1604.01424: A 2.4% Determination of the local value of the Hubble Constant

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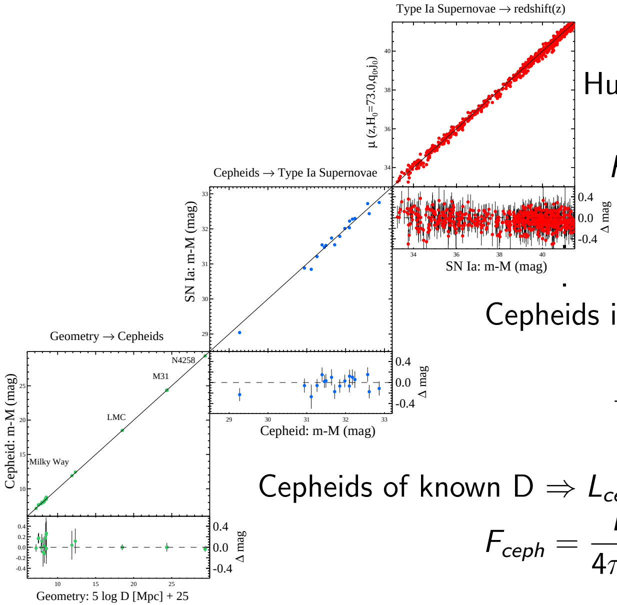
Distance Ladder



Hubble-flow SNIa ⇒ H_0:

$$F_{SNIa} = \frac{L_{SNIa}}{4\pi(zc/H_0)^2}$$

Cepheids in SNIa hosts ⇒ L_{SNIa}:

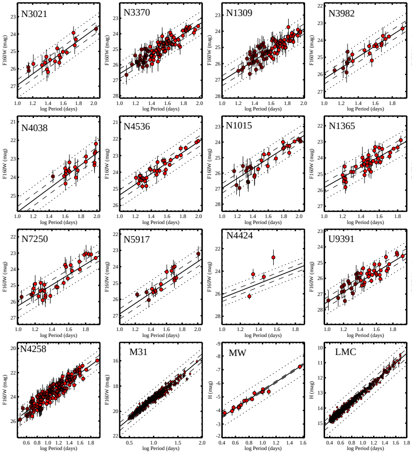
$$\frac{L_{SNIa}}{L_{ceph}} = \frac{F_{SNIa}}{F_{ceph}}$$

Cepheids of known D ⇒ L_{ceph}:

$$F_{ceph} = \frac{L_{ceph}}{4\pi D_{ceph}^2}$$

P-L diagrams for SNIa hosts and Cepheids anchors

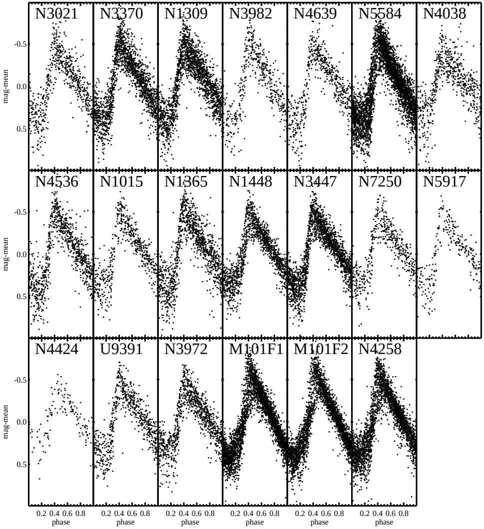
Small numbers: 18 SNIa hosts with Cepheids and 4 Cepheids populations of known distances (based on 1,2,8,15 measurements)



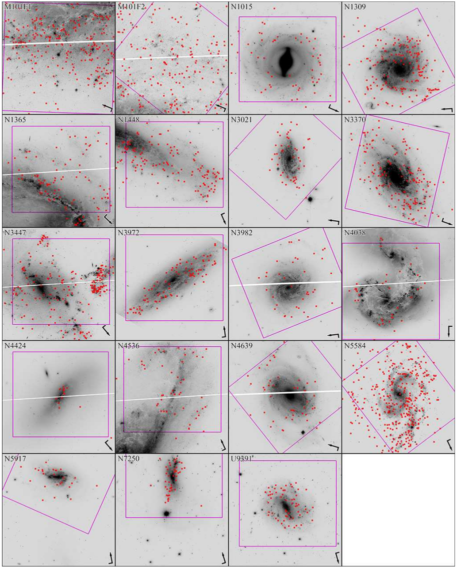
18 SNIa hosts

NGC4258: Maser (resolved binary)
M31: 2 Detached stellar binaries
LMC: 8 Detached stellar binaries
MW: 15 Cepheid parallaxes

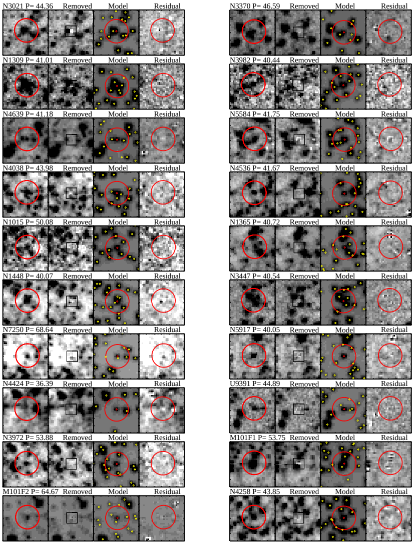
Composite Cepheid Lightcurves (HST)



Cepheid Positions



Cepheid photometry examples



Cepheids in crowded fields:
(raw image; ceph.removed; model; residual)

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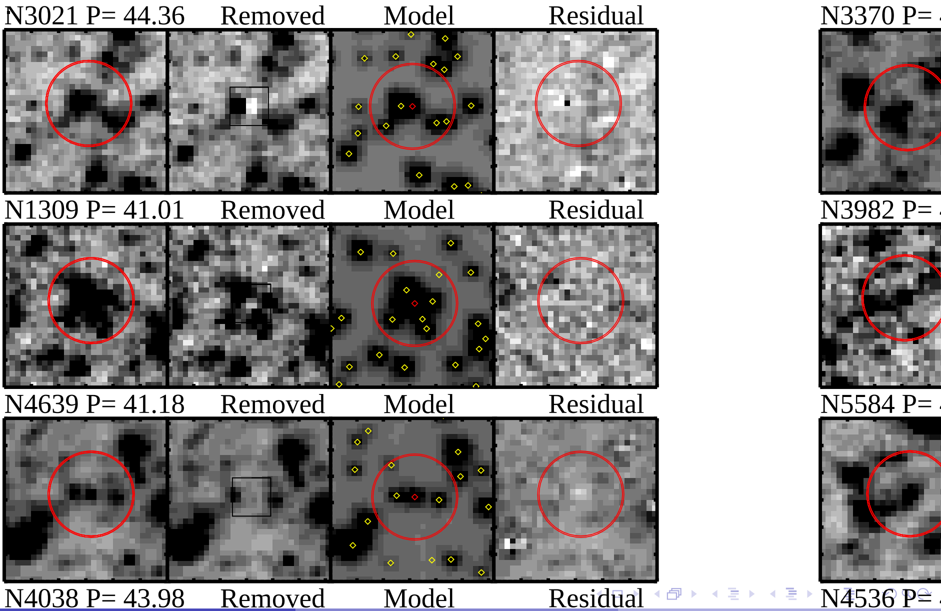
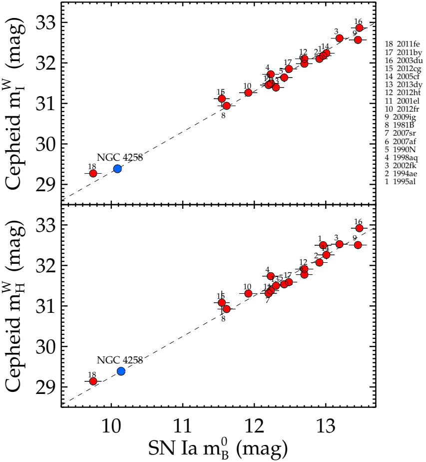
Photometry with HST different from photometry in MW and LMC where cepheids are easily resolved?

Cepheid photometry examples

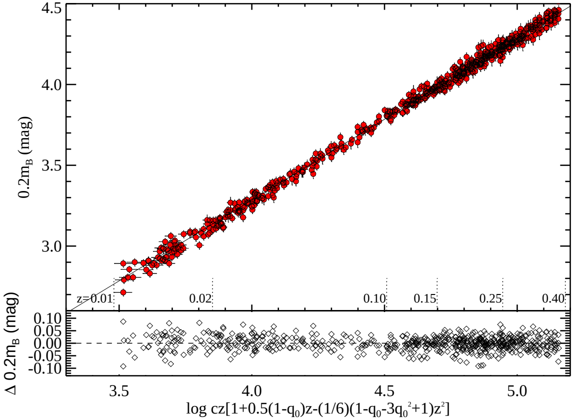


Cepheid Flux vs SNIa Flux



20mag = 10^8 in flux!!

SNIa in Hubble flow



Error budget: HSTkey: Riess2009: R2011: R2016

Different cameras for hosts,anchors

Cepheid periods anchor-hosts

Cepheid metalicity anchor-hosts

Poisson on Hubble flow SNIa

Poisson stats on 18 SNIa calibrators

Poisson stats on Cepheids in hosts

Poisson stats on Cepheids in anchors

Cepheid color,reddening anchor-hosts

Mean distance to anchors

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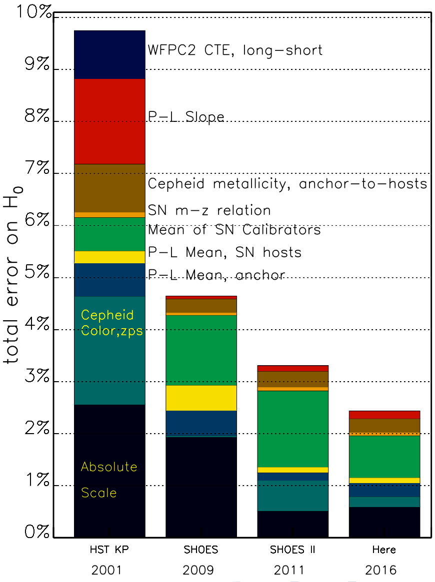
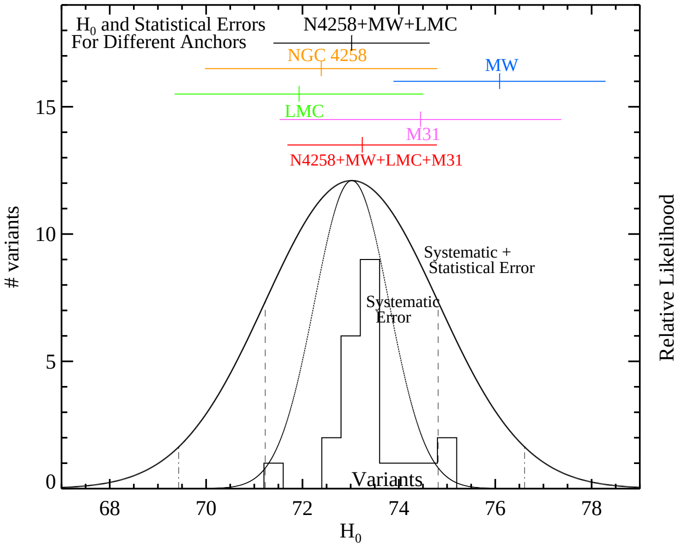
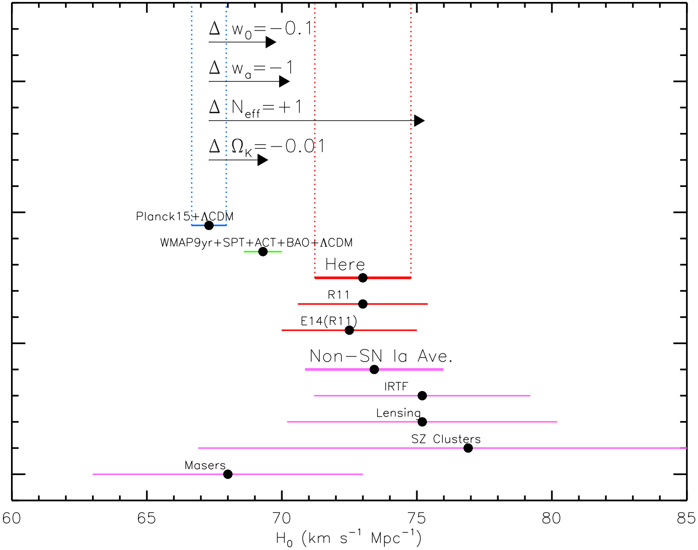


Various anchors



H_0 measurements: summary



H_0 from CMB

Acoustic peak position:

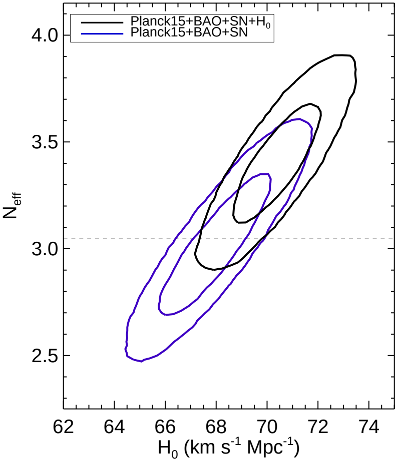
$$\theta \sim \frac{r_d(\Omega_M H_0^2, \Omega_b H_0^2, N_\nu)}{D_A(z = 1070, \Omega_M H_0^2, H_0^2, \Omega_k H_0^2, w)}$$

$(\Omega_M H_0^2, \Omega_b H_0^2$ determined by CMB peak heights relative to Sachs-Wolf plateau.
Assume $(\Omega_k, w, N_\nu) = (0, -1, 3)$, then θ determines H_0.

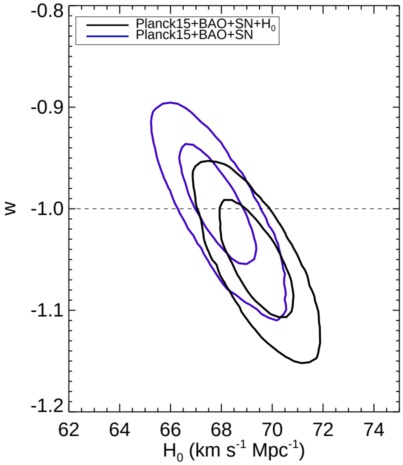
$$r_d \sim \int_{1070}^{\infty} \frac{c_s(\Omega_b H_0^2, z)dz}{(\Omega_M H_0^2(1+z)^3 + \Omega_R H_0^2(1+z)^4)^{1/2}}$$

$$D(z = 1070) \sim \int_0^{1070} \frac{dz}{(H_0^2 + \Omega_M H_0^2[(1+z)^3 - 1] + ...)^{1/2}}$$

H_0 vs N_ν


Planck15+BAO+SN+H$_0$
Planck15+BAO+SN
4.0
3.5
3.0
2.5
N$_{eff}$
62
64
66
68
70
72
74
H$_0$ (km s^{-1} Mpc^{-1})

H_0 vs w



Planck15+BAO+SN+H0
Planck15+BAO+SN
-0.8
-0.9
-1.0
-1.1
-1.2
w
62
64
66
68
70
72
74
H0 (km s-1 Mpc-1)

Future H_0 precision