PHAS 1102/1423
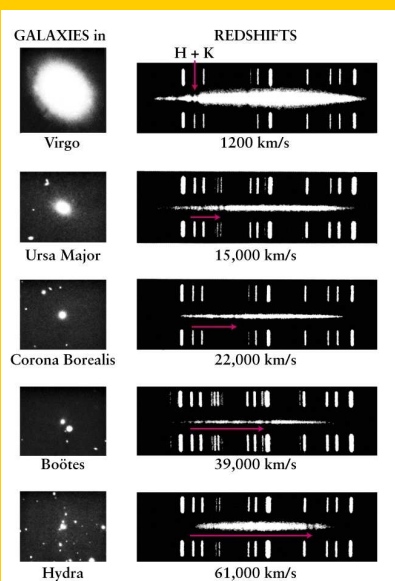
THE EXTRAGALACTIC DISTANCE SCALE

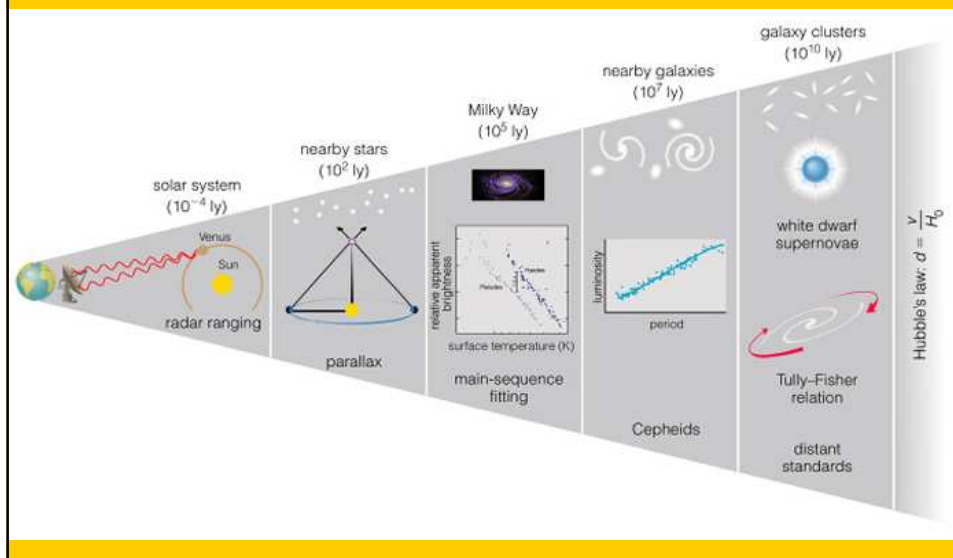

Edwin Hubble

All distant galaxies are receding; their spectra are *red shifted*

GALAXIES in	REDSHIFTS
Virgo	1200 km/s
Ursa Major	15,000 km/s
Corona Borealis	22,000 km/s
Boötes	39,000 km/s
Hydra	61,000 km/s
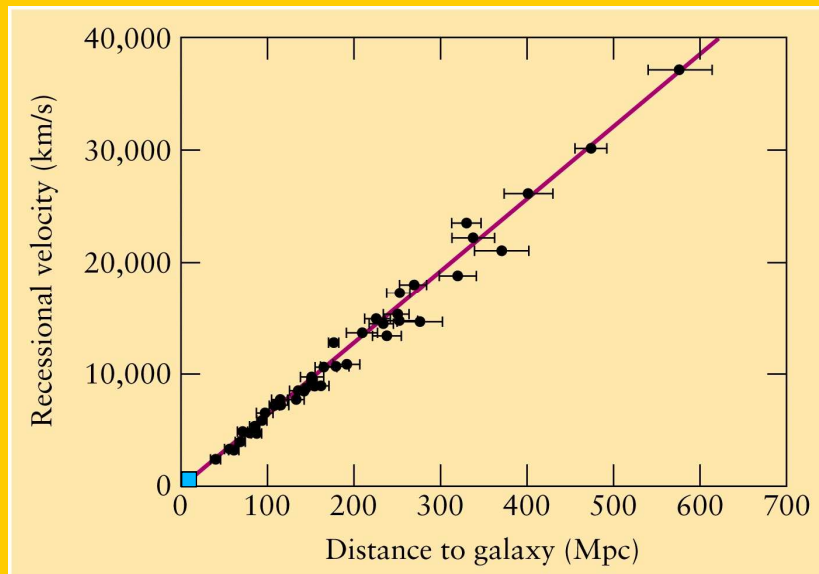
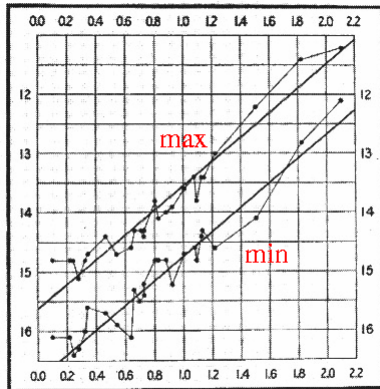$H_0 = 72$ (+/-5) km/s per Mpc

The 'distance ladder'

FIG. 2.

Among Magellanic Cloud Cepheids, Miss Leavitt found a *Period-Luminosity* relationship

"The two resulting curves, one for maxima and one for minima, are surprisingly smooth, and of remarkable form. In Figure 2 ... a straight line can readily be drawn among each of the two series of points corresponding to maxima and minima, thus showing that there is **a simple relation between the brightness of the variables and their periods** ... Since the variables are probably at nearly the same distance from the Earth, **their periods are apparently associated with their actual emission of light"**

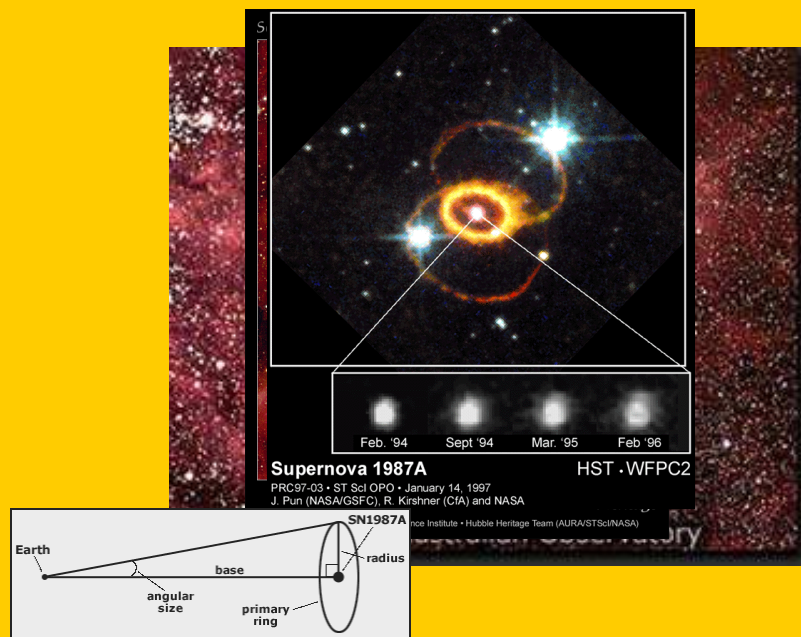How do we calibrate the zero-point of the period-luminosity relation?
Galactic Cepheids:
– Parallaxes
– Cluster fitting
– Baade-Wesselink
Or
– Independent LMC distance determination

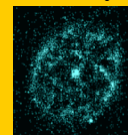## SN 1987A geometric distance

Cepheids allow distances to be determined to galaxies in which bright stars can be resolved.
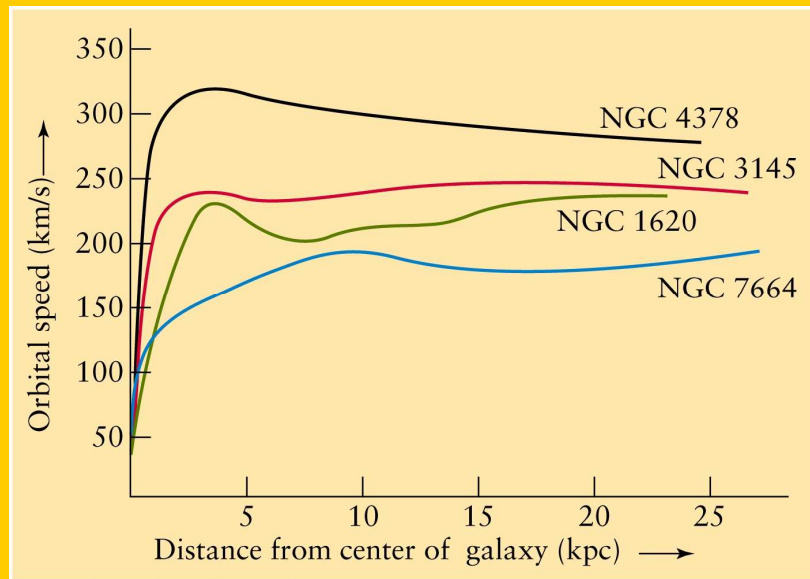
Other techniques for such galaxies:

Novae (have roughly the same absolute magnitude 15 days after their peak [-5.5];   + nova-shell expansion   )
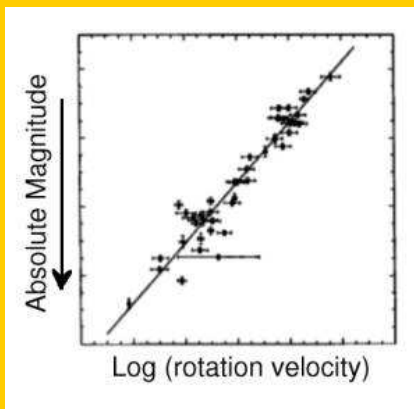
Brightest stars

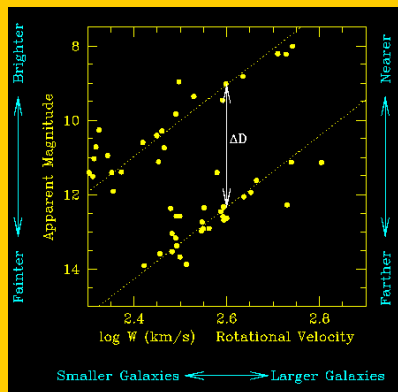Eclipsing Binaries (primary technique!!)

Thereafter: 'Galaxy methods' (increasingly approximate; the 'distance ladder')

Recall rotation curves for spiral galaxies; each has a characteristic rotation velocity
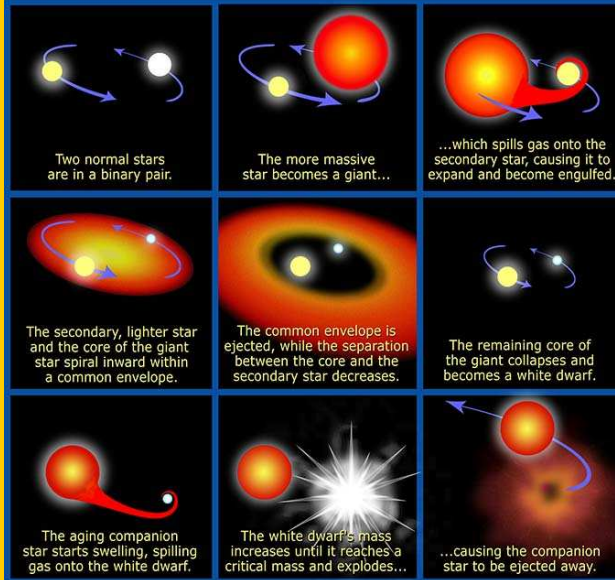

Tully-Fisher:
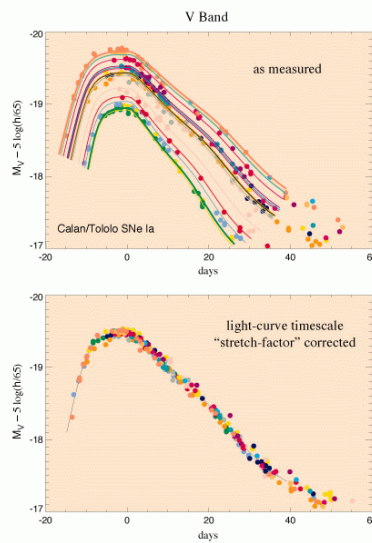rotation velocity proportional to galaxy luminosity

Type Ia supernovae (not other types) make good 'standard candles'…

Type Ia Supernovae (SNe Ia) have become the principal distance indicator for the determination of distances in the Hubble flow and, in connection with their calibration through Cepheids, the Hubble constant