

Measuring Geometrical Distances to Cepheids with II

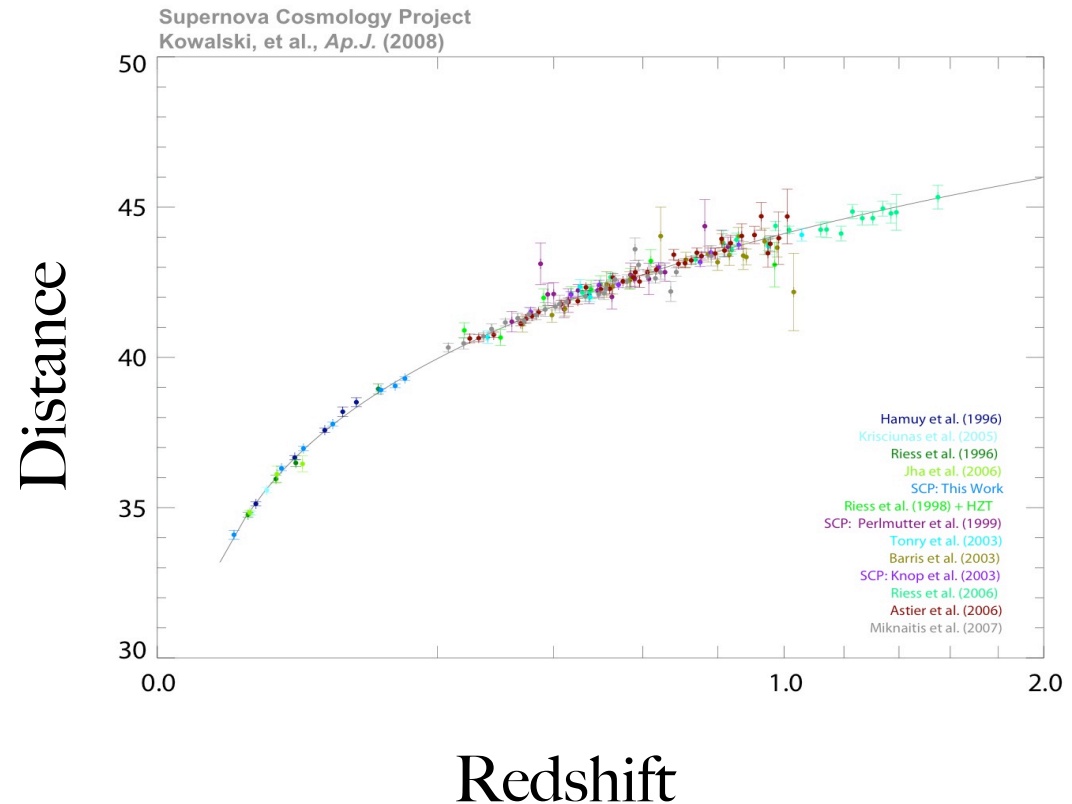
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Workshop on Stellar Intensity
Interferometry in Salt Lake City

Cosmic Distance Ladder



- Variable stars used to measure the Hubble diagram
 - Supernovae bright ($M < 7$) enough are quite rare
 - A few cepheids are bright enough for II

Bright Northern Cepheids

STAR	RA	DEC	V_MAGMEAN	B_MAGMEAN	<SIZE>	Δ SIZE
					[MAS]	[MAS]

(DEC>20):

ALP UMI	2H32M	89 ^o	1.9	2.5	3.1 (CHARA)	0.01
DEL CEP	22H29M	58 ^o	3.9	4.6	1.5 (CHARA)	0.2 (CHARA)
ZETA GEM	7H04M	21 ^o	3.9	4.7	1.7 (PTI/CHARA)	0.2 (PTI/CHARA)
RT AUR	6H28M	30 ^o	5.4	6.1	0.7	0.07
DT CYG	21H31M	31 ^o	5.7	6.3	0.6	0.02
V1334CYG	21H19M	38 ^o	5.8	6.3	0.5	0.01
T VUL	20H51M	28 ^o	5.8	6.4	0.6	0.07
SU CAS	2H51M	69 ^o	5.9	6.6	0.7	0.02
V473 LYR	19H15M	28 ^o	6.2	6.8	COMPLICATED	

(-20<DEC<20):

ETA AQL	19H52M	1 ^o	3.9	4.7	1.8 (PTI/VLTI)	0.2 (PTI/VLTI)
FF AQL	18H58M	17 ^o	5.3	6.1	1.0	0.04
S SGE	19H56M	16 ^o	5.6	6.4	0.8	0.1

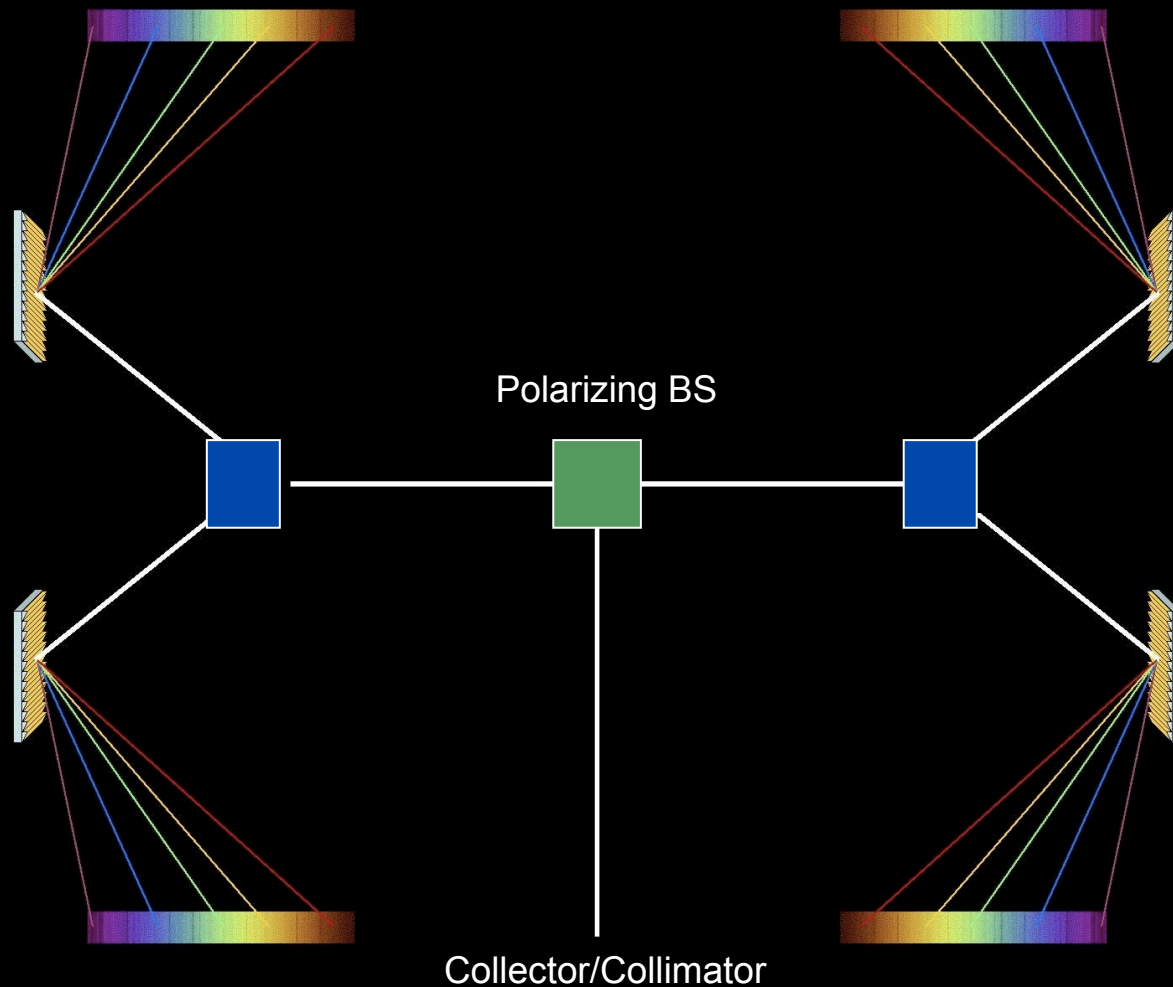
Geometrical Baade-Wesselink Method

- Measure linear expansion spectroscopically
 - Optical
- Measure angular expansion interferometrically
 - FIR - NIR
- Calculate distance
 - Improve the current 10% calibration on the Hubble diagram zero point

Linear Expansion Velocities

- Spectral shift measured with cross correlation of the optical spectrum
- State of the art $\Delta V_r \sim 1$ m/s
 - Driven by searches for extrasolar planets
- Typical Cepheid $\langle V_r \rangle \sim 10$ km/s
- Can be done simultaneously with a spectroscopic II

Spectroscopic II Camera



Angular Diameters

- Translation from UD to LD requires detailed modeling
- Additionally, evidence for CSE in interferometric measurements of Polaris (~1.5%)
- CSE complicates picture for Cepheids “however, it seems likely that the CSE effects... are less important at shorter wavelengths”

Conclusions

- Cepheids seem to be good scientific targets for intensity interferometry
- Next step is to investigate models and quantify the increase in information at optical wavelengths
- Current modeling in optical is based on ambitious NASA projects like the Stellar Interferometer

Selected References

- First detection of angular diameter changes
Lane et al. *Nature* **407**, 485-487 (2000)
Lane et al. *ApJ* **573**, 330-337 (2002)
- Catalogue of Cepheids appropriate for interferometric measurements
Moskalik & Gorynya *Acta Astronomica* **55**, 247-260 (2006)
- Survey of 7 Cepheids with VLTI
Kervella et al. *A&A* **416**, 941-953 (2004)
- Detection of CSE around Polaris
Mèrand et al. *A&A* **435**, 155-162 (2006)