PHYS.ORG

Researchers propose inexpensive 2.2-kilometer telescope that could make exoplanet movies

August 26 2024, by Laurence Tognetti

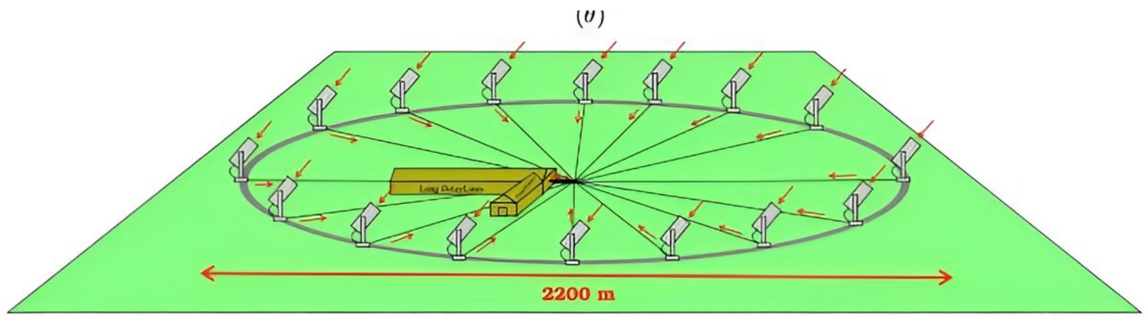

Figure 3: Nominal schematic of the BFT: 16 × 0.5 meter telescopes on a 2.2-km ring, with a central beam delay and combination laboratory.

Credit: *arXiv* (2024). DOI: 10.48550/arxiv.2408.01386

Can a kilometer-scale telescope help conduct more efficient science, and specifically for the field of optical interferometry? This is what a study recently posted to the preprint server *arXiv* hopes to address.

A pair of researchers propose the Big Fringe Telescope (BFT), which is slated to comprise 16 telescopes 0.5-meter in diameter and will be equivalent to a telescope at 2.2 kilometers in diameter. What makes BFT unique is its potential to create real-time exoplanet "movies" like the movies featuring Venus transiting our sun, along with significantly reduced construction costs compared to current ground-based optical interferometers.

This proposal builds upon past optical interferometers, including Georgia State University's Center for High Angular Resolution Astronomy (CHARA) array comprised of six telescopes 1-meter in diameter equivalent to a telescope 330 meters in diameter, and the European Southern Observatory's Very Large Telescope Interferometer (VTLI) comprised of four 8.2-meter telescopes and four movable 1.8-meter telescopes equivalent to a telescope 130 meters in diameter.

Additionally, this proposal comes as the ESO is currently building its Extremely Large Telescope with a 39.3-meter-diameter (130-foot) reflecting telescope in the Atacama Desert in Chile.

Here, Universe Today discusses this incredible proposal with Dr. Gerard van Belle, who is an astronomer at the Lowell Observatory in Flagstaff, Arizona, regarding the motivation behind proposing BFT, the science cases that BFT hopes to accomplish, new methods regarding how BFT will study exoplanets (i.e., real-time movies), how BFT can potentially contribute to finding life beyond Earth, the next steps for making BFT a reality, and the implications for each telescope being 0.5 meters in diameter for both the science and cost.

Therefore, what was the motivation behind proposing BFT?

"The motivation is that somewhere along the line, the community ended up 'leaving money on the table,'" Dr. van Belle tells Universe Today. "There's a really exciting science case here—imaging of bright stars—and it's been overlooked. This is in part because the collective imagination of the people (like me) who build these very high angular resolution imaging arrays has been collectively distracted by pushing on going 'fainter, fainter, fainter,' rather than 'finer, finer, finer.'

"And the nice surprise is that, since we're not going super faint, the telescopes that make up the BFT array are small, and therefore the BFT is surprisingly affordable. The additional third axis here is much of the parts are only recently commercial-off-the-shelf, so that also helps the affordability. So, it's great science that hasn't been done, it's cheap, and it's timely."

The study notes that the "routine imaging of bright main sequence stars remains a surprisingly unexplored scientific realm." For context, while the CHARA array obtained the first image of a single, main-sequence star in 2007, some of the science conducted by CHARA has focused on binary stars, supernova explosions, and dust orbiting stars.

Additionally, while the VLTI obtained the best image of the surface and atmosphere of a red supergiant star, some of the science conducted included direct observations of exoplanets, observing Sagittarius A*, which is the supermassive black hole at the center of the Milky Way, and detection of exozodiacal light.

Like CHARA and VLTI, the BFT will also conduct a wide range of science along with its goal of imaging bright, main-sequence stars. These include studying exoplanet host stars, solar analogs, resolved binaries, and resolved exoplanet transits.

Dr. van Belle tells Universe Today, "The exoplanet hosts are the real meat-and-potatoes case here: the explosion of discoveries over the past three decades on exoplanets has really transformed astronomy. Solar analogs are super important to study.

"Up until now, we have a single solar-like star we can resolve into more than a disk and see how it behaves over time—namely, our own sun. But that's a little like trying to learn anatomy and physiology if you were a doctor to a single patient, ever. So, being able to make resolved images of sun-like stars is really vital to better understanding our own sun—and especially its effect on our home planet."

Dr. van Belle continues, "Observations of binary star systems let us determine the masses because of their orbital motion around each other, and BFT adds extra value by then directly measuring the radii of those stars. Resolved exoplanet transits is going to be the wicked cool one. We will be able to see the resolved disk of another world as it passes in front of its host star.

"This sort of thing will be good for further characterization of exoplanets, as well as searches for exomoons. There's a bunch of other BFT science that isn't part of the core marquee cases—many hundreds of different types of stars that we'll be able to make pictures of and see how those pictures change over time."

Currently, directly viewing exoplanets is obtained through the direct imaging method where astronomers use a coronagraph to blot out the glare of a host star, revealing the hidden exoplanets underneath, although their full shapes aren't observable. Additionally, the transit method is conducted by measuring the dip in starlight caused by the exoplanet traveling in front of it but is not observable due to their small size and the intense glare of the host star.

The resolved exoplanet transits that BFT hopes to achieve means astronomers will be able to observe the full outline of an exoplanet as it passes in front of its host star, thus combining the direct imaging method with the transit method.

An example of this is when Venus passes in front of our sun, enabling astronomers to observe the entire outline of both the planet and our sun, resulting in real-time movies of this incredible astronomical event. With BFT, these real-time movies are anticipated to be made for exoplanets, as well. Therefore, what science can be achieved from these real-time movies?

"As noted above, we'll be able to see these worlds as resolvable disks," Dr. van Belle tells Universe Today. "That'll let us better pin down the linear size, as well as measure the density of these worlds—e.g., rocky or watery, solid or gaseous? Doing such resolving in a wavelength-dependent sense may tell us about the composition of the atmospheres, too—though that's a pretty challenging observation.

"Maybe the more straightforward thing will be attempting to measure the oblateness of the gaseous worlds—e.g., Jupiter is a bit wider than it is tall, because of it being a rapidly spinning clot of gas. Such observations will allow us to measure the rotation rate of those planets."

As of this writing, NASA has confirmed the existence of 5,743 exoplanets consisting of a wide range of sizes and compositions, and they have been found in solar systems containing single planets or up to seven planets.

The methods used to detect exoplanets also demonstrate diversity, including the transit method, radial velocity method, microlensing method, and the direct imaging method. Each with their own unique ways of not only identifying exoplanets, but also gathering data about their surface compositions, atmospheric compositions, and potential for life. Therefore, how can the BFT contribute to finding life beyond Earth?

Dr. van Belle tells Universe Today, "BFT will primarily be doing follow-up of exoplanets, rather than finding them, but in doing so will contribute to much better characterization of the exoplanets and their hosts. A lot of 'is there life out there' is riding on not just the exoplanet but the conditions handed to that exoplanet by its host. Knowing the 'space weather' environment will get much better information from BFT observations."

Along with the potential exoplanet movies and improved science of bright stars, one of the primary driving forces behind BFT is its cost, as the researchers estimate the total cost of the entire project is $28,496,000 for all 16 telescopes at 0.5 meters each. In contrast, the GSU CHARA array cost more than $14.5 million for just six telescopes at 1-meter each, and the construction costs for the VLT/VLTI is estimated in the hundreds of millions of dollars for four 8.2-meter telescopes and four movable 1.8-meter telescopes.

This recent study provides an in-depth cost breakdown for each aspect of the BFT, including beam collection ($4,720,000), beam transport ($2,744,000), beam combination ($4,140,000), beam delay ($4,000,000), infrastructure ($1,943,000), and labor ($5,250,000). But, given that each BFT telescope is smaller than those used on the GSY CHARA and VLTI, thus meaning their collecting aperture size is smaller, what is the significance of using 0.5-meter collecting aperture size and what is the reason for BFT targeting bright stars?

"The 0.5-m telescopes have a big impact on the affordability of the project," Dr. van Belle tells Universe Today. "The smaller telescopes are less expensive, both for the telescope tube and the mount. This in turn means the enclosure is smaller and cheaper, too.

"With half-meter telescopes, simple tip-tilt atmospheric correction is sufficient, rather than more expensive multi-element adaptive optics. And since there are 16 apertures, every reduction in cost per station has a big domino effect. And yes, the major trade happening here is that the facility can only observe brighter objects—e.g., primarily bright stars."

Just like space telescopes, building ground-based takes years of funding, tests, planning, and construction. This involves getting the necessary funding from multiple parties and organizations and finding an appropriate construction site for the location. Additionally, testing the telescopes prior to installation is essential for them to conduct successful science, in both the short- and long-term.

For example, the GSU CHARA array was founded in 1984, which was followed by years of funding efforts that finally completed in 1998, and the construction of the array was not completed until 2003. For the VLT/VLTI, funding began in 1987, construction began in 1991, and was completed in 1998. Therefore, what are the next steps to make BFT a reality?

"So, the BFT is interesting in how it scales," Dr. van Belle tells Universe Today. "Right now, we're doing lab work to verify some of the underlying technology; quite a bit of that tech has already been maturely deployed at places like the Georgia State University CHARA Array, or the European Southern Observatory VLTI facility.

"Following on that, our next steps will be to test, on the sky, a single pair of telescopes. The BFT is daisy-chained from 16 such telescopes, but we can already test its performance with just two. This scalability makes the BFT a much lower-risk telescope than conventional large facilities, where you have to more or less build the whole dang thing before you can test it on sky."

More information: Gerard T. van Belle et al, The Big Fringe Telescope, *arXiv* (2024). DOI: 10.48550/arxiv.2408.01386

Provided by Universe Today

Citation: Researchers propose inexpensive 2.2-kilometer telescope that could make exoplanet movies (2024, August 26) retrieved 26 August 2024 from https://phys.org/news/2024-08-inexpensive-kilometer-telescope-exoplanet-movies.html