Future Plans For the CHARA Array

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CHARA Planning

1. Imagining the Future
2. Science Goals
3. Telescopes, Sites, Beam Transport
4. OPLE, BCL, Combiners
5. The Way Forward
1 Imagining the Future

• What will be the role of the CHARA Array in the next decade?
• Future funding support from NSF will be influenced by recommendations of the Astro2020 review (next discussion)
• Relation to plans for NPOI, MROI, VLTI, Planet Formation Imager
  Monnier et al. 2018 arXiv:1807.11559
  http://www.planetformationimager.eu/Planet_Formation_Imager_Project/Home.html
• Build on current strength and support from GSU, NSF, and our user community
Ground work for discussion

• *Future of optical-infrared interferometry in Europe*
  Pott & Surdej 2018, Experimental Astron., 46, 381

• CHARA Futures Meeting, Sept. 22, 2017
  http://www.chara.gsu.edu/internal-meetings/futures-2017

• *High Angular Resolution Universe*
  Gail Schaefer’s presentation at NOAO Workshop, February, 2018
  https://www.noao.edu/meetings/2020decadal/#agenda

• CHARA/SPICA Science Group meeting, January 2019, Nice,
  Organized by Denis Mourard and Nicolas Nardetto.
  Especially development of plans in relation to PLATO mission
  https://chara-spica-ws.sciencesconf.org/
Guidelines for discussion

• Build on current strengths
• Use our infrastructure at Mount Wilson Observatory
• Consider new components that work together with current telescopes and/or combiners for new capability
• Consider plans that can be accomplished on a 5 to 10 year time scale
2 Science Goals

• Important science drivers in contemporary astrophysics
• Stellar imaging as CHARA specialty; follows community path in radio astronomy (ALMA)
• Fundamental parameters and exoplanet hosts
• Environments: YSOs, mass loss processes
• AGN: work by Matt Anderson and Makoto Kishimoto
• Needs: angular and spectral resolution, wavelength domains, sensitivity

*** DISCUSSION ***
3  Telescopes, Sites, Beam Transport

• Beam transport: light tubes or fiber optics? critical choice for sites in direct line of sight
• Demonstration using 300 m long fibers (now at CHARA) for $J$ and $H$ bands
• Fiber issues: star light injection, wavelength range, transmission, dispersion, polarization, protection from the environment (Labadie et al. 2016)

Fig. 2. Layout and pictures of the ‘OHANA Iki demonstration.
3 Telescopes, Sites, Beam Transport

- Woillez (... Reynaud ...) et al. 2017 all fibers need to be same length: eases somewhat the OPD problem (delay for just position in sky)
- Single mode, polarization maintaining fibers may also work in optical: ZBLAN fluoride fibers
- Free air transport (Theo, Stuart)

https://www.fiberlabs.com/
Telescope sites

• MWO has complicated terrain but options exist
• More options for fiber transport than for light pipes
• Informal poll at CHARA Paris Meeting (March 2018): five “strawman” concepts
(1) Add central telescope behind CRO

- Use extra M1, M2 and build 1 m telescope of same design
- Place near the center of Array
- Increased short baseline coverage for baseline bootstrapping
(2) Add 2 m telescope to the far south

- Connect to S1 by fiber
- Use as pathfinder for PFI technology
(3) Add 2 m telescope close to S1

- Helpful for large objects like supergiants and exozodiacal disks
- Role in baseline bootstrapping
- Might share light pipe with S1 or S2
(4) Add two 2 m telescopes to NW and SW

- Very long baselines for highest resolution
- 660 m from NW to S1, 590 m from SW to E1
- Requires strong bridge for SW light pipe
- Stepping stone to km baseline arrays
(5) Replace all six telescopes with 2 m scopes

- Increase sensitivity using existing light pipes
- Invest in high reflectivity optics
Informal poll from CHARA Paris meeting

<table>
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<th>#</th>
<th>Concept</th>
<th>☹️</th>
<th>😐</th>
<th>😄</th>
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<tbody>
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<td>1</td>
<td>1m near CRO</td>
<td>13%</td>
<td>35%</td>
<td>52%</td>
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<tr>
<td>2</td>
<td>2m far south</td>
<td>23%</td>
<td>45%</td>
<td>32%</td>
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<tr>
<td>3</td>
<td>2m near S1</td>
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<td>35%</td>
<td>39%</td>
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<tr>
<td>4</td>
<td>two 2m to NW and SW</td>
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<td>35%</td>
<td>61%</td>
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<tr>
<td>5</td>
<td>replace all with 2m</td>
<td>17%</td>
<td>26%</td>
<td>57%</td>
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</table>

- extend spatial dynamical range (long and short baselines) and enable bootstrapping
- want better sensitivity, but ...
- keep same aperture to combine new and existing telescopes
- optimize \((u,v)\) sampling for imaging work
- want future \(L, N\) band access
- include other MWI (60-inch and 100-inch) telescopes in Array?
Off axis parabolic telescope to AO deformable mirror and into fibers (D. Leisawitz; J. Kuhn)

Maintain current CHARA design

*** DISCUSSION ***
4 OPLE, BCL, Combiners

- Room for 2 traditional beams in OPLE but would require redesign of beam switchyard for additional beams
- Additional delay (for longer baselines) could be obtained by extending the OPLE rails into the storage area at the east end and/or creating double-pass system
- Beam combiners designed for six or fewer beams, so would other beams be included as subsets? New IO beam combiner for 8 beams?
- Plans ahead for SPICA (Mourard) and MYSTIC (Sept 2019; Monnier)

*** DISCUSSION ***
5 The Way Forward

• All aspects need consideration but science goals are primary: need exciting plans that generate enthusiasm
• Need to develop a conceptual paper with general scheme
• Follow with a feasibility study of technical and other challenges
• Build a consensus among all the stakeholders: GSU, CHARA collaboration, MWI, Carnegie, Forest Service, LA County
• Long lead time required (for example, environmental review process)
Approximate timeline

- 2019 – conceptual paper, discussions with stakeholders
- 2020 – feasibility study, funding proposal (MSIP due 11/15/2020)
- 2021 – additional funding, hire project leaders
- 2022 – telescope construction, site preparation, OPLE/BCL parts
- 2023 – telescope installation, OPLE/BCL work
- 2024 – systems integration, software, testing
- 2025 – commence science operations
One final task ...

Let’s extend our thanks to our Lowell Observatory hosts:

Gerard van Belle
Jelena Lane