

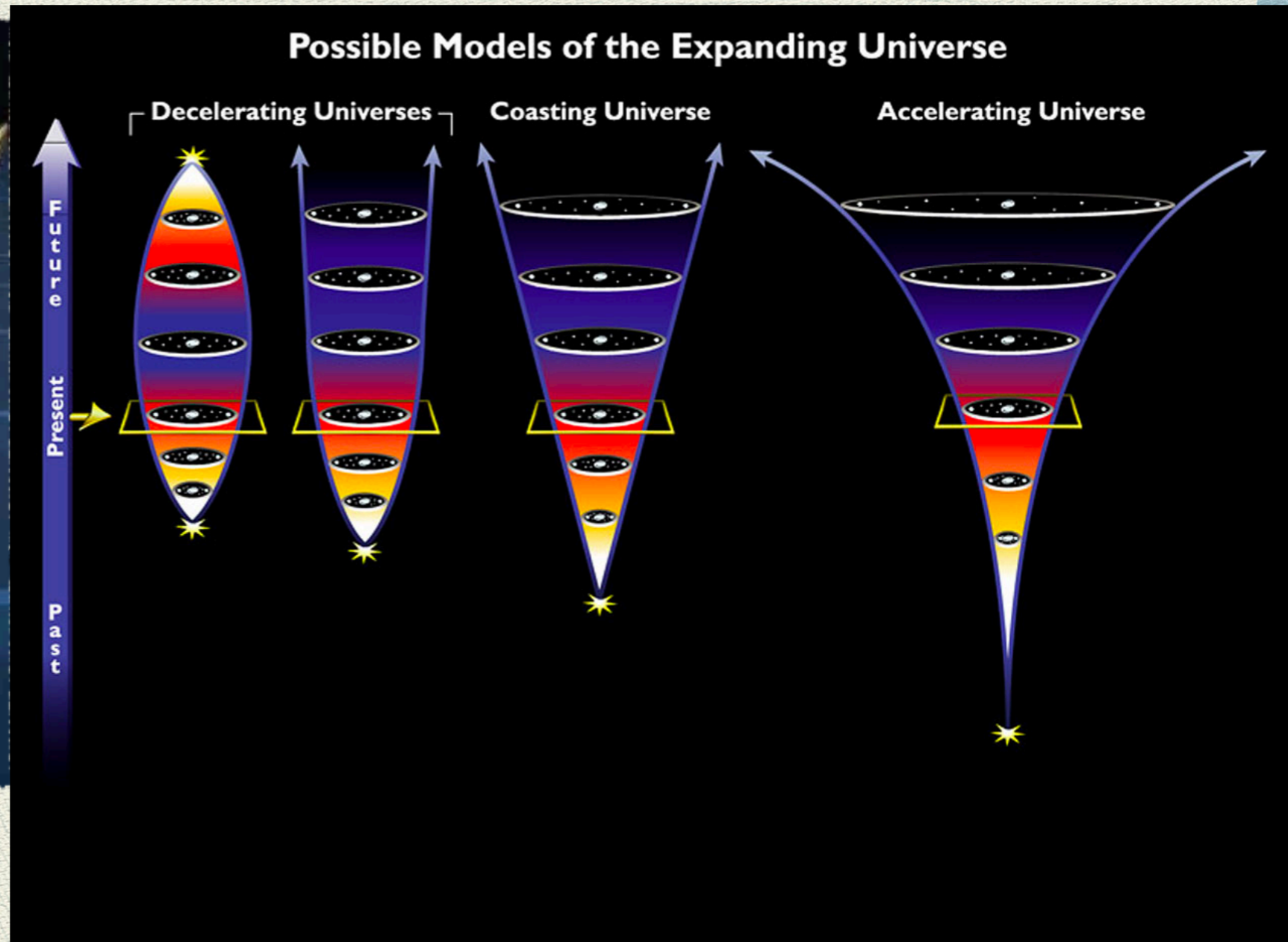
The accelerating Universe

Nobel Prize in Physics 2011

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Brief Overview



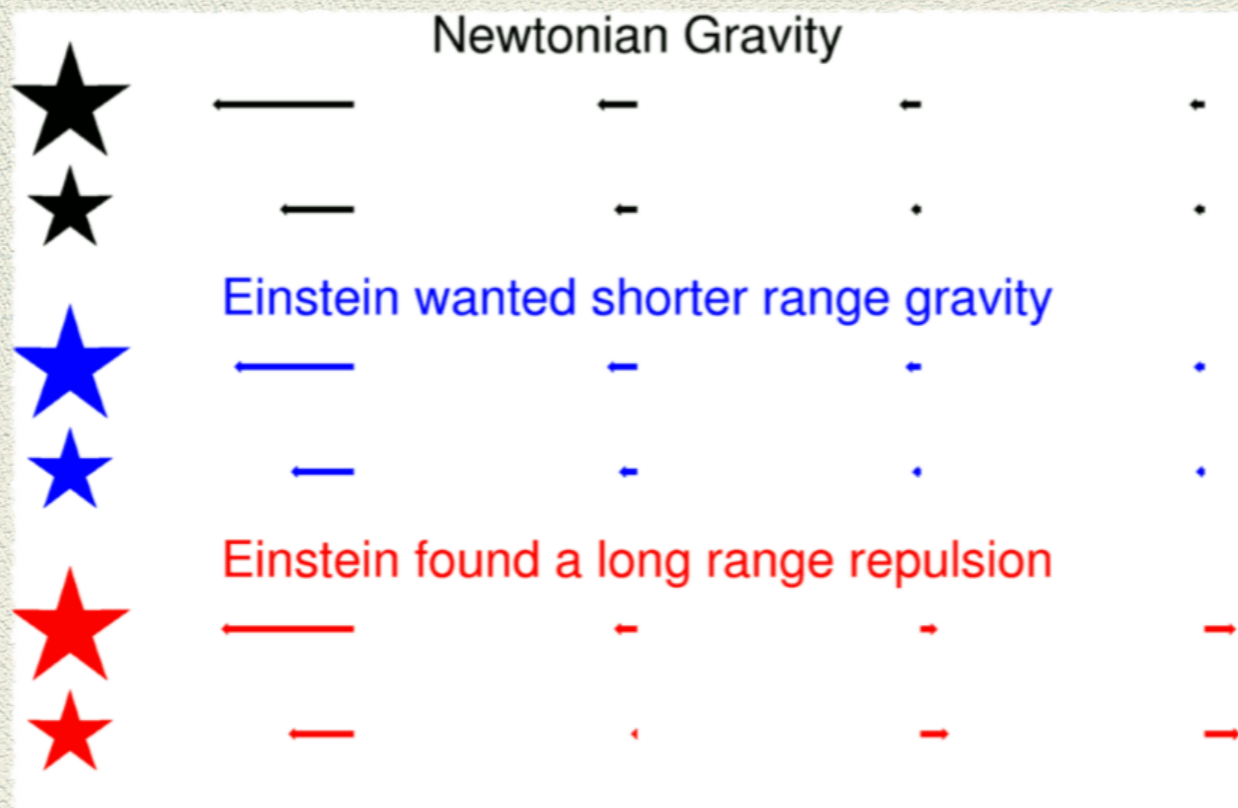
Background

Einstein: Static Universe

Expand/collapse

???

Λ →



“This was my greatest blunder” :(

Friedmann equations

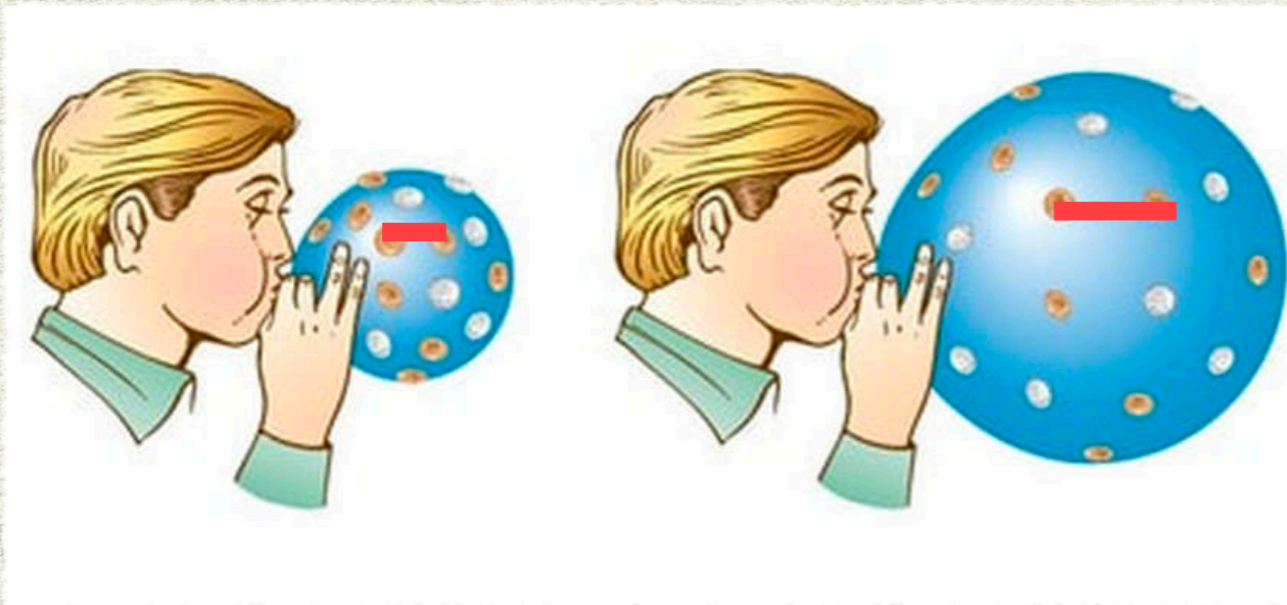
$$1 = \Omega_M + \Omega_\Lambda + \Omega_k$$

Background

Robertson-Walker Metric

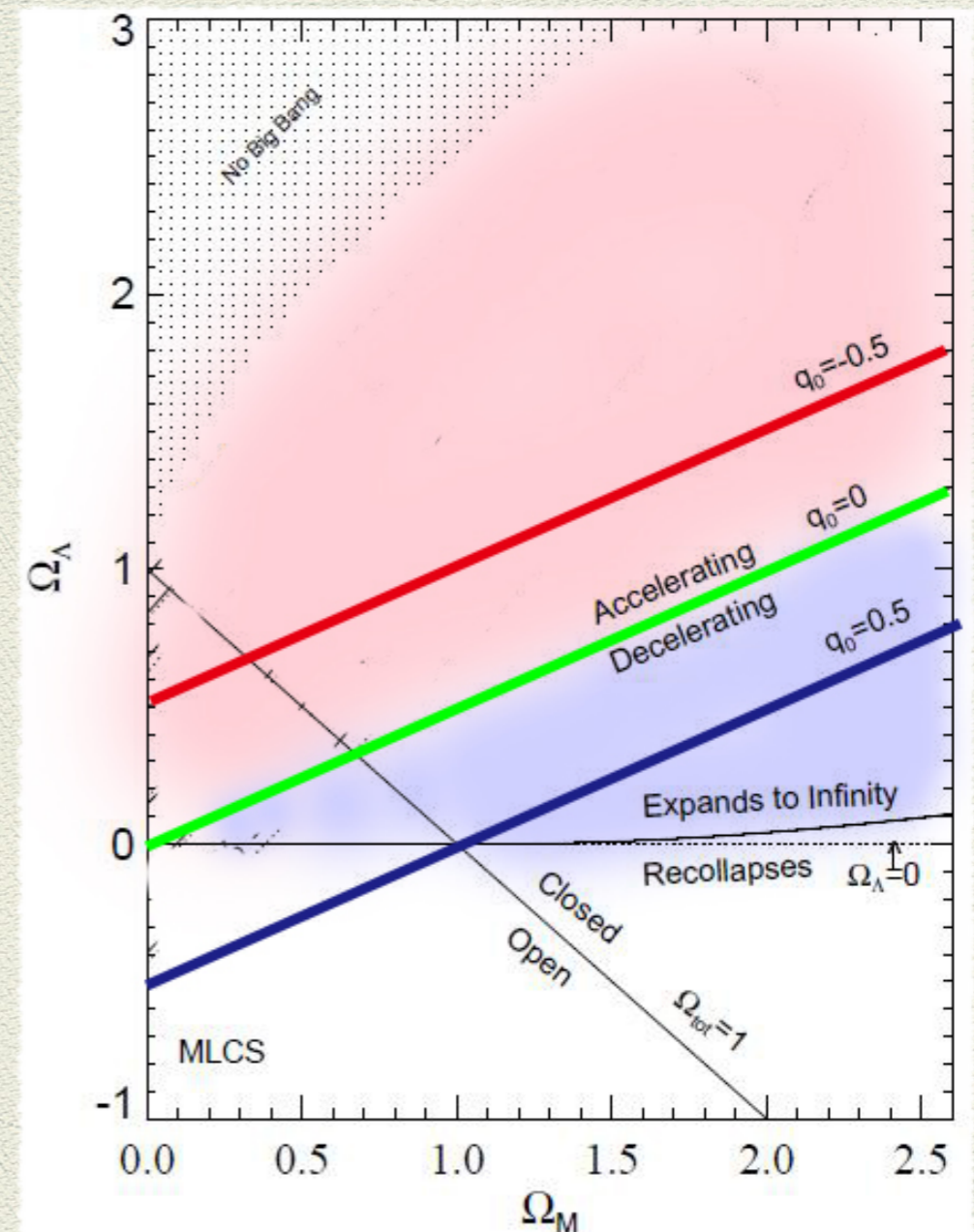
$$ds^2 = dt^2 - R^2(t) \left\{ \frac{dr^2}{1-kr^2} + r^2 d\theta^2 + r^2 \sin^2 \theta d\phi^2 \right\}$$

R(t): Cosmic scale factor



$$q_0 \equiv -\ddot{R}(t_0)R(t_0)/\dot{R}^2(t_0)$$

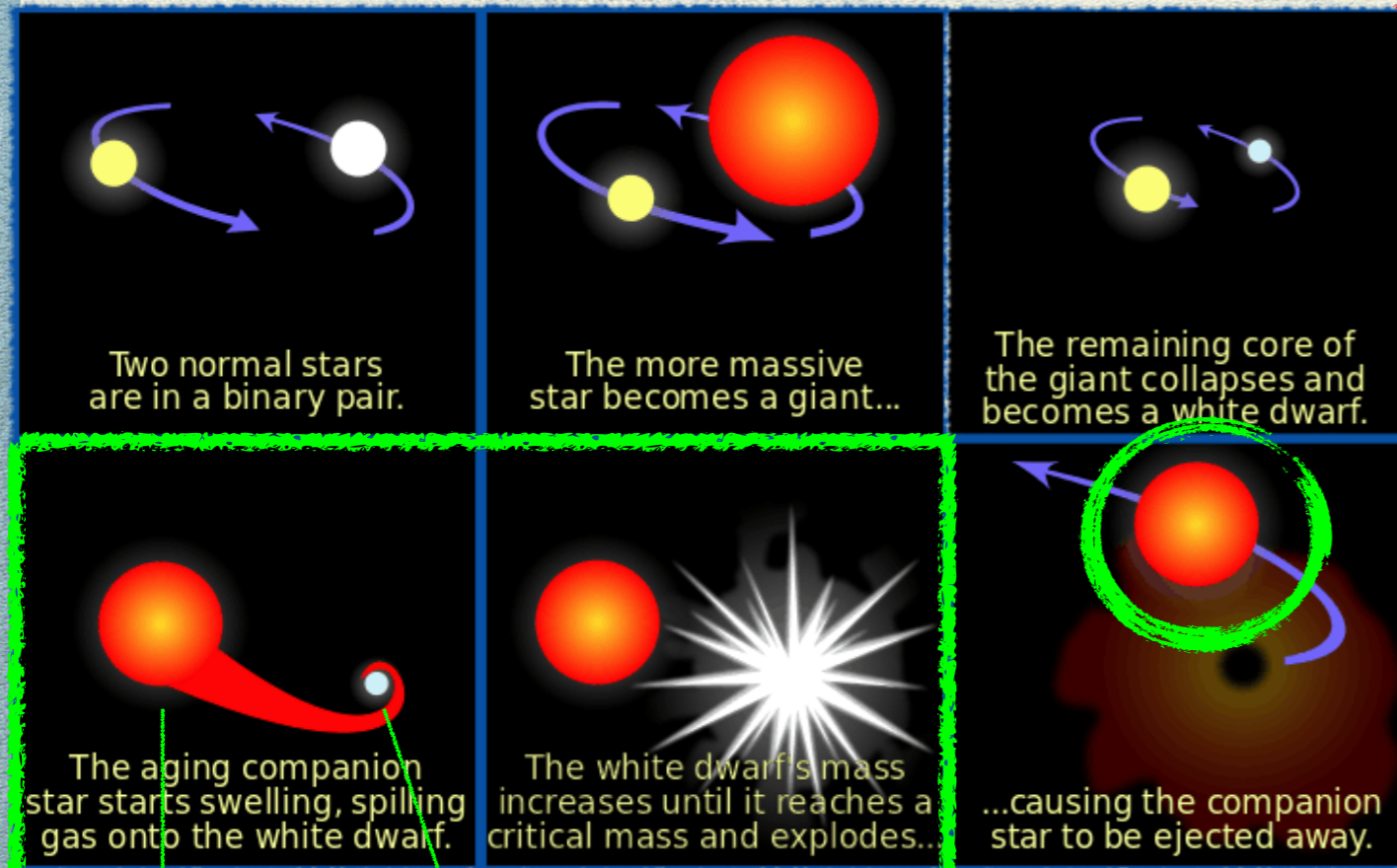
$$= (\Omega_M/2) - \Omega_\Lambda$$



Methodology

Single degenerate model

The formation of type 1a SN



carbon-oxygen WD

MS/RG/He star

accretes matter

~~> 1.44 M_{sun}~~ 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 mag

Methodology

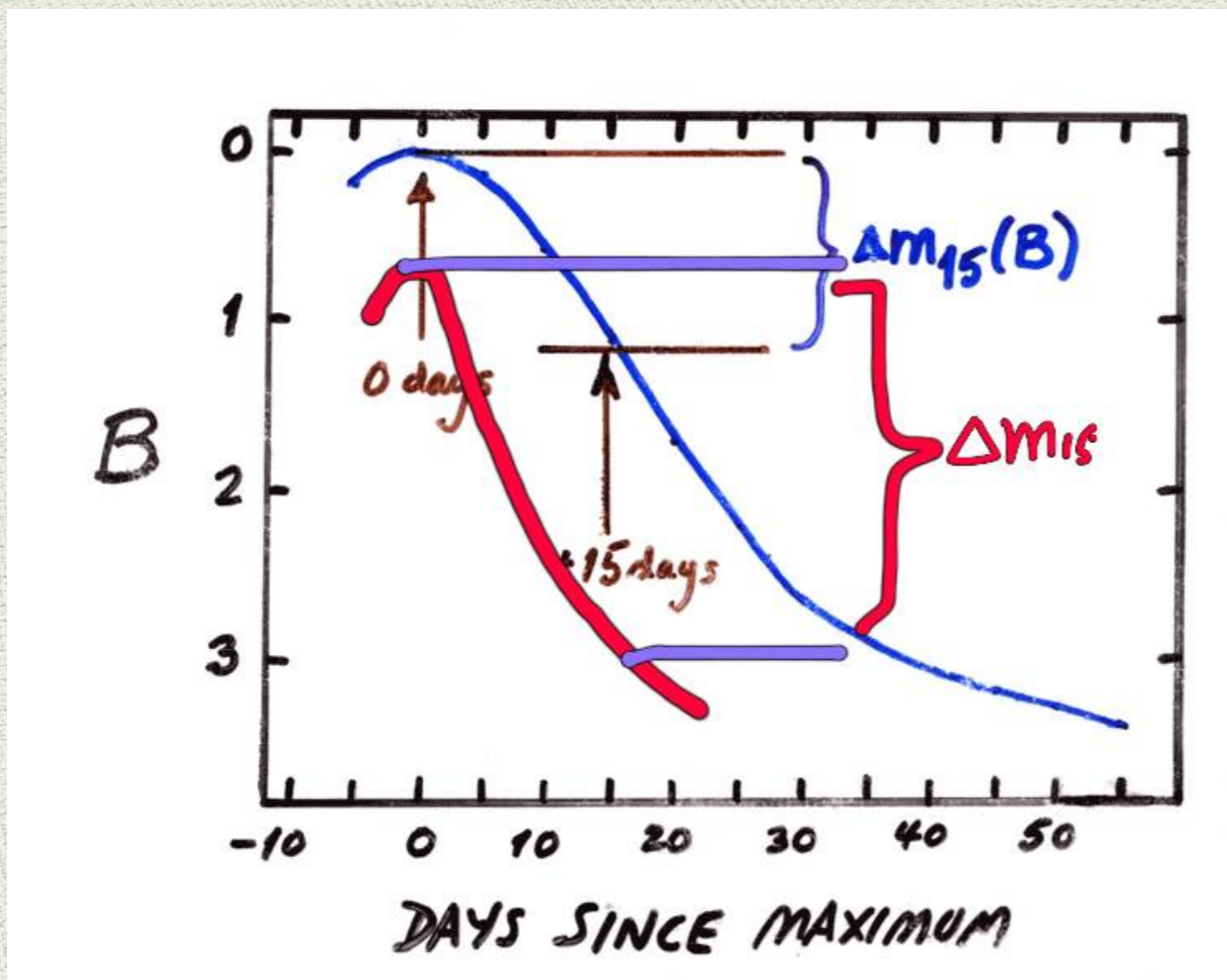
other factors effect the explosion

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

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

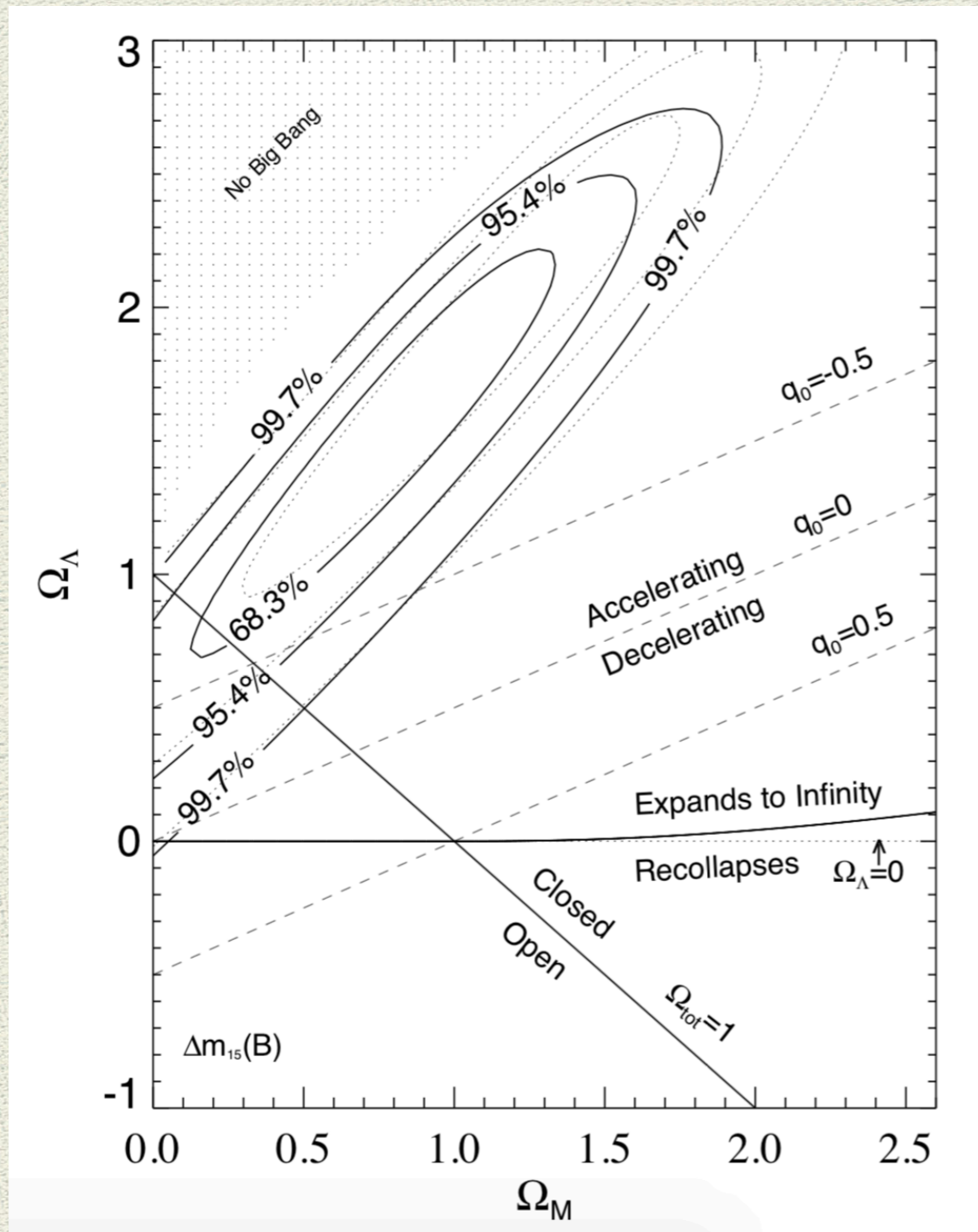
2. Friedmann-Robertson-Walker cosmologies

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

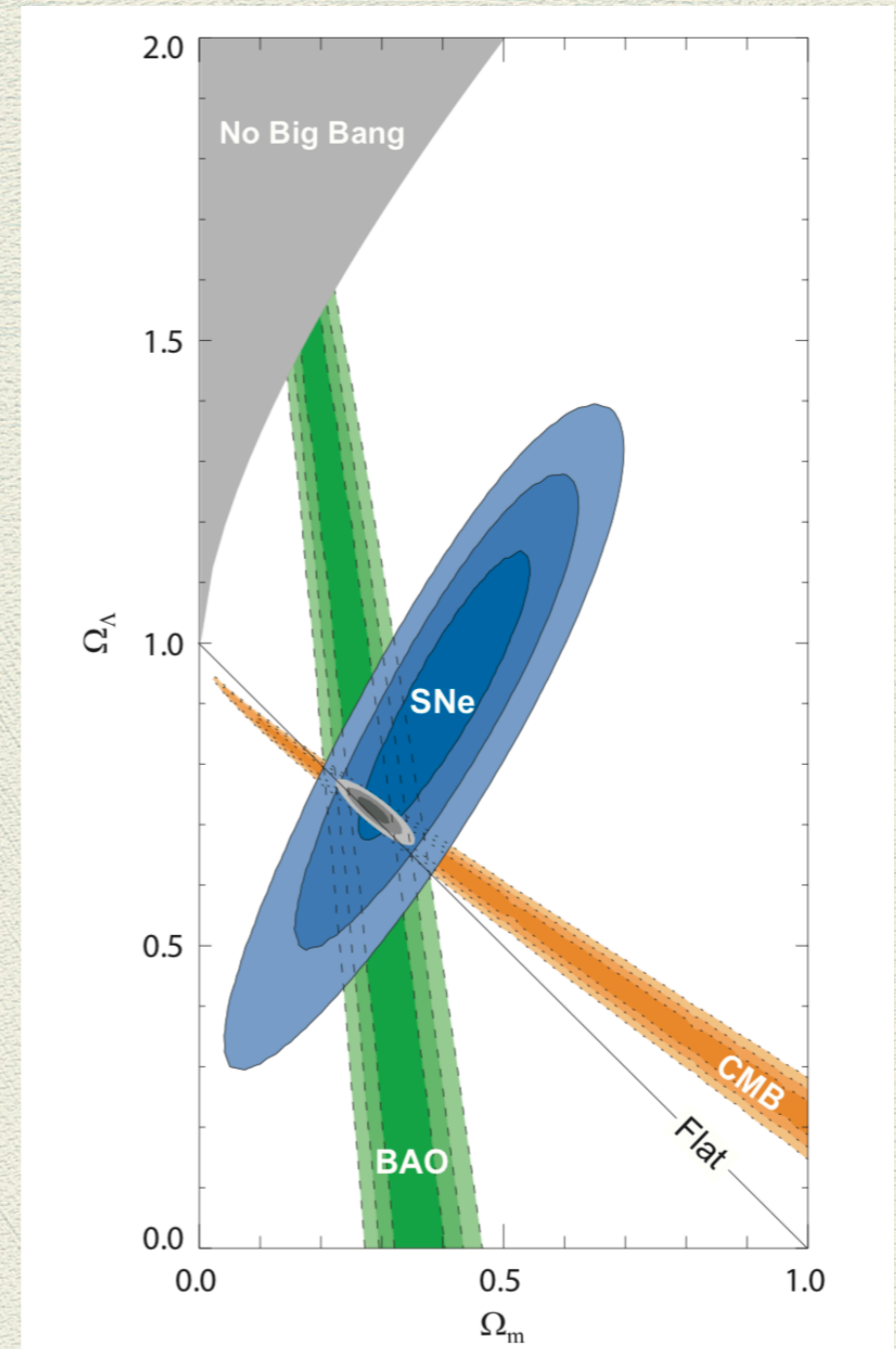
→ χ^2 statistic

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

Result



SN χ^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

González Hernández et al. (2012)

Double Degenerate model

P > 80%

Single Degenerate model

P < 20%

1
2 3
distinguish 2 models

search the signature
from the non-degenerate companion

surviving companion

UV excess: between supernova ejecta and the companion
progenitor system: images

Not clear

Thank you!