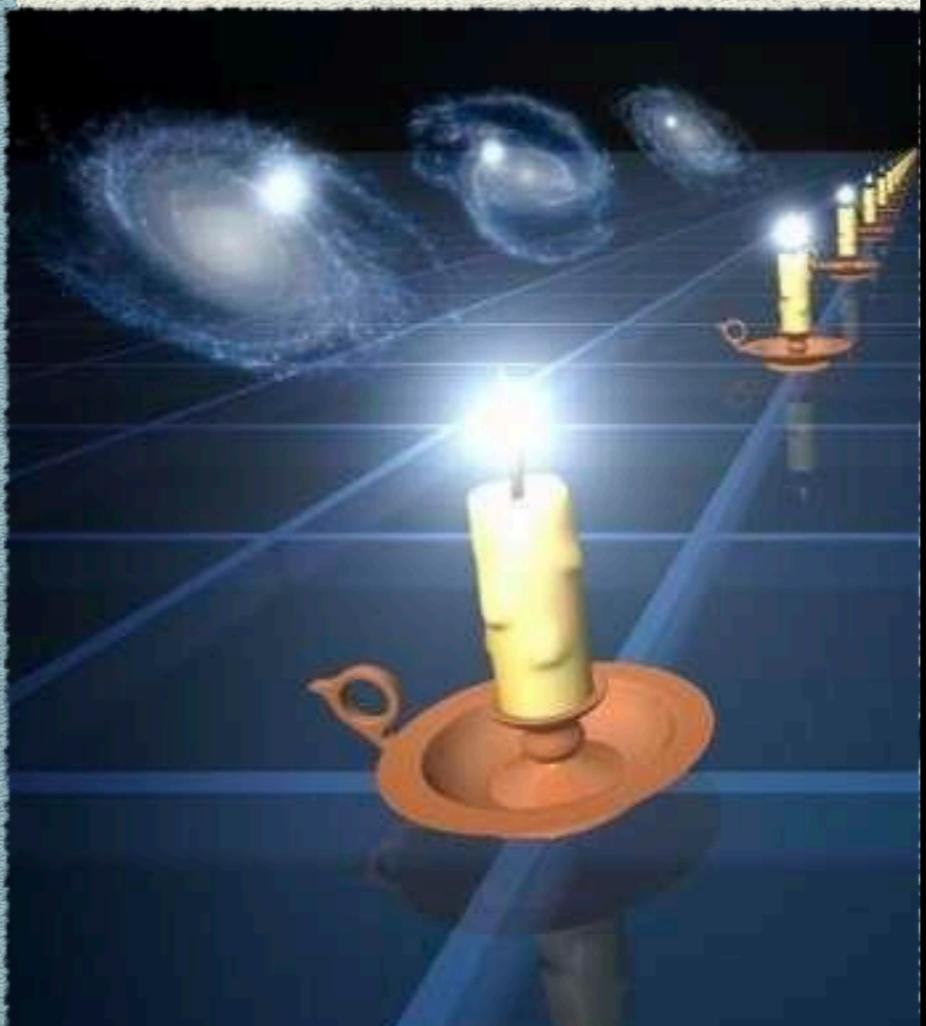


# The accelerating Universe

*Nobel Prize in Physics 2011*

*Ji Xuan  
Shan Xinrui*

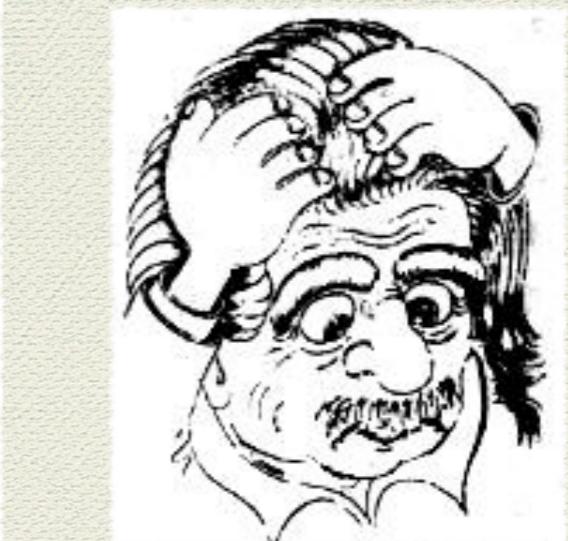
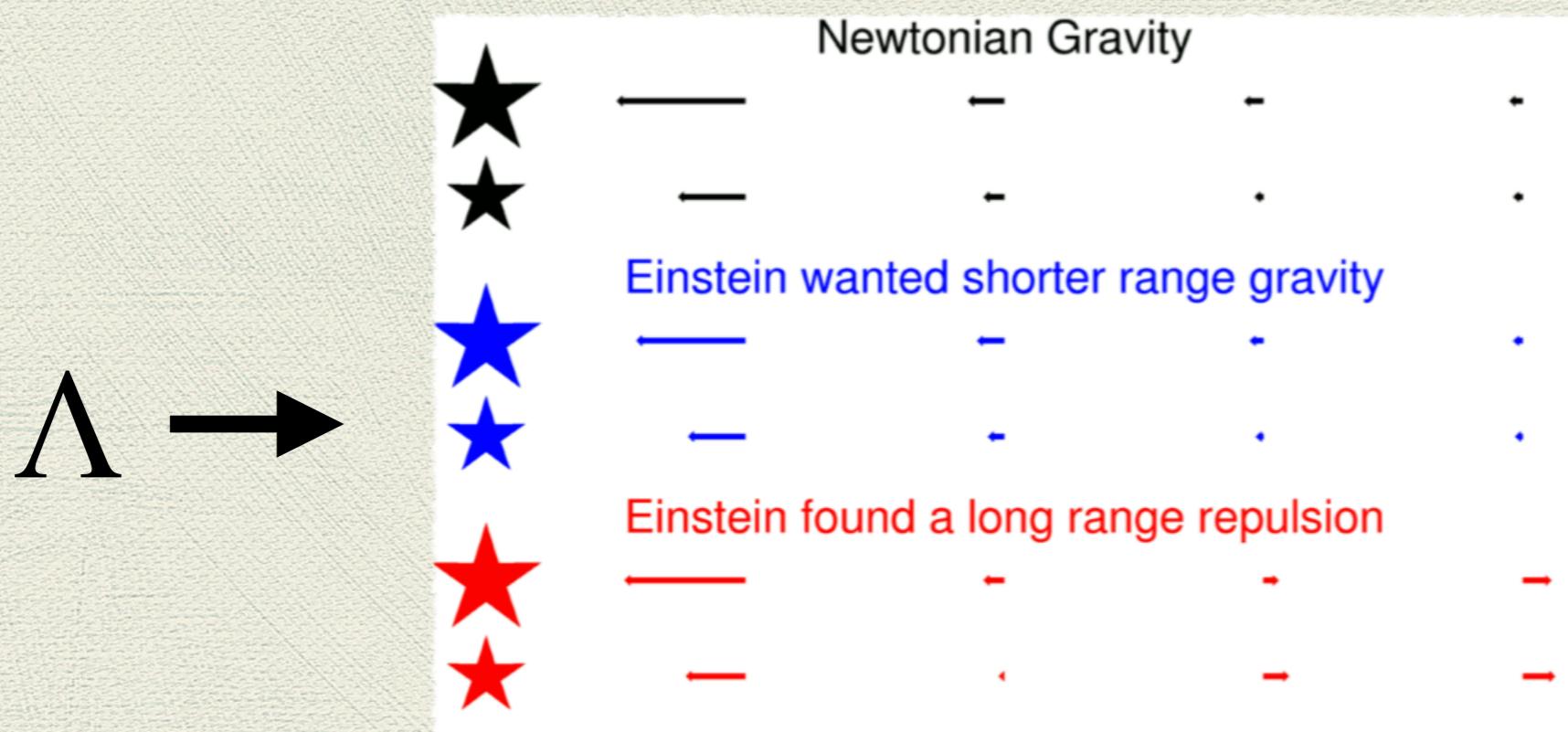
# Brief Overview



# Background

**Einstein: Static Universe**    **Expand/collapse**

?



**“This was my greatest blunder”** :(

# Friedmann equations

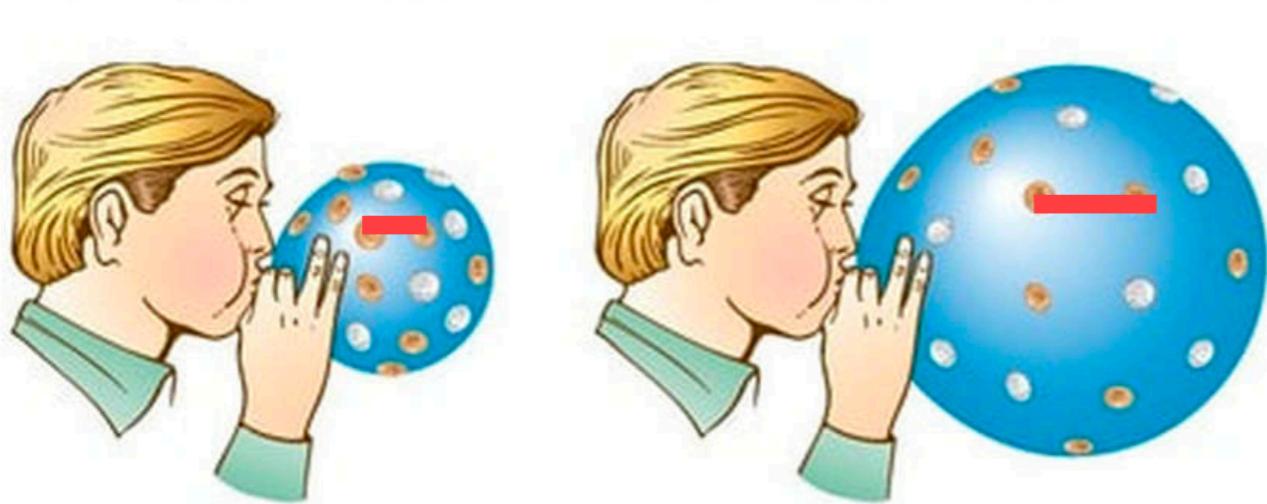
$$1 = \Omega_M + \Omega_\Lambda + \Omega_k$$

# Background

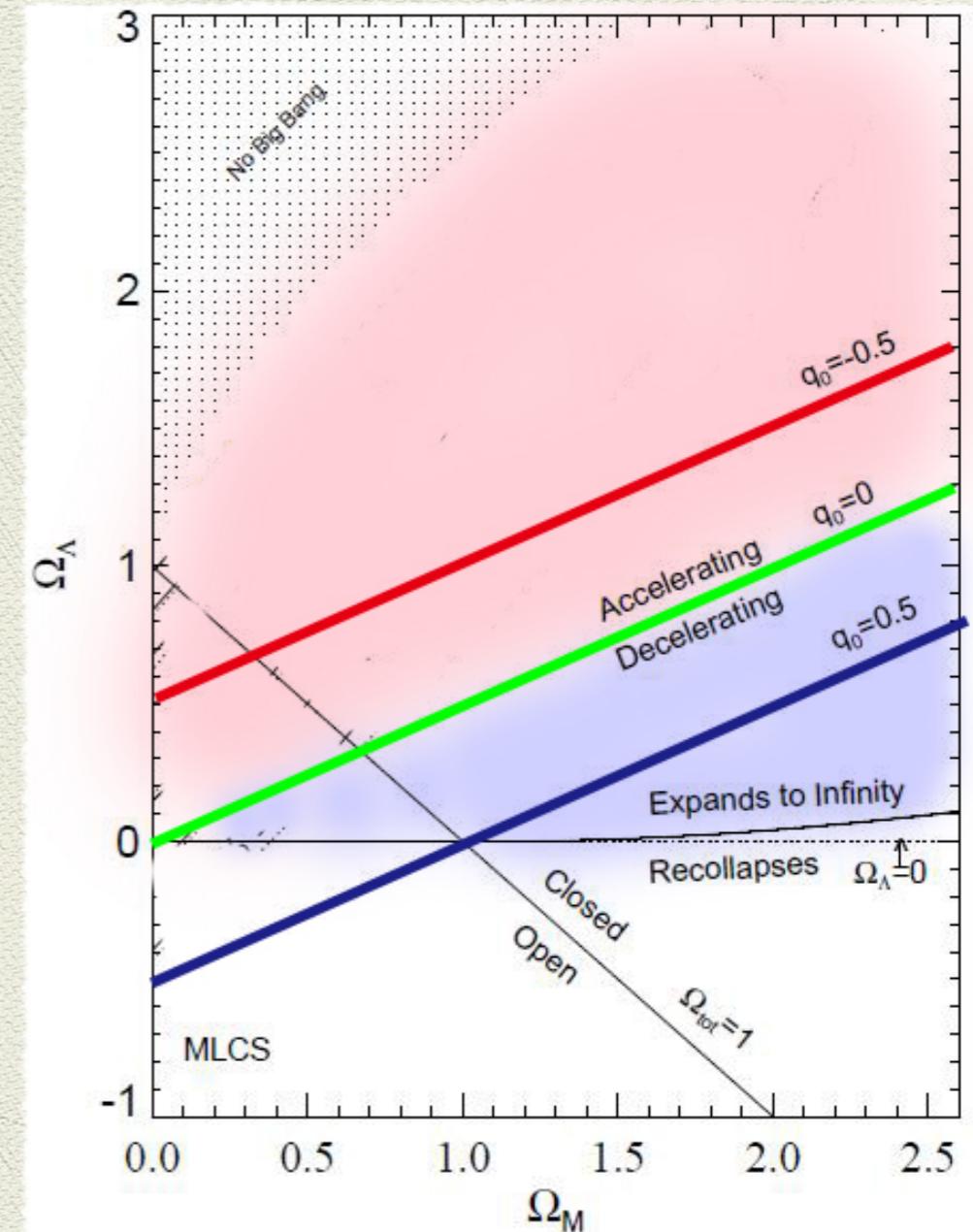
## Robertson-Walker Metric

$$ds^2 = dt^2 - R^2(t) \left\{ \frac{dr^2}{1-kr^2} + r^2 d\theta^2 + r^2 \sin^2 \theta d\varphi^2 \right\}$$

$R(t)$ : Cosmic scale factor



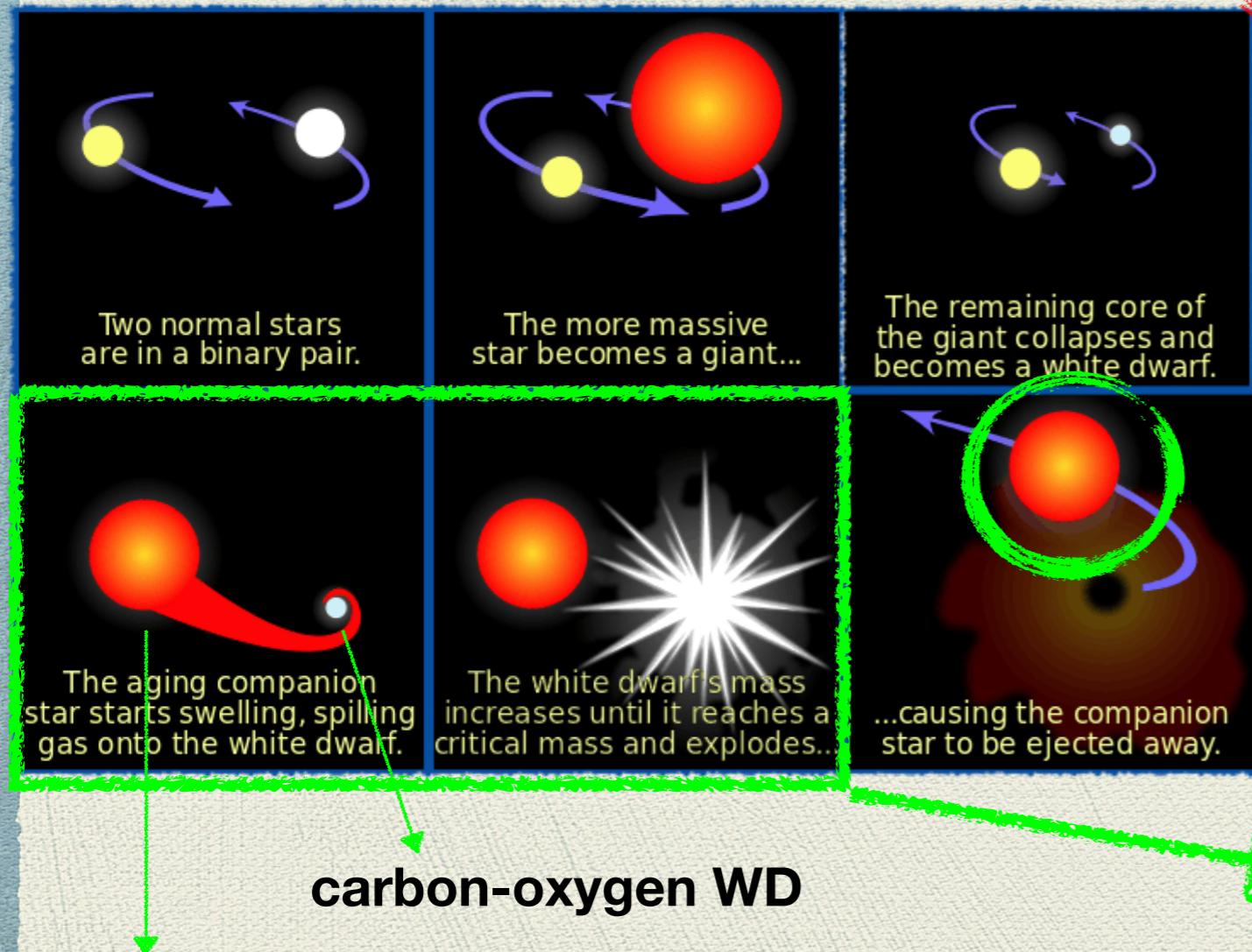
$$\begin{aligned} q_0 &\equiv -\ddot{R}(t_0)R(t_0)/\dot{R}^2(t_0) \\ &= (\Omega_M/2) - \Omega_\Lambda \end{aligned}$$



# Methodology

## Single degenerate model

### The formation of type 1a SN



accretes matter  
~~>1.44 M<sub>sun</sub> can't support neutron star~~  
reach 99% of mass limit  
high density and T  
ignite carbon fusion  
~s releasing energy of whole star ( $1.4M_{\text{sun}}$ )  
unbind the star in a SN  
 $M = -19.3 \text{ mag}$

MS/RG/He star

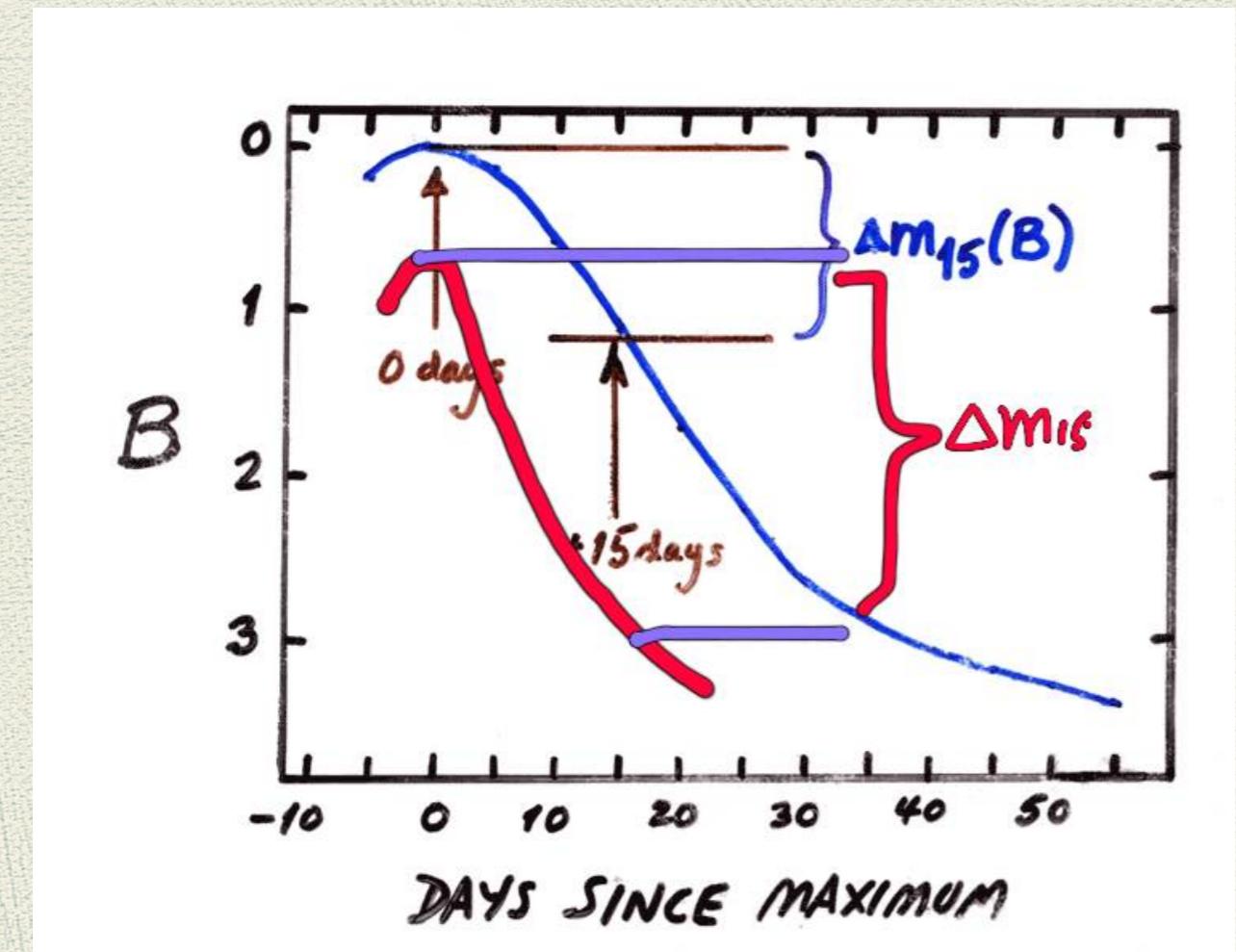
# Methodology

other factors effect the explosion

peak brightness dispersions of 0.4 to 0.6 mag

X consistent  
X -19.3 mag

Phillips relationship



standardizable candles

$$M_{max}(B) = -21.726 + 2.698\Delta_{m15}(B)$$

# Methodology

## 1. Observation

$$D_L = \left( \frac{L}{4\pi l} \right)^{1/2}$$

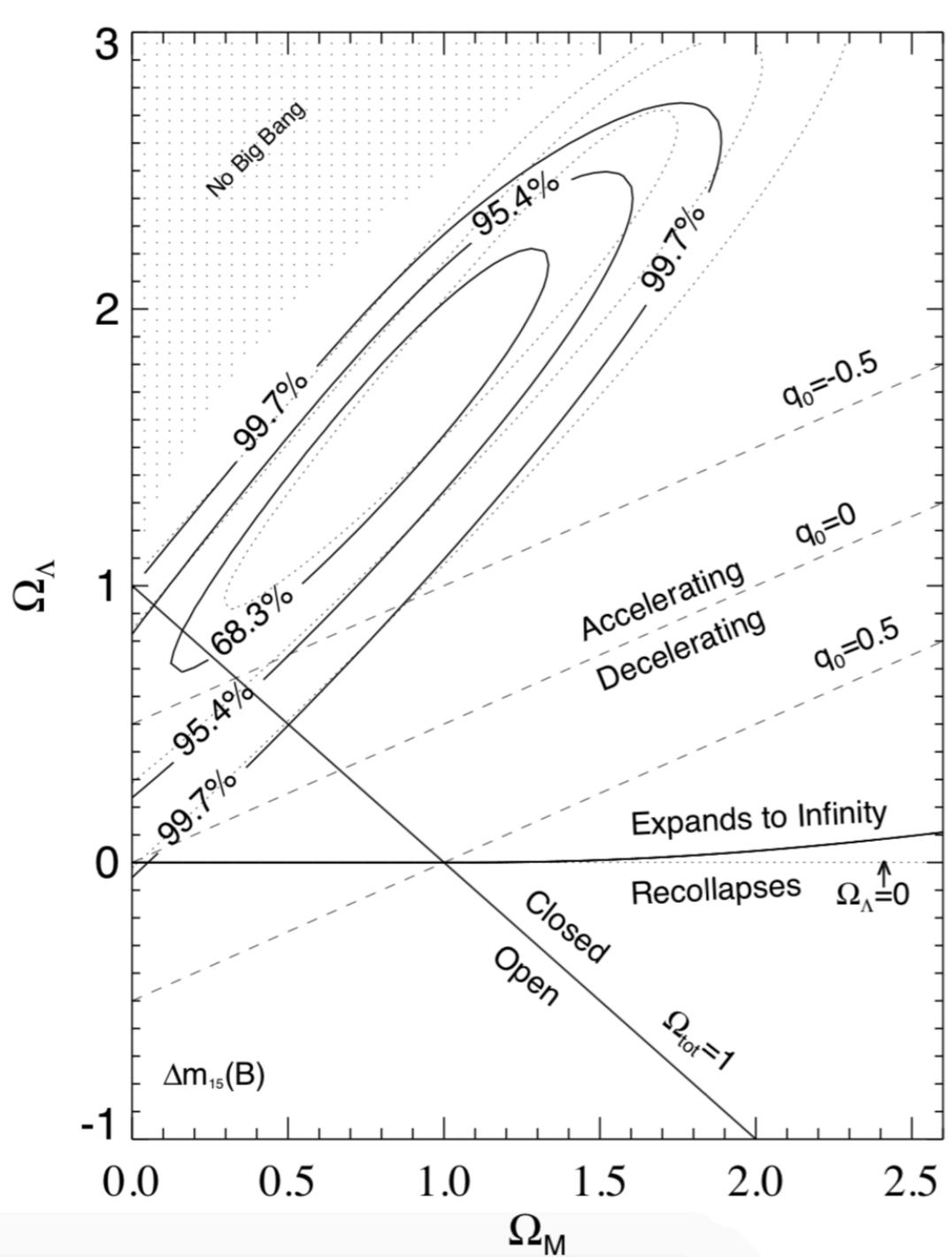
## 2. Friedmann-Robertson-Walker cosmologies

$$D_L = cH_0^{-1}(1+z)|\Omega_k|^{-1/2} \sin n \left\{ |\Omega_k|^{1/2} \times \int_0^z dz [(1+z)^2(1+\Omega_M z) - z(2+z)\Omega_\Lambda]^{-1/2} \right\}$$

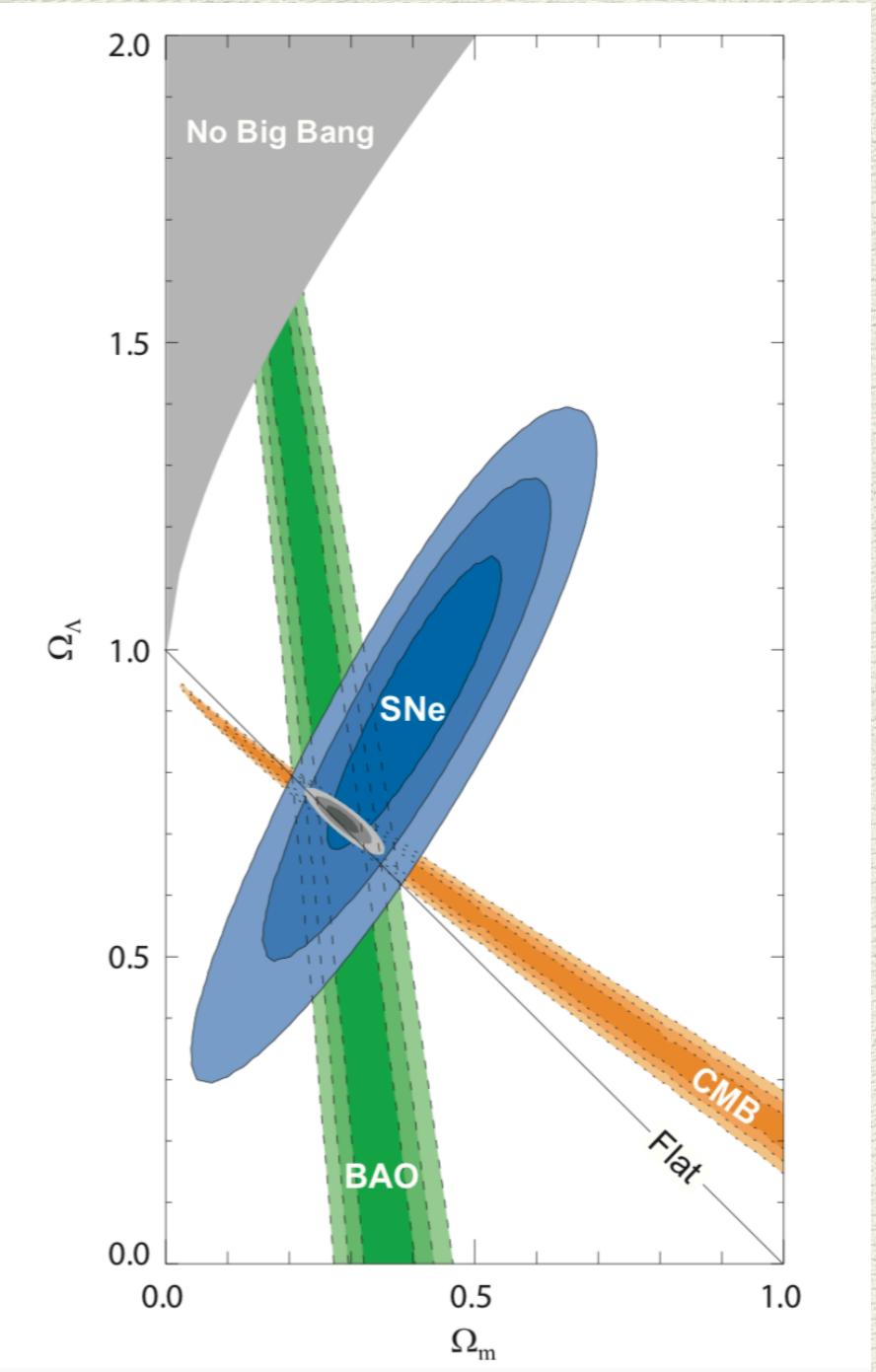
→  $\chi^2$  statistic

$$\chi^2(H_0, \Omega_M, \Omega_\Lambda) = \sum_i \frac{[\mu_{p,i}(z_i; H_0, \Omega_m, \Omega_\Lambda) - \mu_{0,i}]^2}{\sigma_{\mu_{0,i}}^2 + \sigma_v^2}$$

# Result



**SN  $\chi^2$  statistic**  
Riess et al. 1998



**Combination of CMB, BAO, SN**  
Kowalski et al. 2008

# Remain Problems: 1a SN

**Double Degenerate model**  
merger of two WDs

$$M_{total} > 1.4M_{sun}$$

**? Standard candle**

	1	2	3
González Hernández et al. (2012)			<b>distinguish 2 models</b>
<b>Double Degenerate model</b> $P > 80\%$		<b>search the signature from the non-degenerate companion</b>  surviving companion UV excess: between supernova ejecta and the companion progenitor system: images	<b>Not clear</b>

Thank you!