

# Observational Astronomy - Spring 2014

## Homework 11 - Cosmology 2

- Figure 1 on the next page shows a photograph of a Type-1A supernova which occurred in the galaxy NGC 3370 in 1994. Figure 2 shows the light curve of this supernova, showing how the brightness varied with time. By comparing the rate of decline of this light curve with other measured supernovae of this type, we can see (the “+” sign in Figure 3) that a supernova of this type has a peak intrinsic brightness given by an absolute magnitude  $M = -19.0$ . Using this and the measured apparent magnitude from Figure 1, calculate:
  - The distance to the galaxy NGC 3370.
  - The speed at which NGC 3370 is moving away from us, assuming a Hubble constant of 70 km/sec/Mpc.
  - The redshift  $z$  of NGC 3370.
- The Cosmic Microwave Background (CMB) is radiation emitted when the universe cooled sufficiently that it became transparent. The radiation is measured today to be a nearly perfect blackbody with a temperature  $T$  of  $2.74^\circ$  K, meaning that it is just  $2.74^\circ$  above absolute zero. Answer the following questions about the CMB:

- Using the relation that you learned in lab that the peak wavelength of a blackbody of temperature  $T$  is given by  $\lambda_{\text{peak}} \times T = 3.0 \text{ mm K}$ , calculate the peak wavelength of the CMB.
- In what region of the electromagnetic spectrum is this wavelength?
- The CMB has been redshifted by about a factor of 1000 since it was emitted, so it is at  $z=1000$ . Using the relation:

$$z = \frac{\lambda_{\text{observed}} - \lambda_{\text{emitted}}}{\lambda_{\text{emitted}}},$$

calculate the peak wavelength at which the CMB was emitted.

- In what region of the electromagnetic spectrum is this wavelength?
- At what temperature was the CMB emitted?
- In what direction is the CMB? In other words, where do astronomers need to point their microwave detectors to detect the CMB radiation?

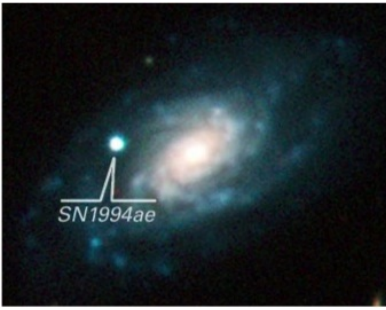


Figure 1: Supernova 1994AE in galaxy NGC 3370.

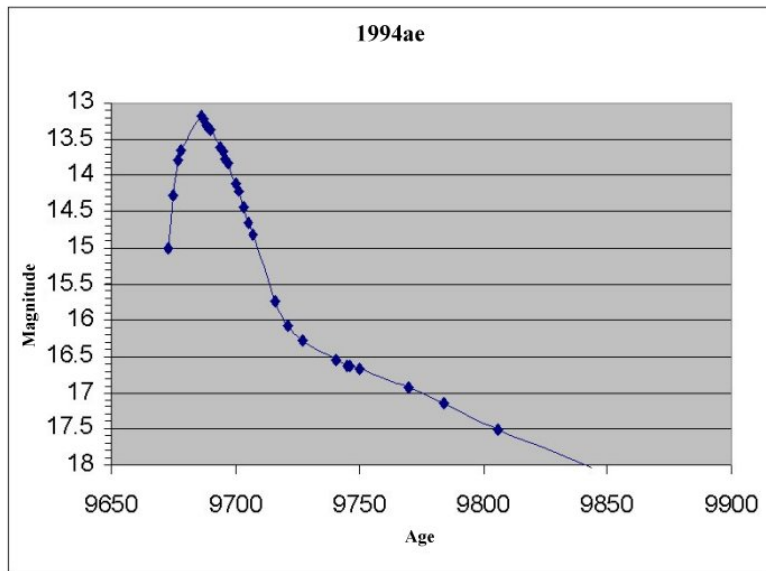


Figure 2: The light curve of SN1994AE.

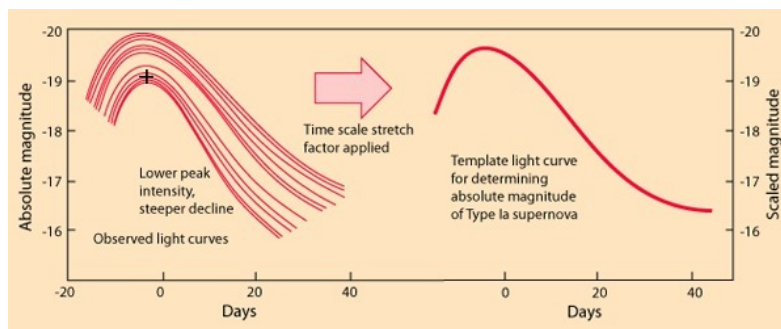


Figure 3: The intrinsic brightnesses of Type 1A supernovae.