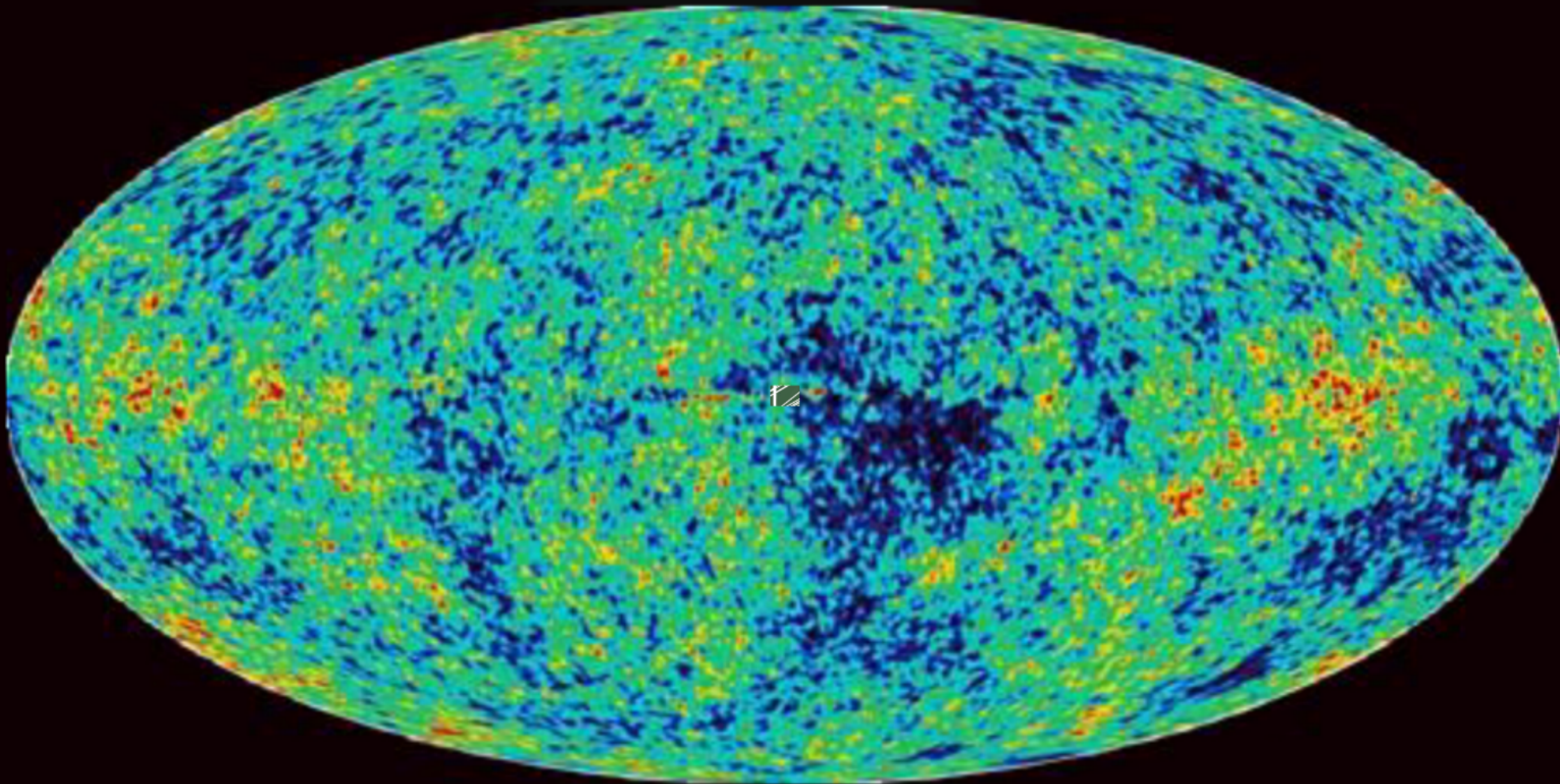
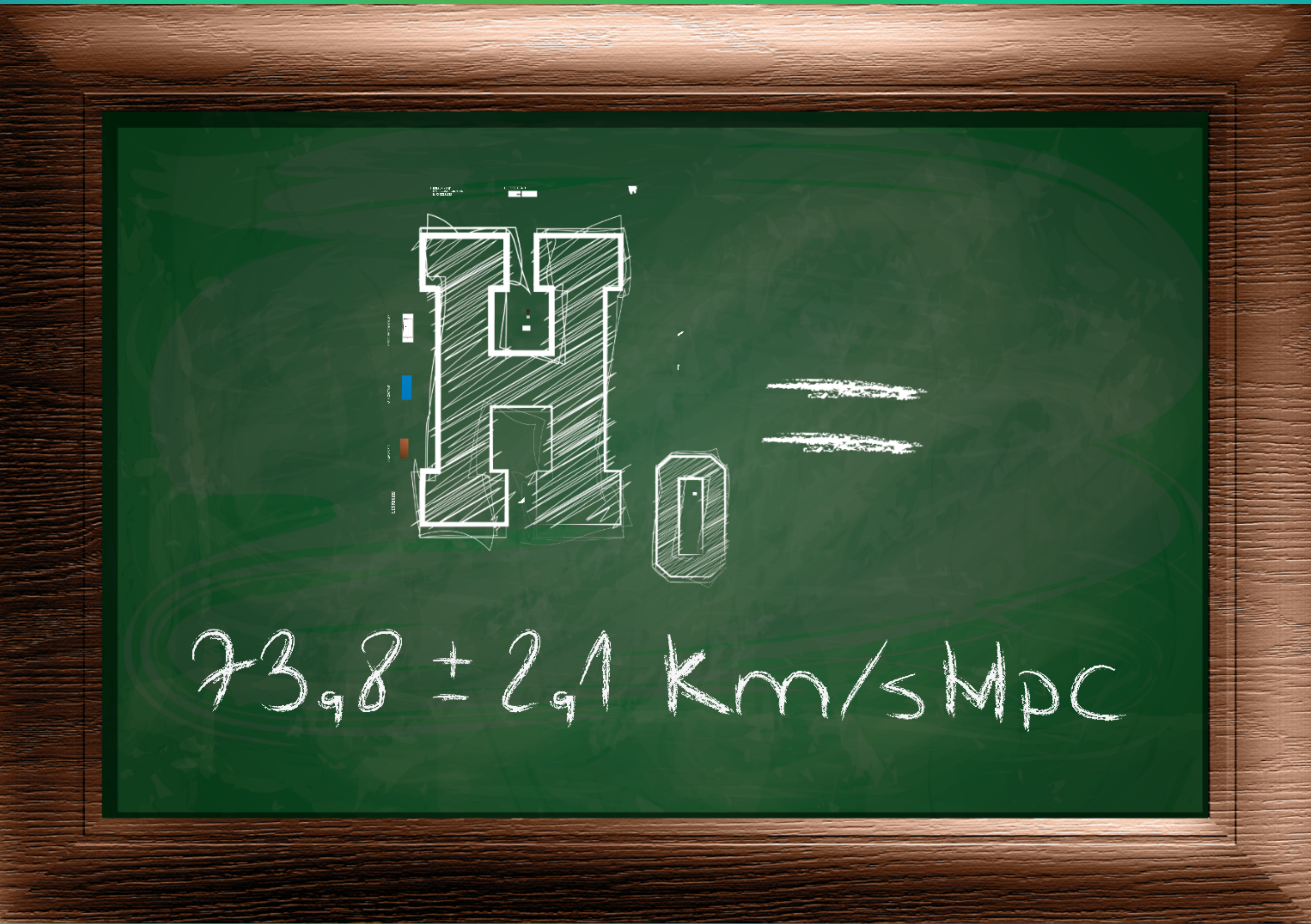




$H_0 =$
73,8 ± 2,1 Km/sMpc

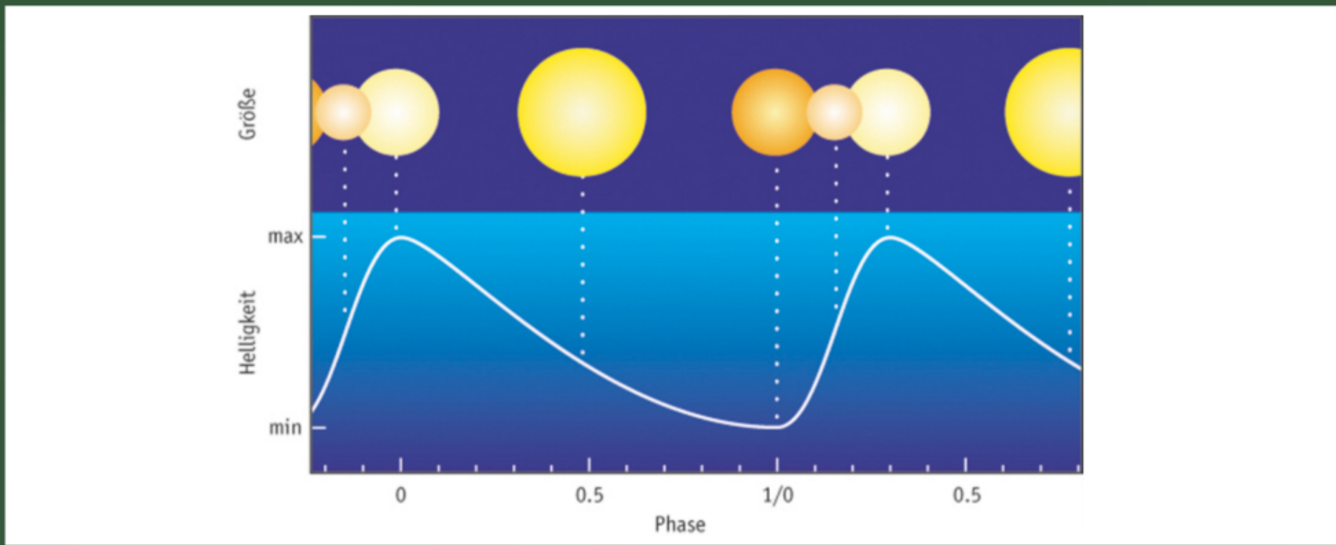
# 1. CEPHEIDS

# 1.1 DISCOVERY

- 1784, Delta Cepheid in Cepheus
- 1912 dicovery of another Cepheid in the magelanic cloud
- their luminosity is proportional to their period

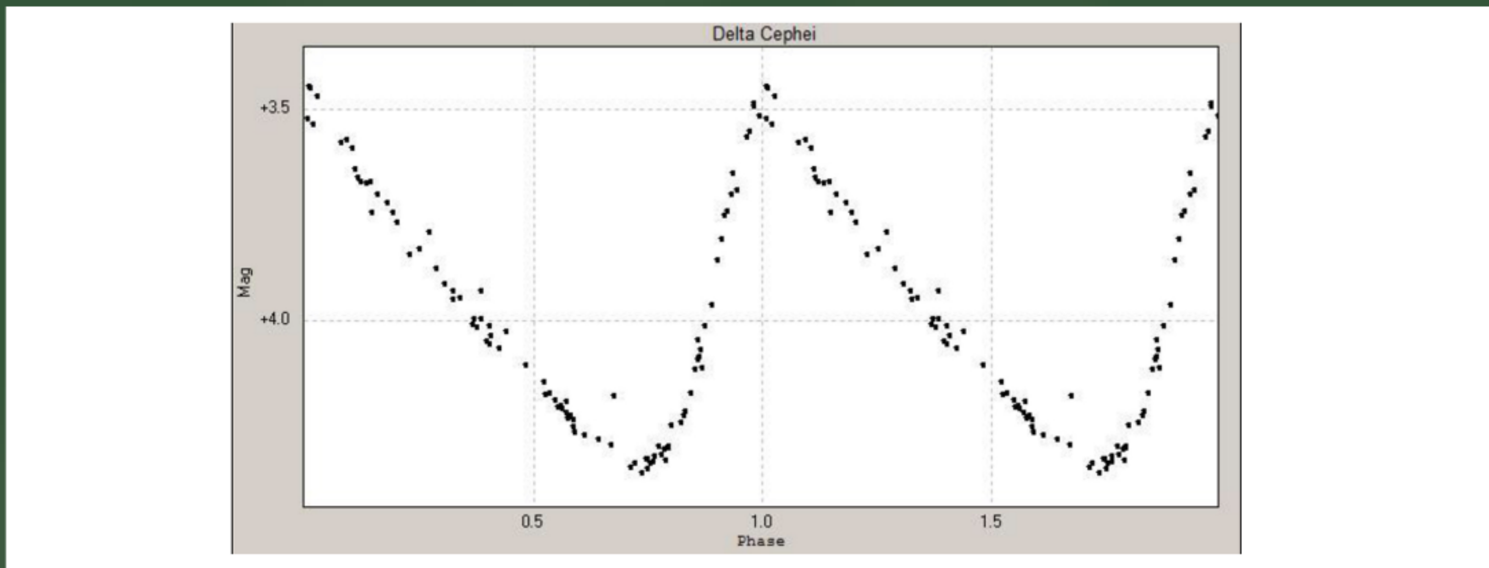
# 1.2 STRUCTURE

- determined by opacity of matter
- matter very opaque
- matter nearly transparent
- oscilatte between two states:
  - Compact state
  - expanded state



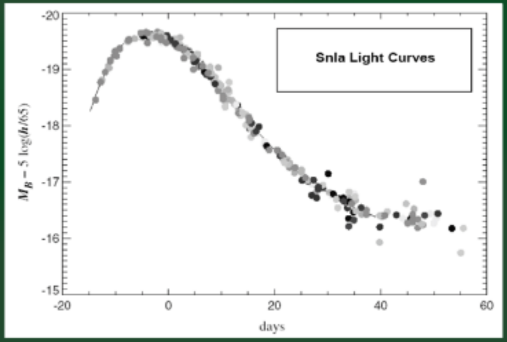
# 1.3 WHAT ARE THEY USED FOR?

- Distance determination through their period
- Cosmological ruler
- Determine the Hubble constant
- With the HST distance calculation to 20 Mpc



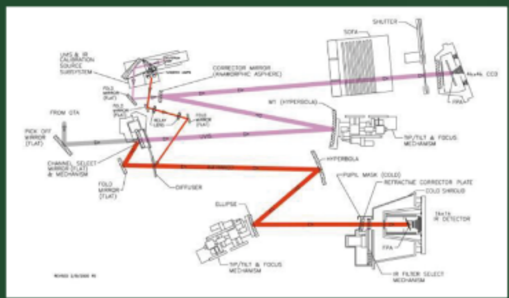
# 2. MEASURING OF THE HUBBLE CONSTANTE WITH CEPHEIDS

# 2.1 SUPERNOVA Ia

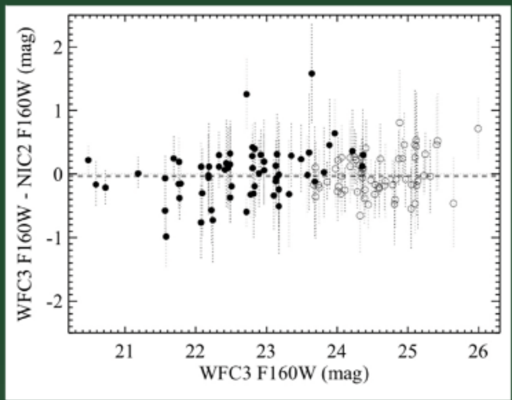



- light-curves always the same
- cosmological candle
- use for Cross calibration of the Wide Field Camera 3

# 2.2 WIDE FIELD CAMERA 3, WFC3




- Observation from 200–1700 nm
- two channels: IR red, UVIS Pink
- mechanism sends incoming light into desired channel

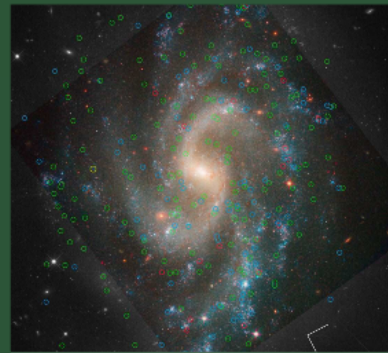


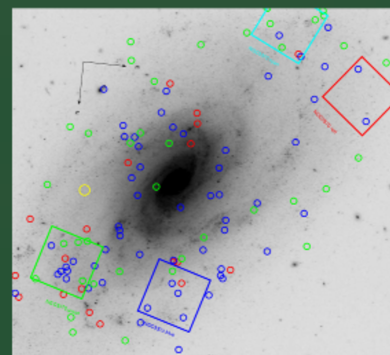

- it discovered 730 new Chepeids in 8 Host galaxies
- near IR with Single photometric Systems
- calibration with the same zeropoint
- Signal-to-Noise Ratio in a quarter of exposure time

# 2.3 DETERMINATION OF THE HUBBLE CONSTANTE

# SYSTEMATICS

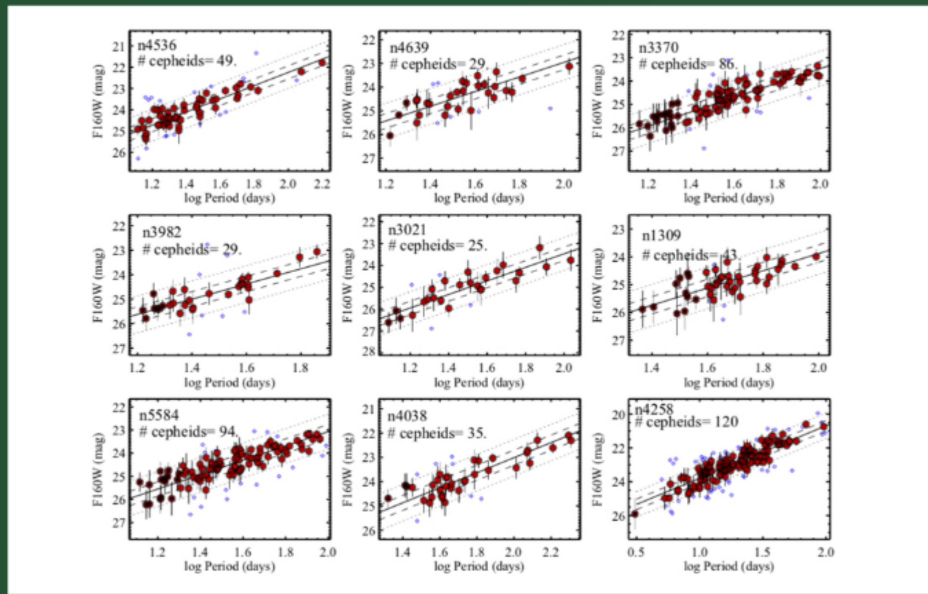
- 7% systematic error because of different zeropints
- measurments of the flux of Cepheids
- use of Cepheids with simular metallicity and period
- we can measure the Hubble constante with a precision of 4,7%
- Cepheids in the NGC 5584, NGC4038 and NGC 3370
- distance anchor NGC 4258





# SOFTWARE CALCULATION

- automatically calculation of the WFC3 data
- Position uncertainity of the Cepheids is under 2,4 ms
- the P-L relation has outliers
- after outliers reduction: 484 Objekts left



# CALCULATING $H_0$

With Cepheids in all galaxies:

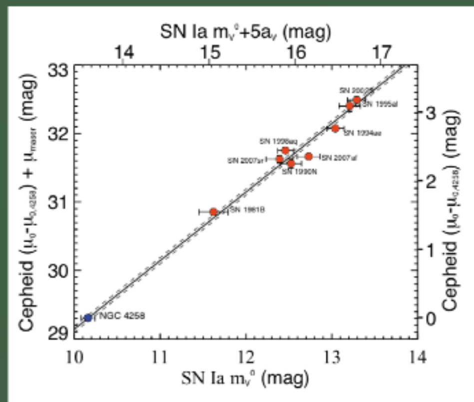
$$m_{W,i,j} = (\mu_{0,i} - \mu_{0,4258}) + zp_{W,4258} + b_W \log P_{i,j} + Z_W \Delta \log [O/H]_{i,j}$$

$$m_{W,i,j} = m_{H,i,j} - R(m_{V,i,j} - m_{I,i,j}),$$

$$R \equiv A_H/(A_V - A_I)$$

$$m^{0}_{v,i} = (\mu_{0,i} - \mu_{0,4258}) + m^{0}_{v,4258}.$$

inclusion of relationship between host Masses and calibrated SN Ia



$$\log H_0 = \frac{(m^0_{v,4258} - \mu_{0,4258}) + 5a_v + 25}{5}$$

$$H_0 = 73{,}8 \pm 2{,}1 \text{ Km/sMpc}$$

Uncertainity 50% Lower

## Improvements:

- distance uncertainity to host at 3%
- Independent calibration of the first rung of the distance ladder
- High signal-to-noise ratio measurments of the Milky Way parallaxes

# Measuring the Hubble constante with just Milky Way Cepheids

$$m_{W,i,j} = \mu_{0,i} + M_{W,1} + b_W \log P_{i,j} + Z_W \Delta \log [O/H]_{i,j'}$$

$$M_{W,i,j} = M_{W,1} + b_W \log P_{i,j} + Z_W \Delta \log [O/H]_{i,j}.$$

$$m^{0}_{v,i} = \mu_{0,i} - M^{0}_{v.}$$

$$\log H_0 = \frac{M_v^0 + 5a_v + 25}{5}.$$

$$\downarrow$$

$$H_0 = 75{,}7 \pm 2{,}6 \text{ Km/sMpc}$$

with using the parallaxes
and the distance to NGC 4258
we get

$H_0 = 74{,}5 \pm 2{,}3$ km/sMpc

and using an improved H-band
and the distance modulus of the Cepheids
we get

$H_0 = 71{,}3 \pm 3{,}8$ km/sMpc

↓

with all parameters combined
we get

$H_0 =$

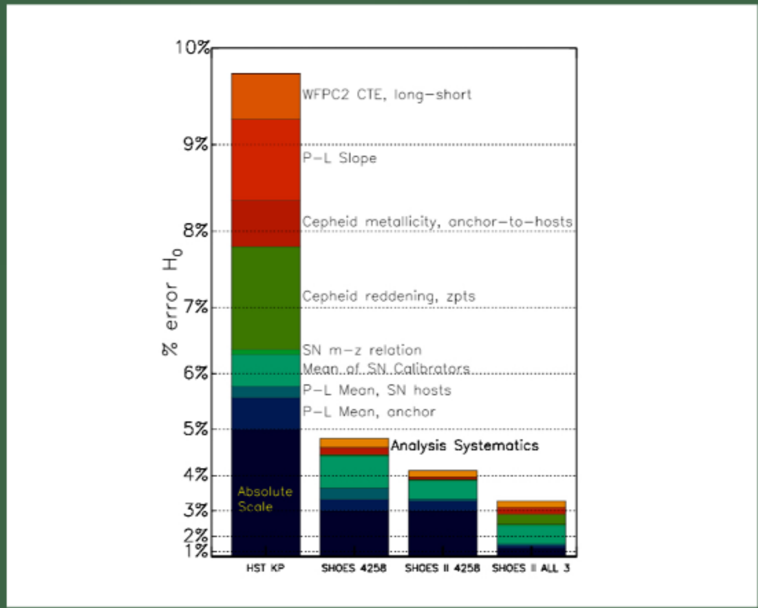
73,8 ± 2,1 Km/sMpc

Uncertainity: 2,9% Lower

## 2.4 ERRORS AND IMPACTS ON THE HUBBLE CONSTANTE

# OUTLIERS

- larger difference in metallicity and period
- changes less then 1 km/sMpc
- no rejection of outliers means a increase of 1,3 km/sMpc
- use higher threshold for Cepheids outliers
- neglecting reddening correction raises H0 about 1,3 km/sMpc
- best is simultaneously modeling the distribution of Cepheids and outliers



# CHEMICAL ABANDANCE

- Calibration of log [O/H]
- Te-scale
- reduces log [O/H]
- that means the mean apparent metalicity: 12 + log [O/H]
- using just the Milky Way Cepheids, $H_0$ is increased by 2,0 km/sMpc
- metalicity correction: −0,10 ± 0,09 mag/dex

# SUPERNOVE SYSTEMATICS

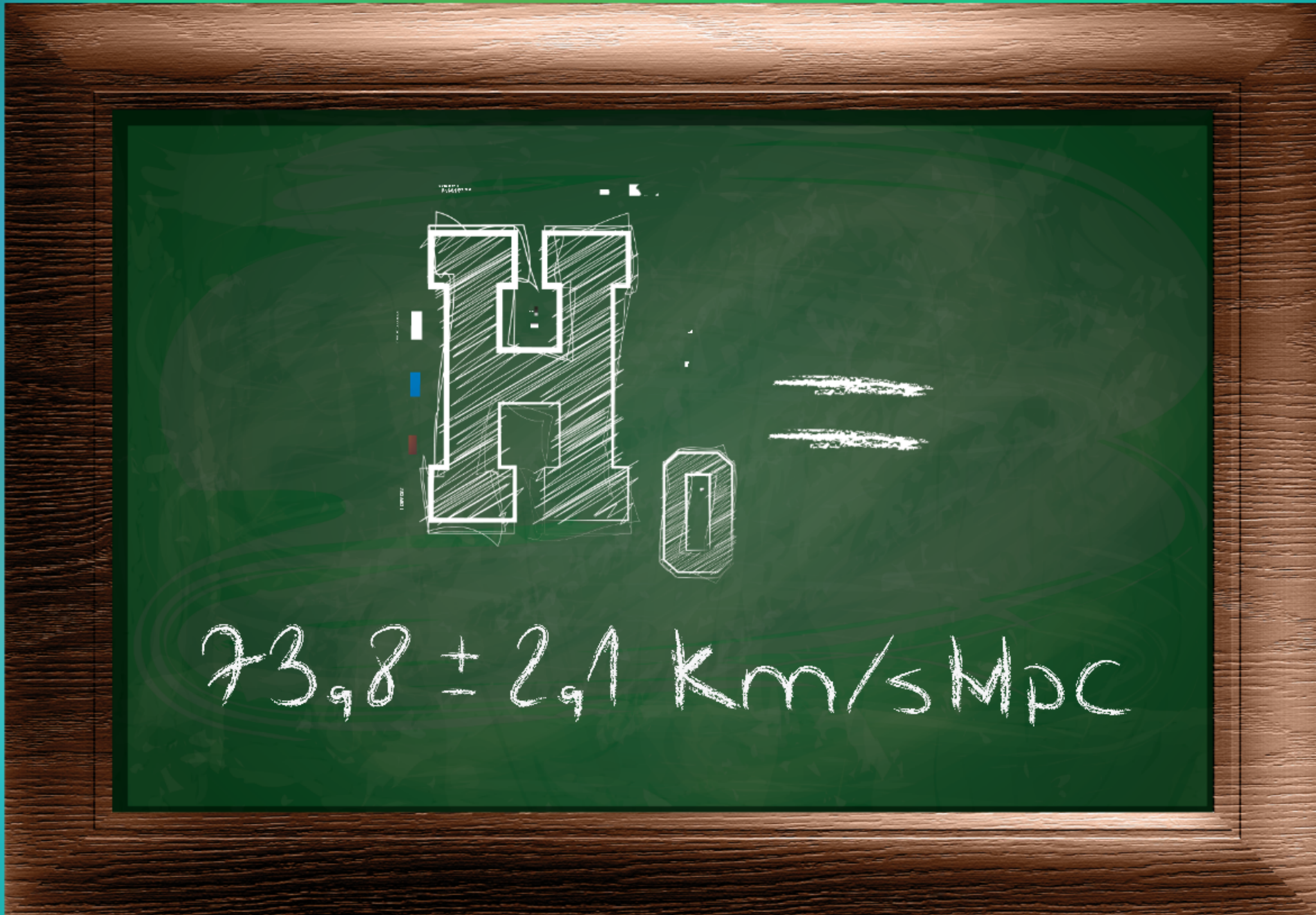
- Variants of Supernove measurment
- use SALT-II light-curve fitter
- with SALT-II we get $H0 = 73{,}8 \pm 2{,}4$ km/sMpc with uncertainity of 3,3%

# 3. EXAMPLE FROM THE ASTROLAB

- period: P = 50,4542 d
- mean mag = 23,6 ± 0,23 mag
- M = −2,760 * Log (P−1,0) − 4,160 = − 12,22 mag
- Distance modulus: D = m − M = 35,82 pc

# 4. FUTURE FOR THE HUBBLE CONSTANTE

- with the launch of JWST, hope to reduce the error of the first rung
- better cross calibration, with more Supernove, because a bigger observation sample
- not just observe 30 Mpc but 50 Mpc observations
- With this better value we could interpret a new species for neutrinos
- also we have a more exact value for he dark energy parameter $w = -1{,}08 \pm 0{,}10$



H0 =
73,8 ± 2,1 Km/sMpc