Can intensity interferometry help with Hubble?

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Radio interferometer

- Two telescopes, each records electric field .
- Later, correlate the recorded electric fields.
- Correlation (‘visibility’) measures the FT of the sky

- Angular resolution
- Correlation can be measured in software, so no restriction on baseline .
- EHT uses mm, and baselines the size of the Earth (km)! How to improve resolution?



ALMA observatory

Optical interferometer

- Visible light has over 1000x smaller than radio, so we could get over 1000x better resolution

- But the frequency is > 1000x higher, so we can’t record the electric field at these frequencies.
  ⇒ Cannot correlate in software!

- Instead: physically combine light beams. Combined beams interfere, producing interference fringes.

- This restricts baseline lengths. In practice, . So not any better for optical interferometers than VLBI.

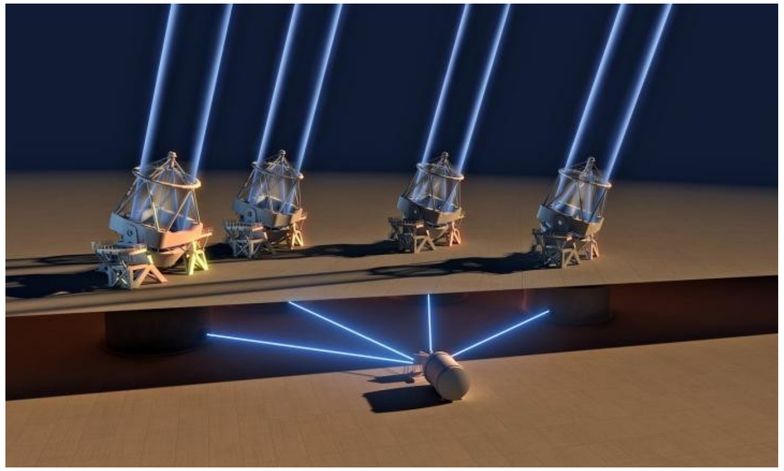


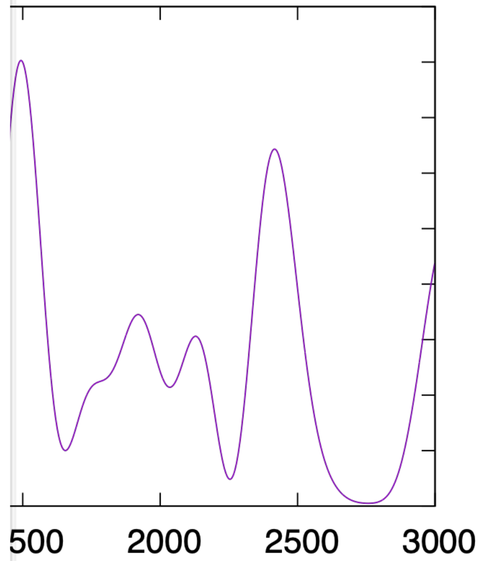
Image credit: ESO

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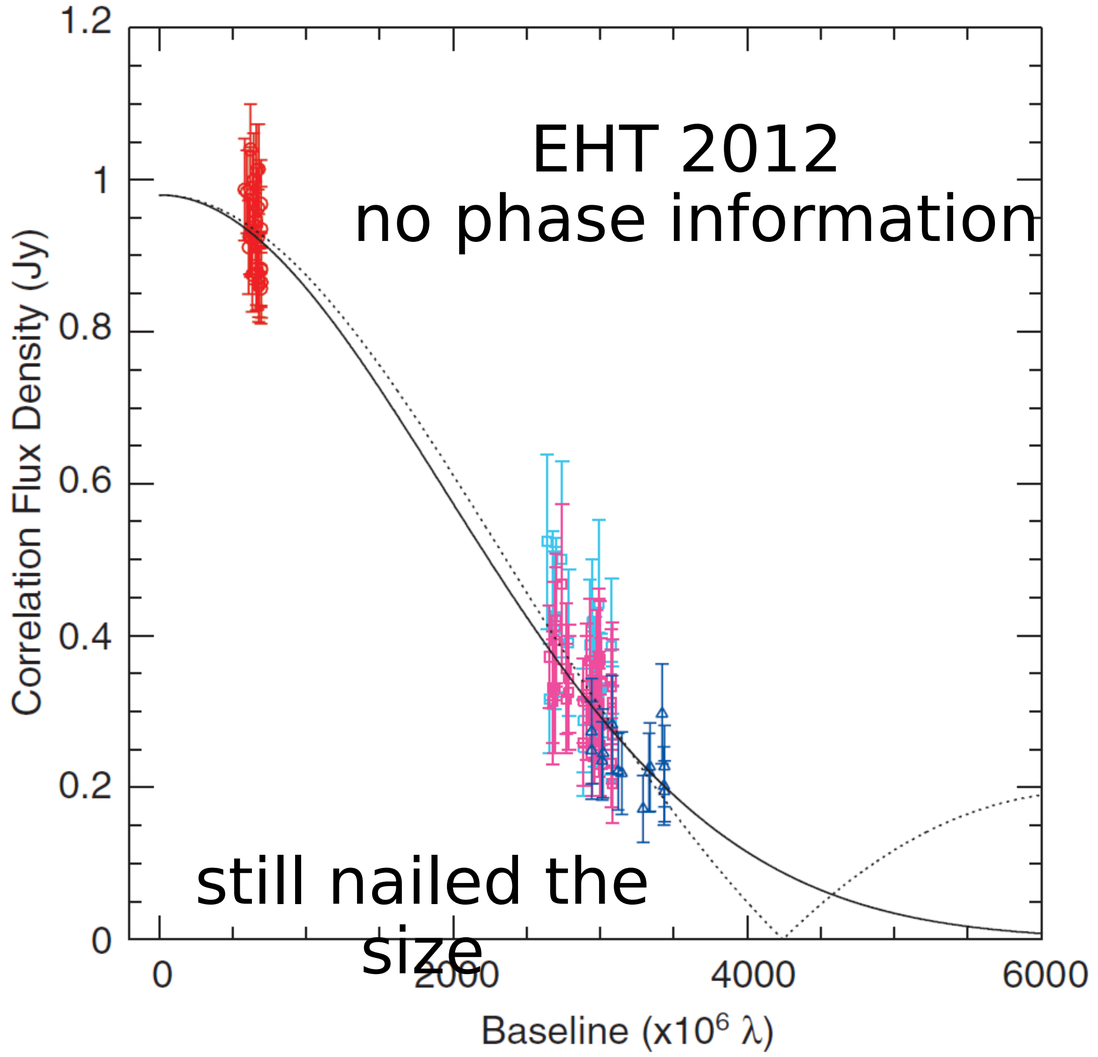
Inte
whe

- Intensit
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- You can



amplitude

Fig. 1. Measuring the size of the M87 core with 1.3-mm VLBI. Correlated flux density data from 3 consecutive days of observing are plotted as a function of baseline length (in units of observing wavelength). The CARMA-SMT baselines are shown in red; the two baselines from CARMA dishes to the JCMT are shown in magenta and teal; the SMT-JCMT baseline is shown in blue. Calibration errors of 5% have been added in quadrature to the 1σ random errors associated with the incoherent fringe search performed on each baseline. The weighted least-squares best-fit circular Gaussian model is shown as a solid line and has a total flux density of 0.98 Jy and a FWHM size of 40.0 micro–arc sec. A hybrid model (dotted line) combines a circular Gaussian of the same size with a thin ring of diameter 40.0 micro–arc sec, which represents the expected shadow feature due to illumination of the central supermassive black hole from behind by a counterjet in M87. In the hybrid model, the Gaussian and ring components each contribute one-half of the flux density. On VLBI baselines shorter than the null spacing, the VLBI interferometric phase is zero, but on baselines beyond the null spacing, the phase is 180°.



Intensity interferometry of AGN

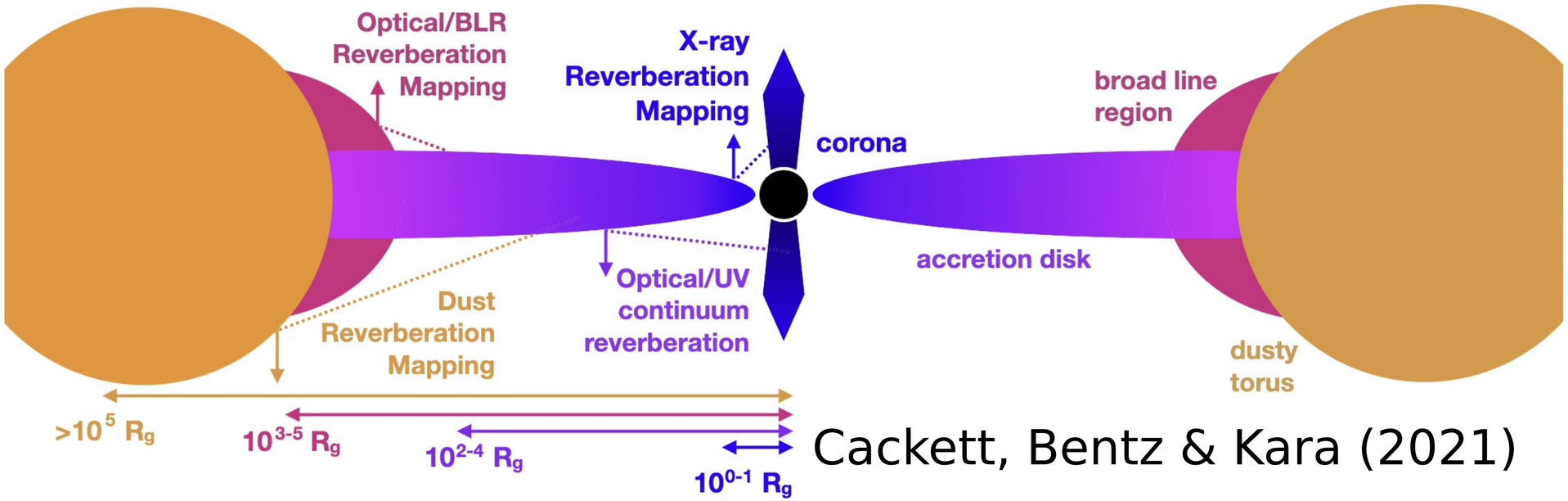
Science case for building next-gen intensity interferometers:

- Direct geometric measurement of H_0
- Probe AGN physics (e.g., measure inclination, test unification model)
- Futuristic: strong-field gravity, binary AGNs, …

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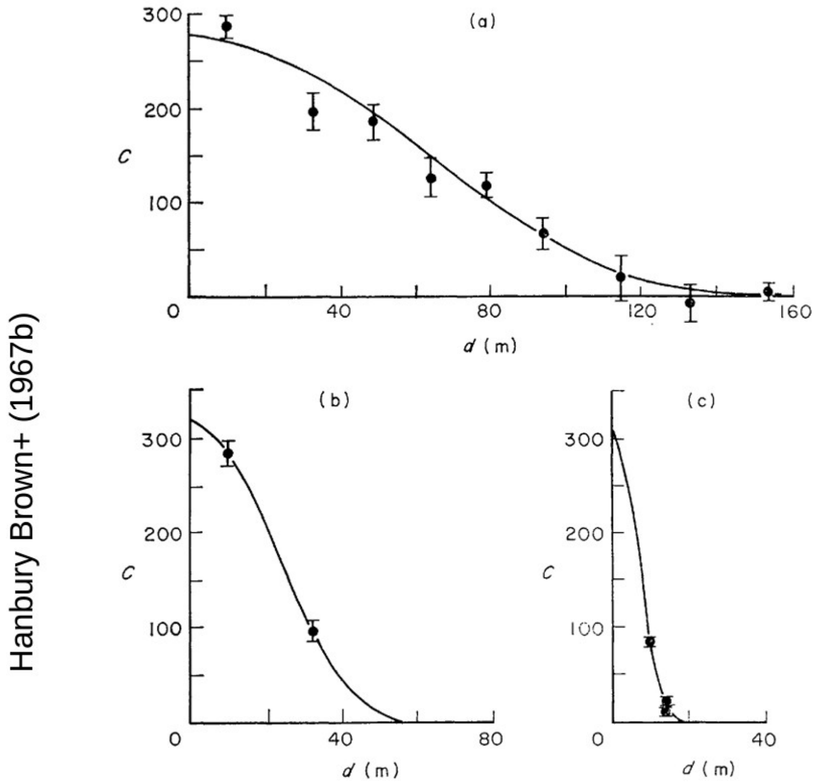
Reverberation mapping gives a physical size

- AGN luminosity varies over time, for both continuum and lines.
- But line variability **lags** the continuum variability: central source illuminates larger “broad line region”, which cools by line emission
- Time delay gives physical size



Cackett, Bentz & Kara (2021)

Intensity interferometry gives an angular size



Hanbury Brown+ (1967b)

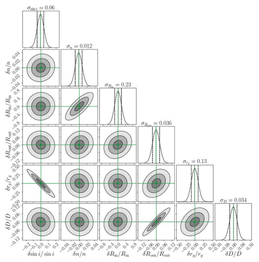
FIG. 3. *Examples of the observed variation of correlation with baseline for three stars.* (a) β Cru (1965); (b) α Eri (1965); (c) α Car (1965).

Measuring H_0

- Reverberation mapping ⇒ **physical size** of line-emitting region.
- Interferometry ⇒ **angular size** of the same region (same photons)
- Comparing the two tells us the **angular diameter distance** to the AGN
- Since these are line emitters, we also have **redshift**

Q: Can intensity interferometry help with Hubble?

A:



5 AGN,
Picosecond detectors,
14 dishes 88m² each,
24 hours, 50 spectral channels

3% H0 measurement

(see 2403.15903)