Contributed Talk

The CHARA Array - building towards the Michelson Array (No. 1072)

S6e: The future of visible/infrared High-Angular Resolution Astronomy in Europe

Survey and instruments

Tue. 24th Jun. 15:45 - 16:00 Kane G2

Presenter

Nic Scott
The Chara Array

Authors

Nic Scott [1], Gail Schaefer [1], Robert Ligon [1], Narsireddy Anugu [1], Christopher Farrington [1], Rainer Koehler [1], Karolina Kubiak [1], Cyprien Lanthermann [1], Nils Turner [1], Douglas Gies [2]

Affiliations

[1] The CHARA Array

[2] Georgia State University

Abstract

The CHARA Array has been in full science operations for 20 years. It currently operates the longest baselines for optical and near infrared interferometry in the world, making it the highest resolution facility in history. Throughout its operation the CHARA Array has demonstrated many "firsts" including but not limited to: Gravity darkening on a single star (α Leo), “p-factor” in the Baade-Wesselink method for Cepheids (δ Cep), hot exozodiacal dust around a main sequence star (Vega), exoplanet stellar host diameter (HD 189733), angular diameter for a halo star (μ Cas A), image of a single main-sequence star (Altair), image of an interacting binary (β Lyr), shortest period binary yet resolved (σ^2 CrB – 1.14 days), image of a binary star system in eclipse (ε Aur), earliest measurements of a nova diameter after eruption (Nova Del 2013), images of starspots (λ And, ζ And), μas wobbles of binary companions, image of a hypergiant gas ejection (RW Cep), and resolution of an AGN dust torus (NGC 4151).

The CHARA Array hosts some of the most advanced interferometric beam combiners in existence and has been continually upgrading its facilities and instrumentation. Adaptive optics systems for all six telescopes are now online, as well as a secondary "lab" AO system. New beam combiners expand the 6-beam imaging capabilities across multiple wavelength bands (R, H, K) and push toward greater sensitivity. Our mobile 7th

capabilities across multiple wavelength bands (R, H, K) and push toward greater sensitivity. Our mobile 7th telescope (T7) is an additional 1 meter aperture Planewave telescope mounted in a mobile enclosure. It has achieved first light and is undergoing the installation of its adaptive optics system. Optical fibers with lengths of 650m now connect S1, S2, and S3/T7 to the lab and have achieved fringes with a lab light source. The S4 mobile site will be commissioned in 2025 and will extend the maximum baseline out to 550m.

Future improvements are planned that will optimize the AO systems for correcting visible wavelengths atmospheric distortions. A central 2m telescope (C0) and 7th delay line system are in the proposal process. This would improve sensitivity and imaging capabilities for extended objects. C0 will also serve as a testbed to replace the existing 1m telescopes with 2m telescopes. The next generation of beam combiners will push toward greater sensitivity, higher contrast, and multi-wavelength imaging capabilities. Building on T7, we have identified sites that extend the maximum baseline out to 1 km. Future beam transport technologies may soon be tested at the Array, perhaps direct optical with adaptive optics for open-air transport and/or quantum entanglement technologies.

Simultaneous multi-wavelength imaging, beam transport, and control upgrades will improve many science goals: increased stellar diameter measurement precision, exoplanet host diameter and limb darkening measurements, and high contrast binary detection. New insights into stellar outflow and ejection/dimming events and the relation between mass ejection/outflow and Be star circumstellar disks may be revealed. Future science priorities will include stellar system evolution: planetary formation and young stellar objects, imaging the sites of planet formation in the inner region of circumstellar disks, and measuring the contraction of pre-main sequence stars. Longer baselines and improved sensitivity would allow for imaging of more contact and interacting binaries. Greater sensitivity will access dozens of AGN targets, where the dust sublimation region could be resolved, and km baselines would directly resolve the accretion disk and investigate possible binary black holes at the center. Imaging exoplanet transits remains a challenging possibility, accessible only through > 1 km baselines. Direct imaging of a hot Jupiter would require a new phase referencing mode of a nearby star.

The demonstration of these new technologies and their abilities to meet these ambitious science goals are the pathfinders for what will ultimately become "The Michelson Array". The Michelson Array is a proposed vast expansion of CHARA, with up to 12 sites across Mt Wilson for 2-4 meter telescopes linked via optical fiber to an expanded beam combining lab. This array would have 66 possible baselines, with a maximum baseline of 1.1 km, achieving angular resolutions of 60 μas. Such a facility would represent the next generation of long baseline optical/NIR interferometry.