Distances in Cosmology

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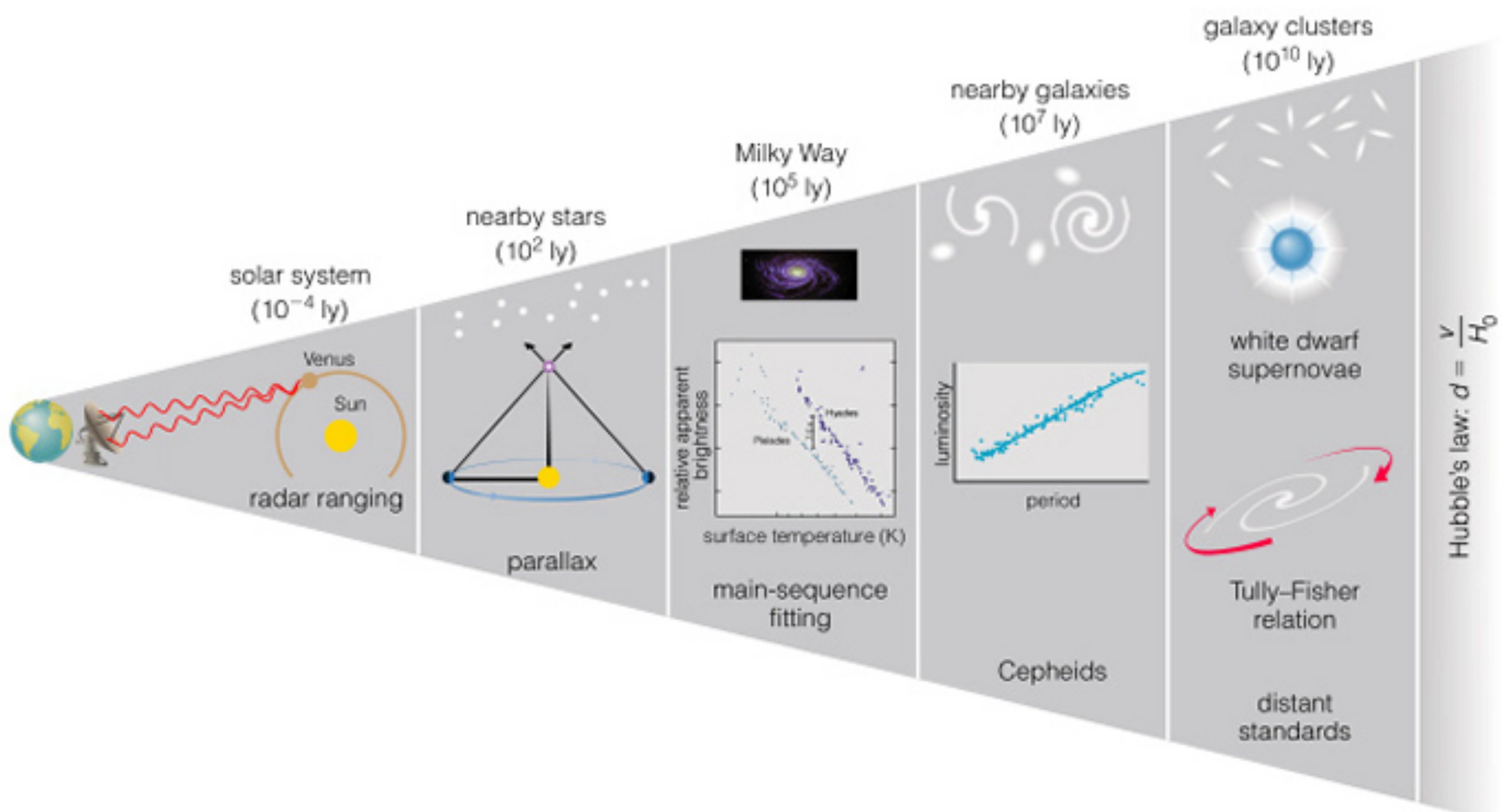
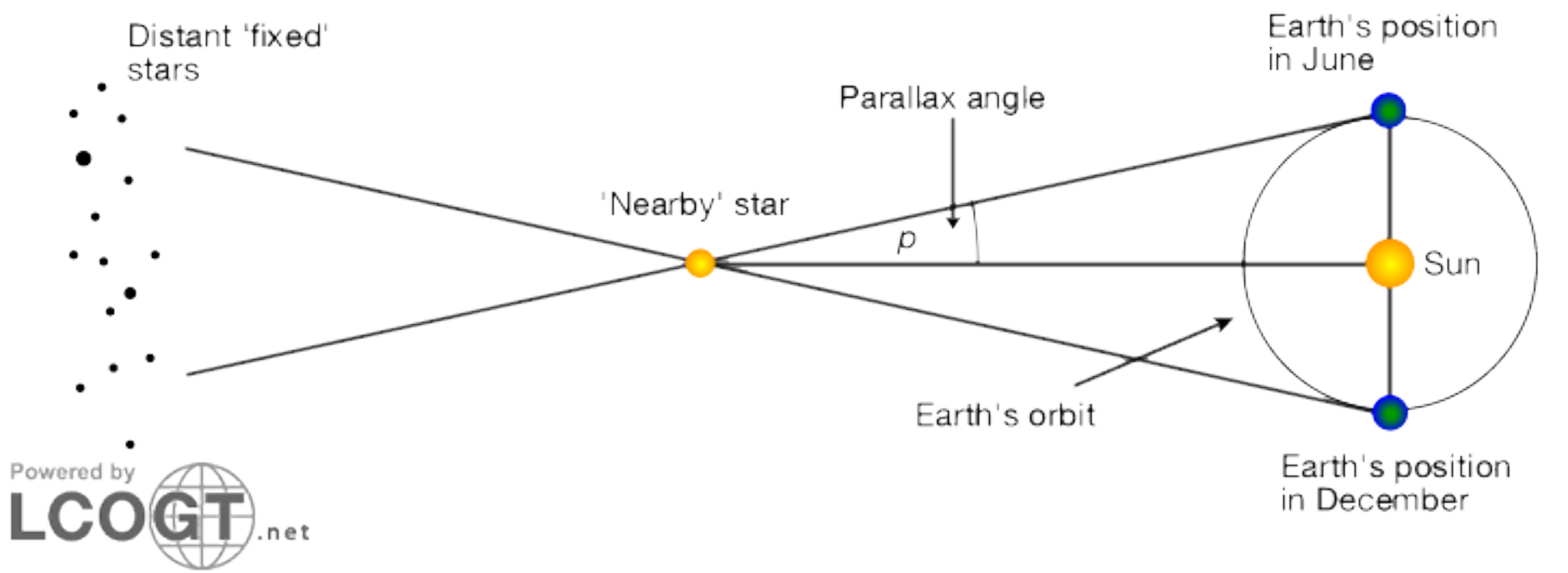
Cosmic Distance Ladder

= succession of methods by which astronomers determine the distance to celestial objects



Parallax



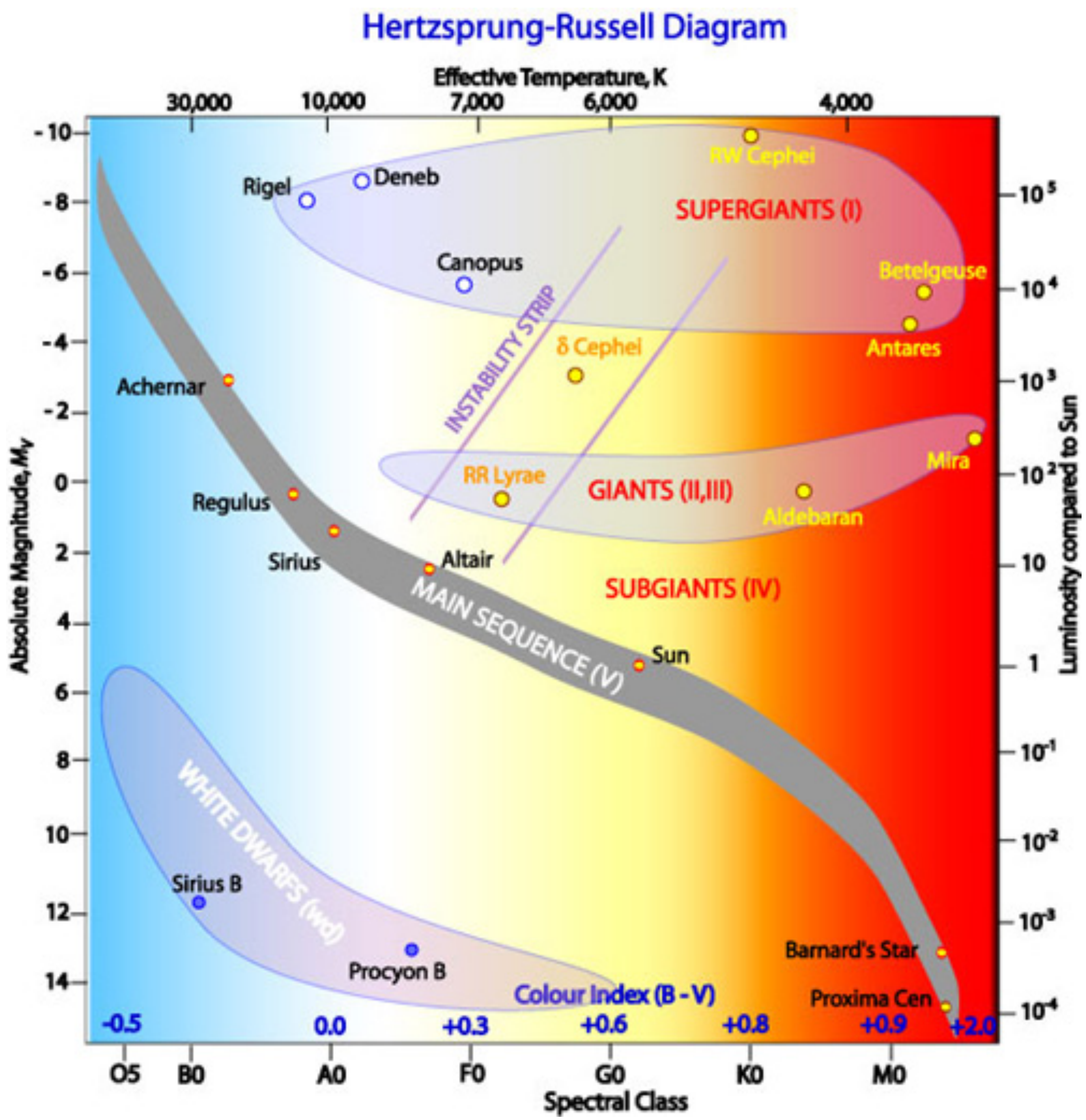
Def. Parsec: $\frac{1\,\mathrm{Au}}{1\,\mathrm{pc}} = 1'' = 1\,\mathrm{arcsec}$

$$1\,\mathrm{pc} = 3.26\,\mathrm{lyr}$$
$$= 3.09 \cdot 10^{16}\,\mathrm{m}$$

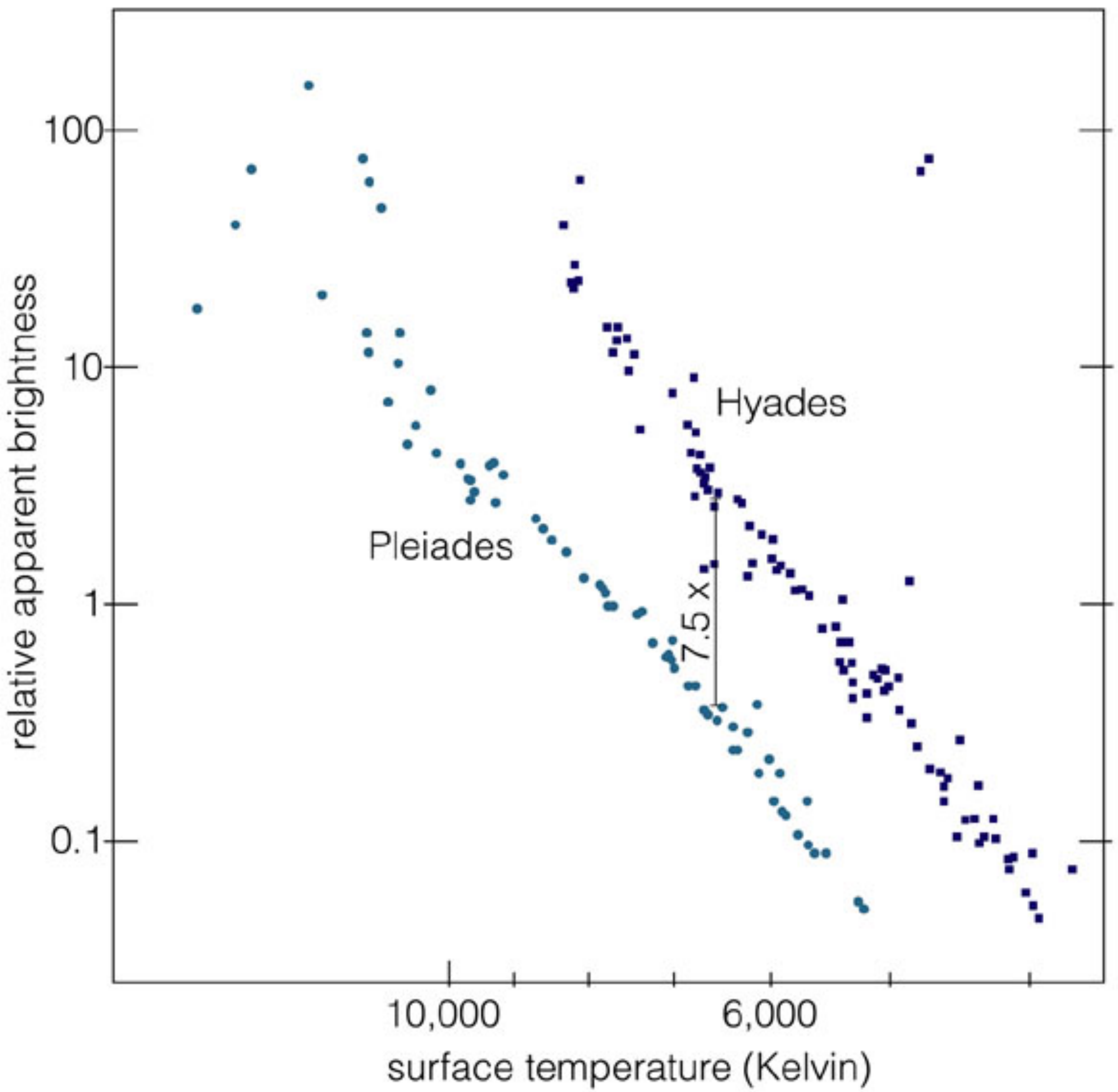
With the Hubble telescope: Can reach up to 5000 parsec.

Hertzsprung-Russell diagram

„Main sequence stars“ have a known relation between temperature (spectral class) and luminosity!



Main sequence fitting



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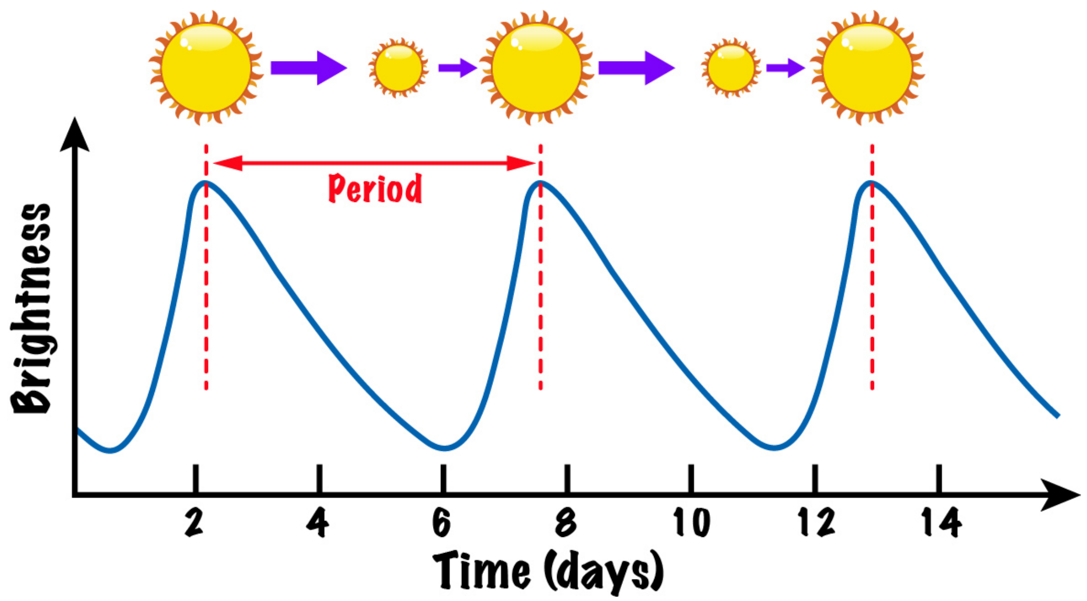
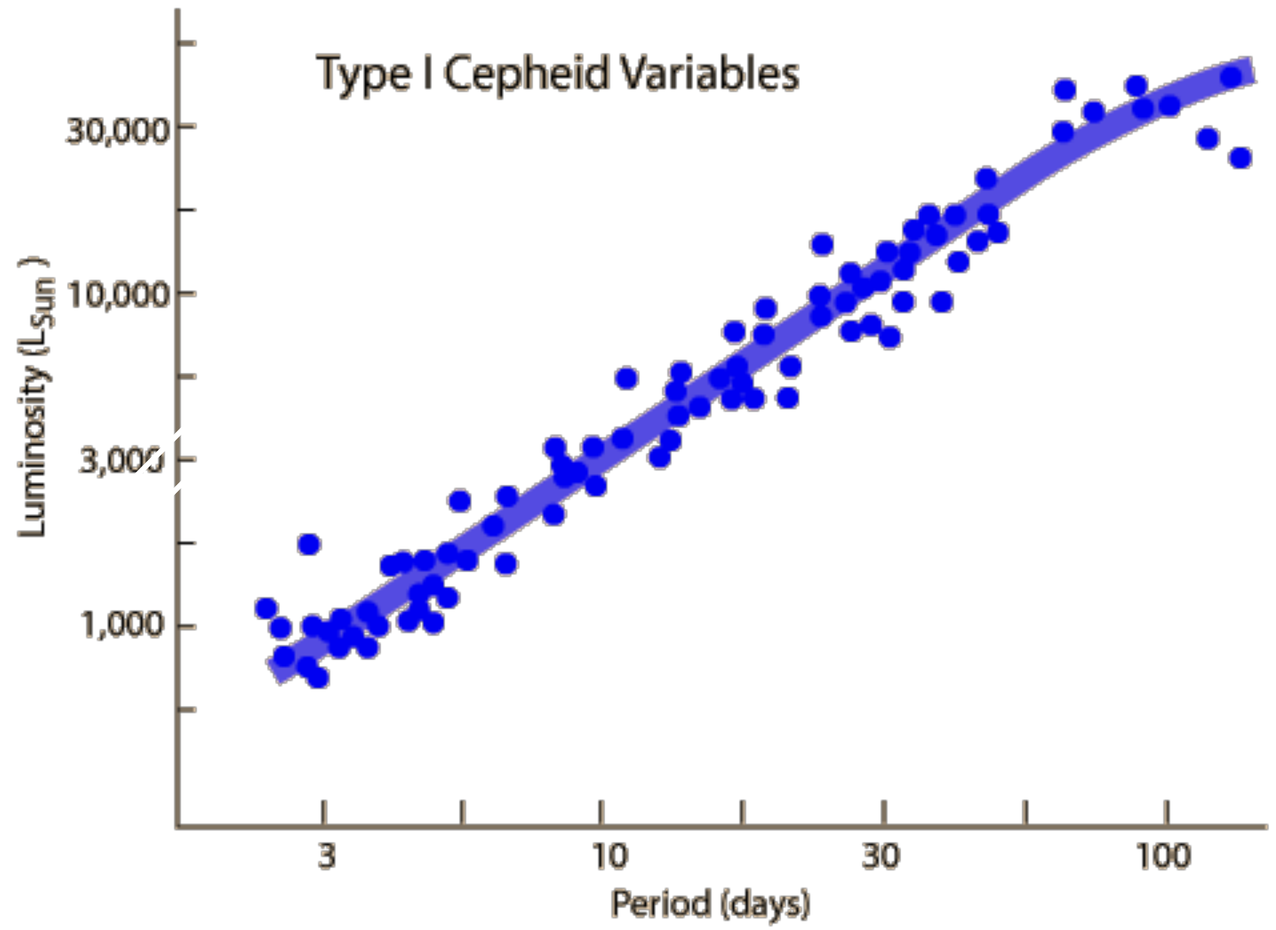
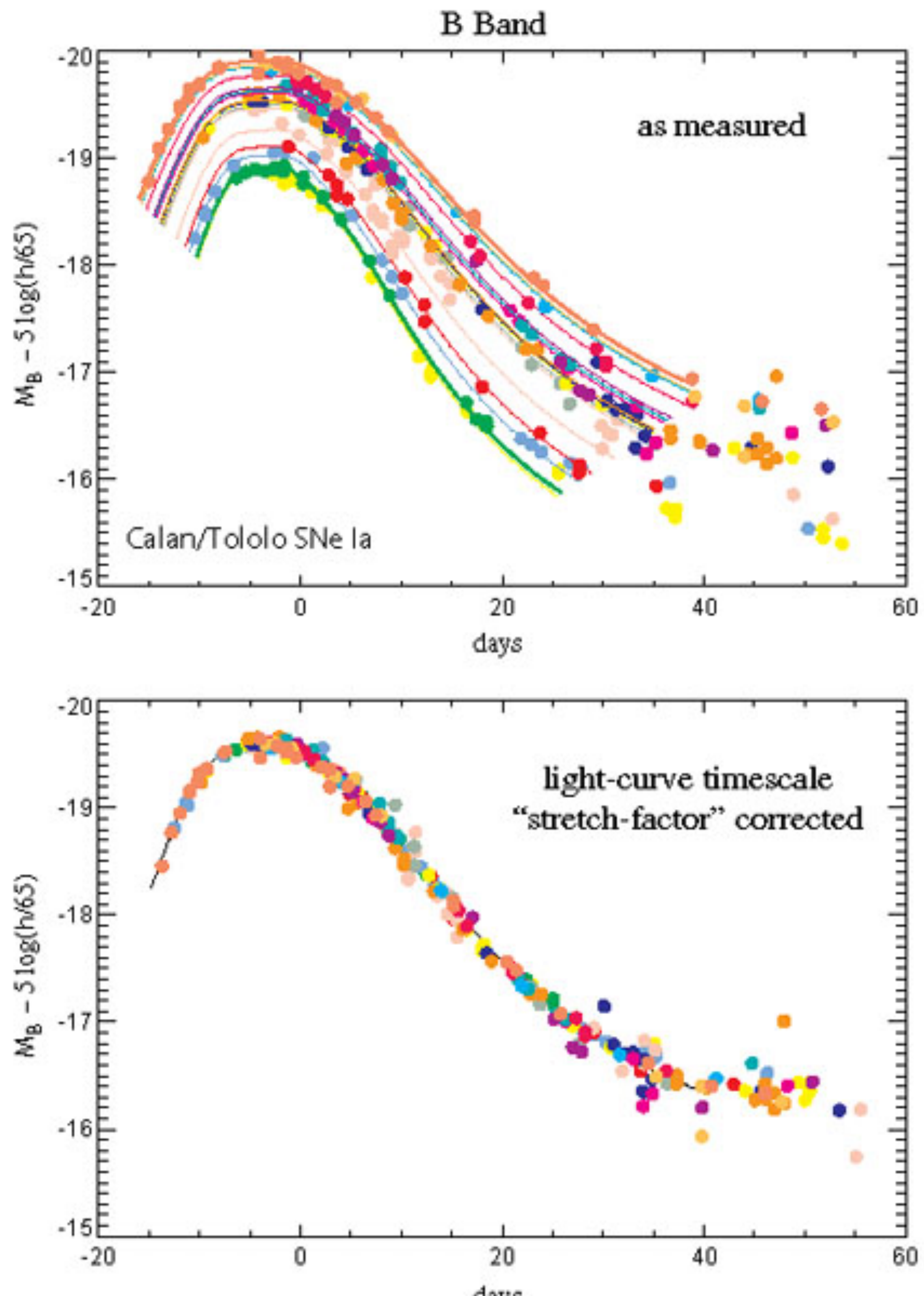
Cepheids = periodically pulsating stars





Known luminosity (when period is measured) → **Standard candle**

Supernovae of Type Ia



Kim, *et al.* (1997)

Cosmological redshift

1912: Vesto Slipher discovered the shift of spectroscopic lines in distant galaxies.

1923: Edwin Hubble measured the distance to a cepheid outside of the milky way.

1927: Georges Lemaître combined the data of Slipher, Hubble and Milton Humason and postulated the expansion of the universe in accordance with GR.

1929: Hubble confirmed Lemaître's hypothesis with more data.

Def. redshift:

$$z = \frac{\lambda_{\rm obs} - \lambda_0}{\lambda_0}$$

For small redshifts:

$$z \approx \frac{D}{c} H_0$$

D… proper distance

For large redshifts:

$$D_L = (1+z) \int_0^z \frac{dz'}{H(z)}$$

D_L… luminosity distance

Conclusion

With a succession of distance measurement methods, starting from determining the scale of our own solar system, we managed to measure the distance of galaxies outside the milky way and even observe the expansion of the universe!