# A1Y Introduction to Cosmology

## 10 lectures, exploring the development of cosmology, and some of the key ideas of Big Bang theory



Access course website via A1Y website, or at http://www.astro.gla.ac.uk/users/martin/teaching/ username = 'aone'; password = 'aone'

## www.space-art.com



# **Type Ia Supernova**

White dwarf star with a massive binary companion. Accretion pushes white dwarf over the Chandrasekhar limit, causing **thermonuclear disruption** 

Red star:

extended

matter

atmosphere,

**loses H-rich** 

Good standard candle because:-

Accretion disk

Narrow range of luminosities at maximum light Observable to very large distances

#### Some examples of B band SNIa light curves





In the Milky Way, Doppler analysis of HI 21cm radio emission, has revealed the spiral structure of the Galaxy

#### **Doppler Shift**





## The Tully Fisher Relation for Spirals



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# **Problem:**

Need to determine  $H_0$ from remote galaxies, where peculiar motions are less important....

....but....

We cannot use primary distance indicators to measure their distance

**Need Distance Ladder!!** 



**HST** has 'bypassed' one stage of the Distance Ladder, by observing Cepheids beyond the Local Group of galaxies

This has dramatically improved measurements of  $H_0$ 







(A redshift of 0.2 corresponds to a recession velocity of 60,000 km/s and a distance of about 850 Mpc )







positive curvature

negative curvature

zero curvature

Geometry of the Universe affects the relationship between distance and redshift of the supernovae





NASA and R. Gilliland (STScl) STScl-PRC00-33



Hubble Space Telescope • WFPC2



Figure 13: Behaviour of the scale factor in different cosmologies.







## Abell clusters















# **Gravitational Lens in Abell 2218**

HST · WFPC2

PF95-14 · ST Scl OPO · April 5, 1995 · W. Couch (UNSW), NASA

Large Magellanic Cloud

MACHO's gravity focuses the light of the background star on the Earth

> A MACHO = Massive Compact Halo Object



So the background star briefly appears brighter

## Lightcurve of a microlensing event





negative curvature

positive curvature

zero curvature

Geometry of the Universe affects the relationship between distance and redshift of the supernovae



negative curvature

positive curvature

zero curvature



The presence of matter 'warps' spacetime

## We can measure the geometry and the density of the Universe using Type Ia Supernovae



#### Hubble diagram of distant Type Ia supernovae





Map of the density and peculiar velocity field in the Local Supercluster

## Cluster baryons from X-ray maps



