Cosmic distance ladder

V_r = radial part of velocity

$$z = \frac{\lambda_{obs}}{\lambda_{emit}} - 1 = \sqrt{\frac{1 + v_r/c}{1 - v/c}} - 1$$

measure → V_r

observe → $\frac{V_T}{d}$

Cepheids "standard candles"

SN 1a "2nd standard candle"

∞ for point of conversion →

$$\tan\varphi = \frac{V_T}{V_r}$$

Matter

"Baryonic"

p, n, e^- ... → nuclei → H

gas

dust (^{4}He, "metals")

Stars + planets

open and globular clusters

→ galaxies

galaxy groups, clusters, superclusters, mega clusters

intergalactic gas

Dark