SHARPEST EYES ON THE SKY

THE WONDERS OF OPTICAL INTERFEROMETRY

THOMAS GAUDIN

ASTRO ON TAP

NOVEMBER 2023

Image Credit: *NASA, ESA, CSA, STScI, Spitzer, WISE*

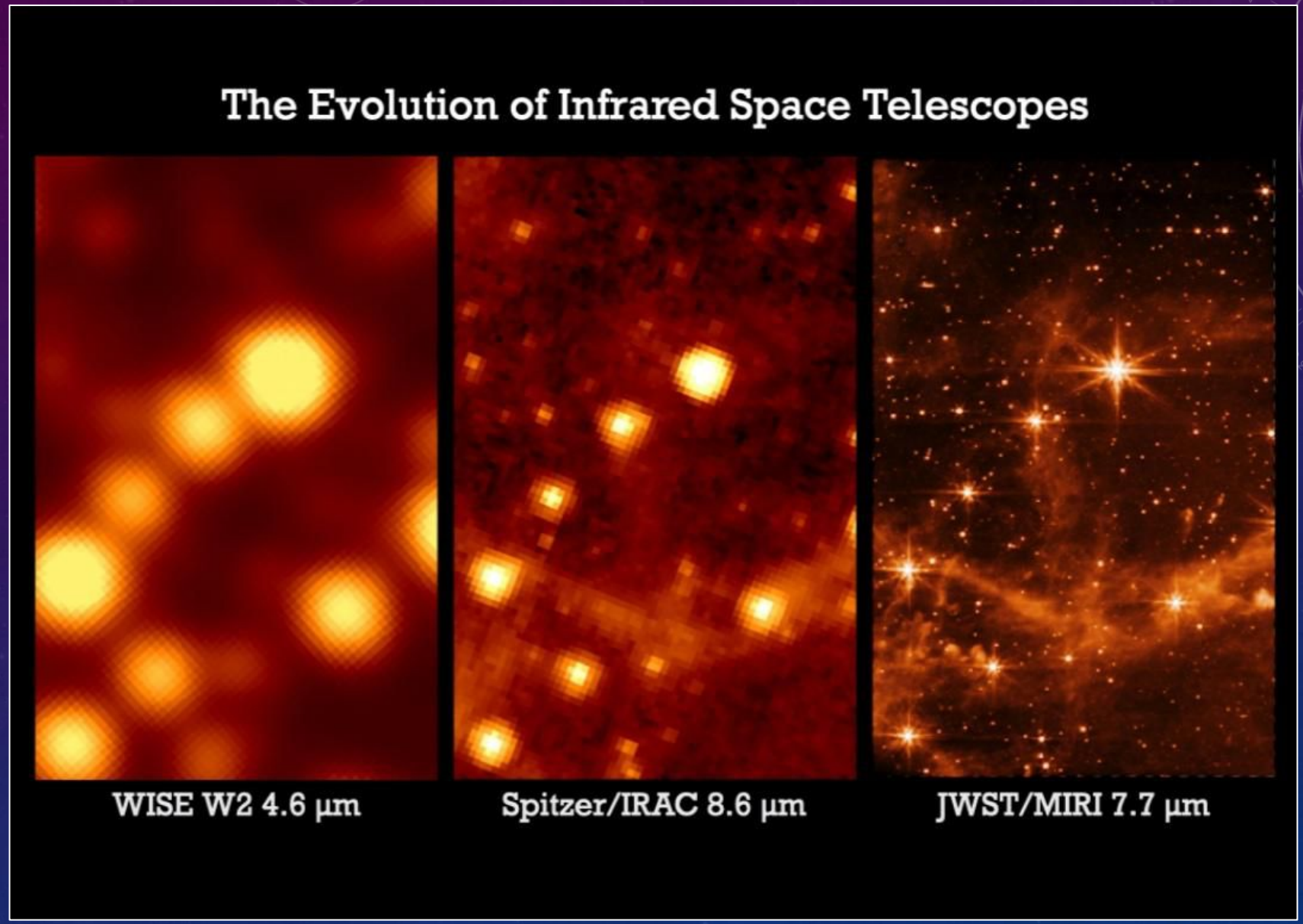
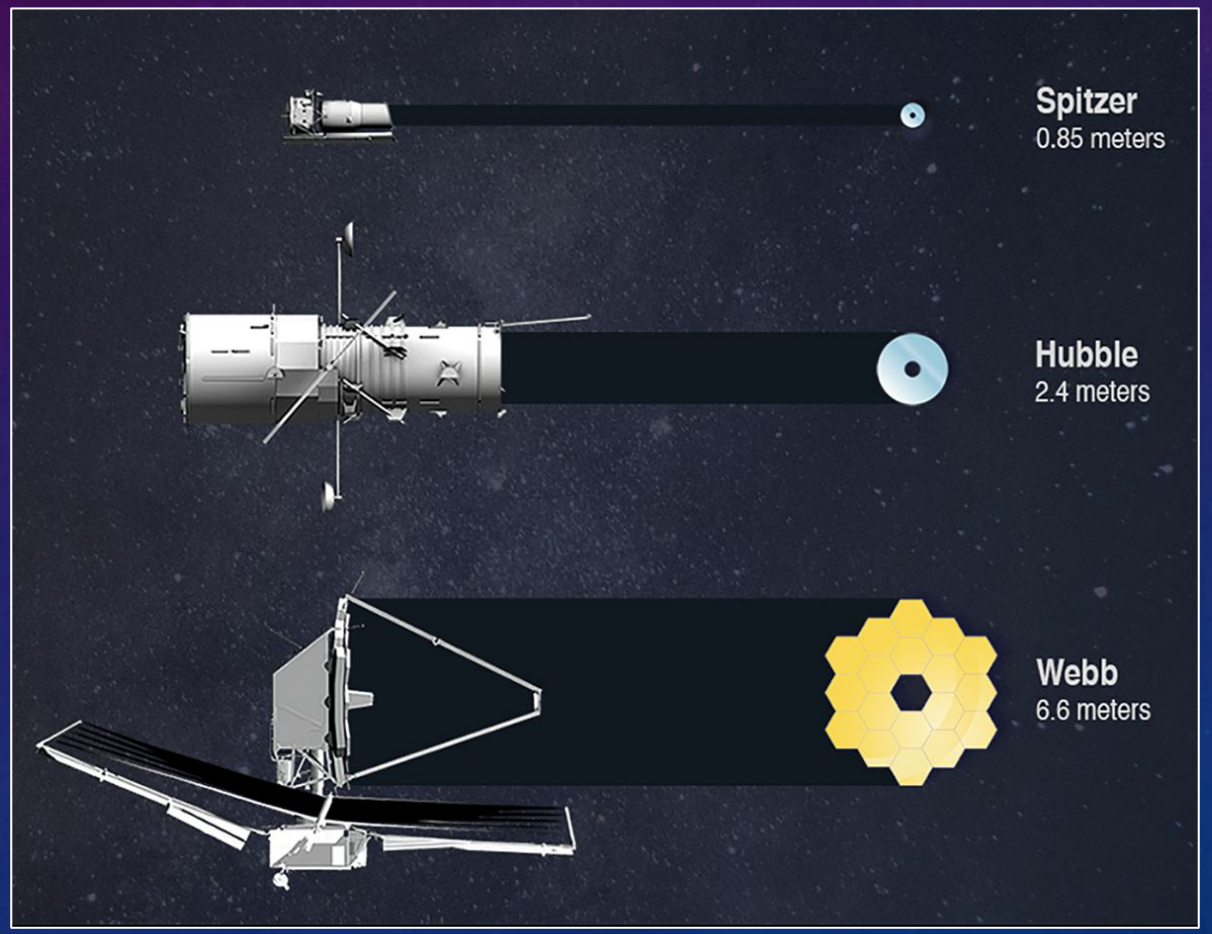
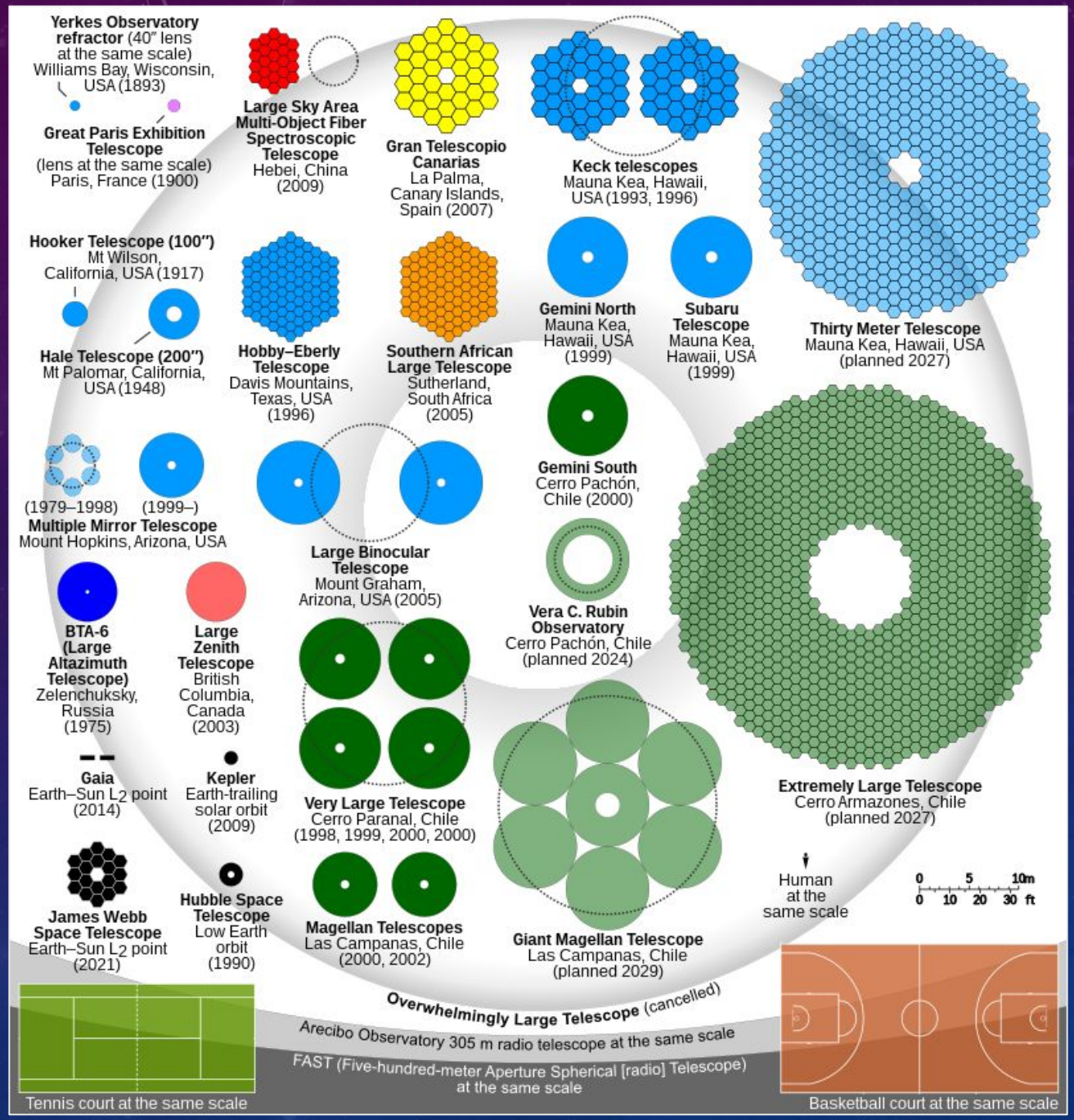


Image Credit: *STScI*

ANGULAR RESOLUTION DEPENDS ON TELESCOPE SIZE




Yerkes Observatory refractor (40″ lens at the same scale) Williams Bay, Wisconsin, USA (1893)
Great Paris Exhibition Telescope (lens at the same scale) Paris, France (1900)
Large Sky Area Multi-Object Fiber Spectroscopic Telescope Hebei, China (2009)
Gran Telescopio Canarias La Palma, Canary Islands, Spain (2007)
Keck telescopes Mauna Kea, Hawaii, USA (1993, 1996)
Thirty Meter Telescope Mauna Kea, Hawaii, USA (planned 2027)
Hooker Telescope (100″) Mt Wilson, California, USA (1917)
Hale Telescope (200″) Mt Palomar, California, USA (1948)
Hobby–Eberly Telescope Davis Mountains, Texas, USA (1996)
Southern African Large Telescope Sutherland, South Africa (2005)
Gemini North Mauna Kea, Hawaii, USA (1999)
Subaru Telescope Mauna Kea, Hawaii, USA (1999)
(1979–1998)
(1999–)
Multiple Mirror Telescope Mount Hopkins, Arizona, USA
Large Binocular Telescope Mount Graham, Arizona, USA (2005)
Gemini South Cerro Pachón, Chile (2000)
Vera C. Rubin Observatory Cerro Pachón, Chile (planned 2024)
BTA-6 (Large Altazimuth Telescope) Zelenchuksky, Russia (1975)
Large Zenith Telescope British Columbia, Canada (2003)
Gaia Earth–Sun L2 point (2014)
Kepler Earth-trailing solar orbit (2009)
Very Large Telescope Cerro Paranal, Chile (1998, 1999, 2000, 2000)
Extremely Large Telescope Cerro Armazones, Chile (planned 2027)
James Webb Space Telescope Earth–Sun L2 point (2021)
Hubble Space Telescope Low Earth orbit (1990)
Magellan Telescopes Las Campanas, Chile (2000, 2002)
Giant Magellan Telescope Las Campanas, Chile (planned 2029)
Human at the same scale
0 5 10m
0 10 20 30 ft
Overwhelmingly Large Telescope (cancelled)
Arecibo Observatory 305 m radio telescope at the same scale
FAST (Five-hundred-meter Aperture Spherical [radio] Telescope) at the same scale
Tennis court at the same scale
Basketball court at the same scale

LARGE TELESCOPES CREATE ISSUES

- Extremely heavy
- Gravity provides size constraint
- Very, very expensive
- Hard to stuff into a rocket

ROLE OF INTERFEROMETRY

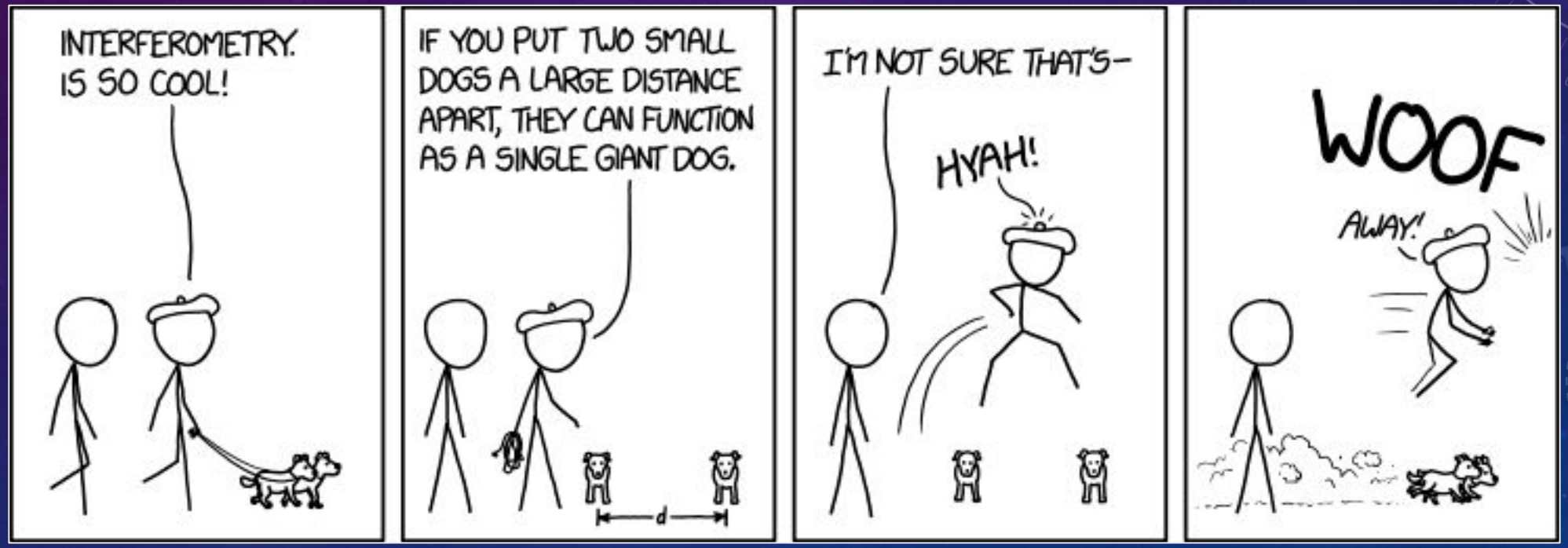
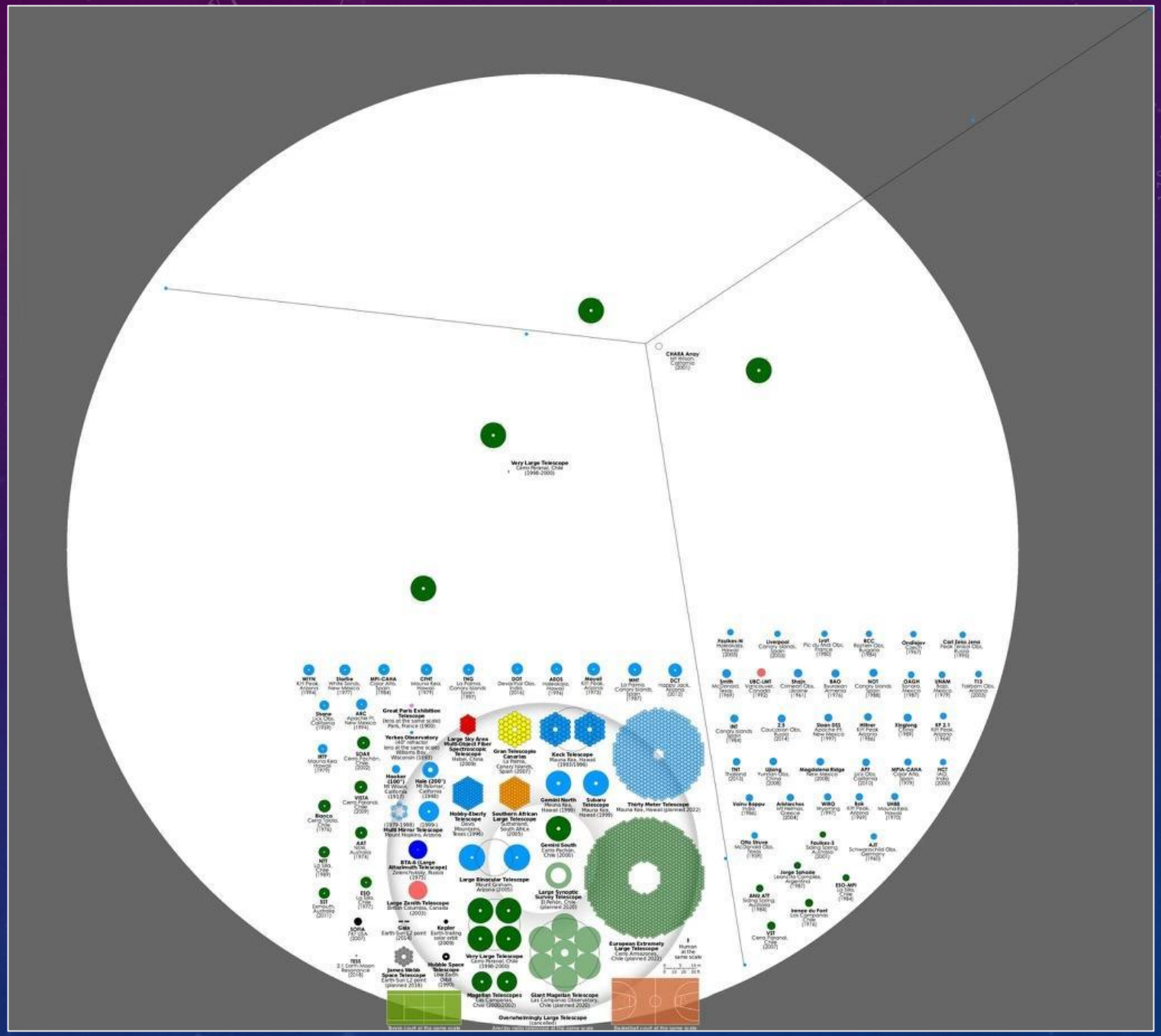
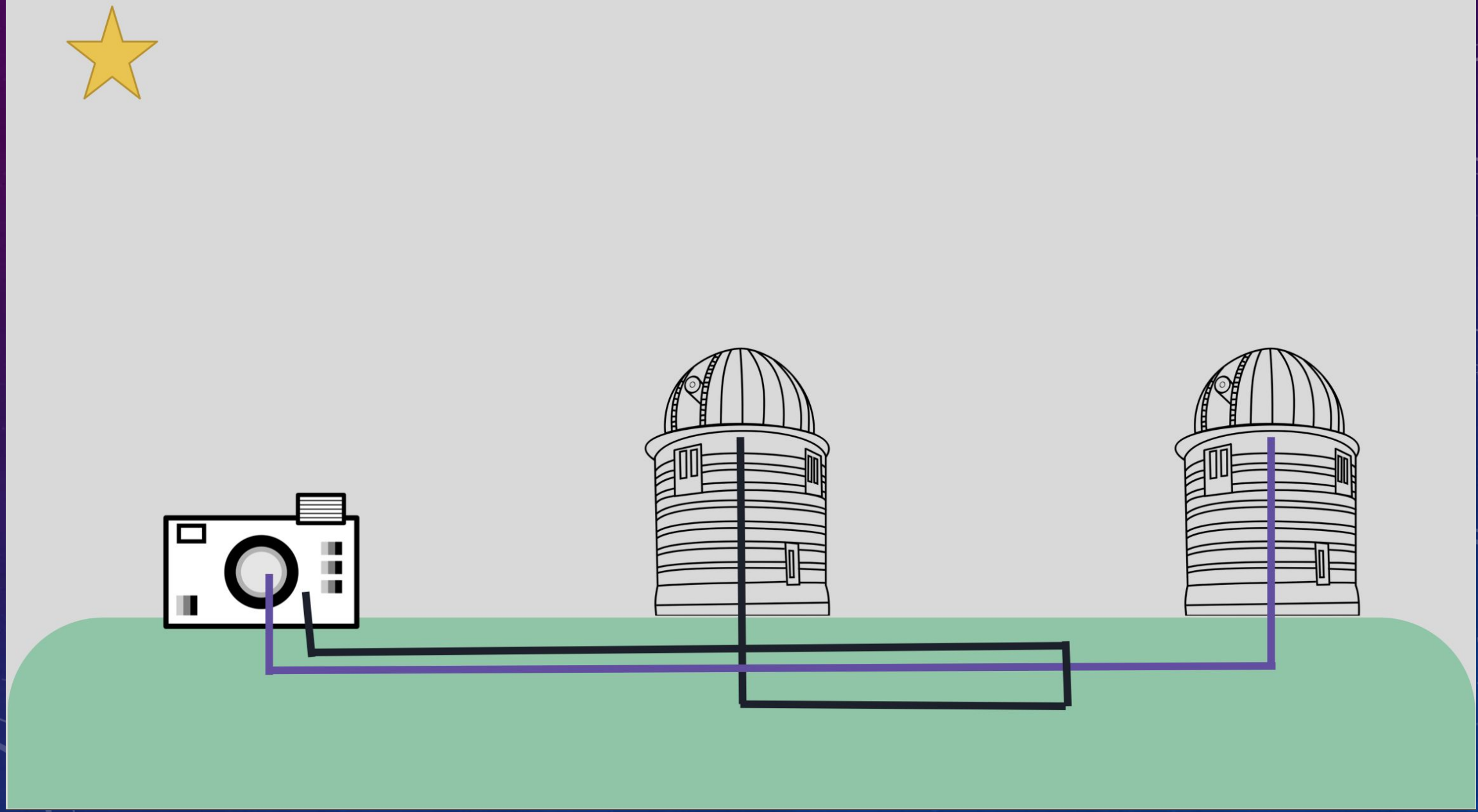
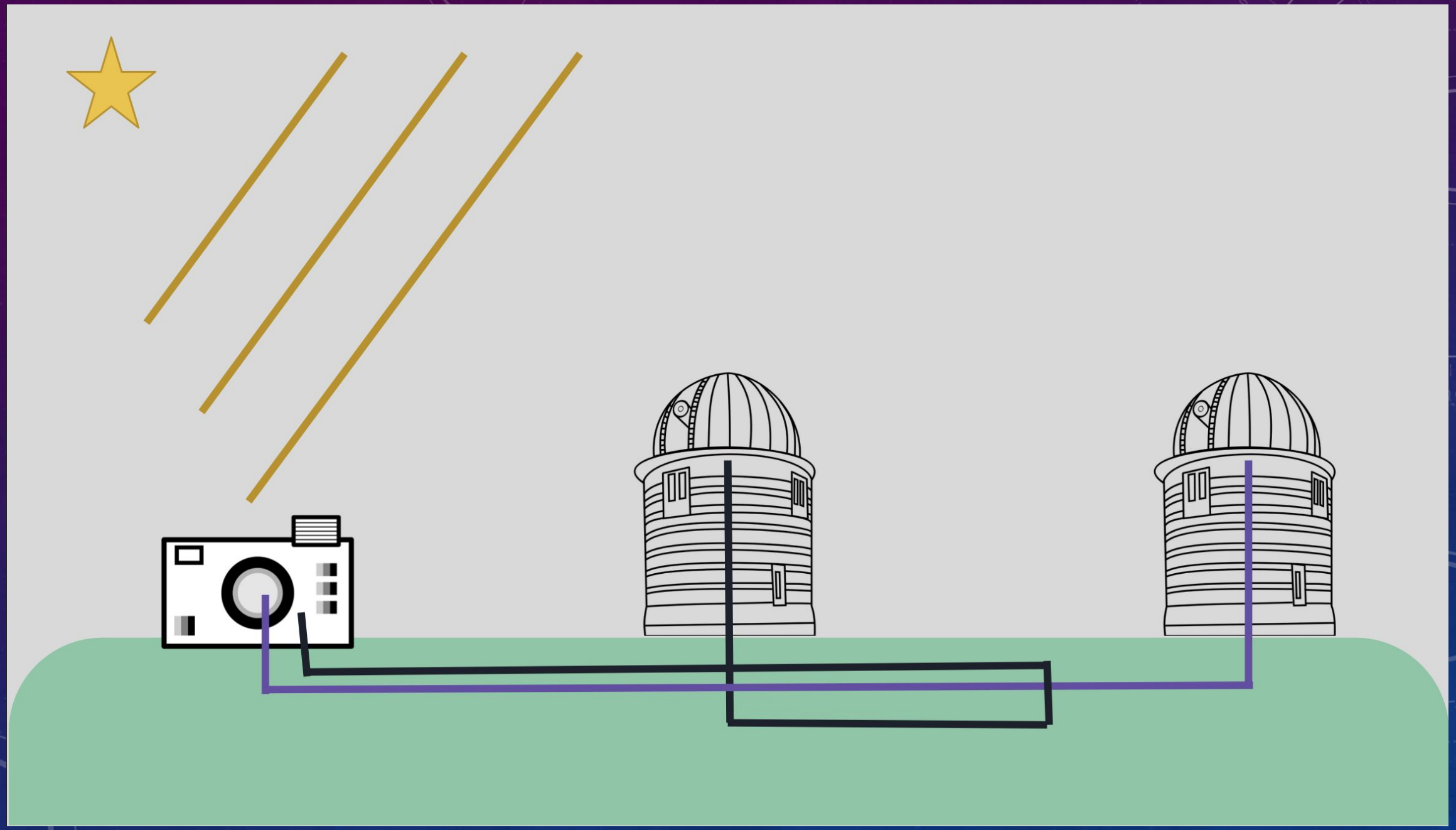
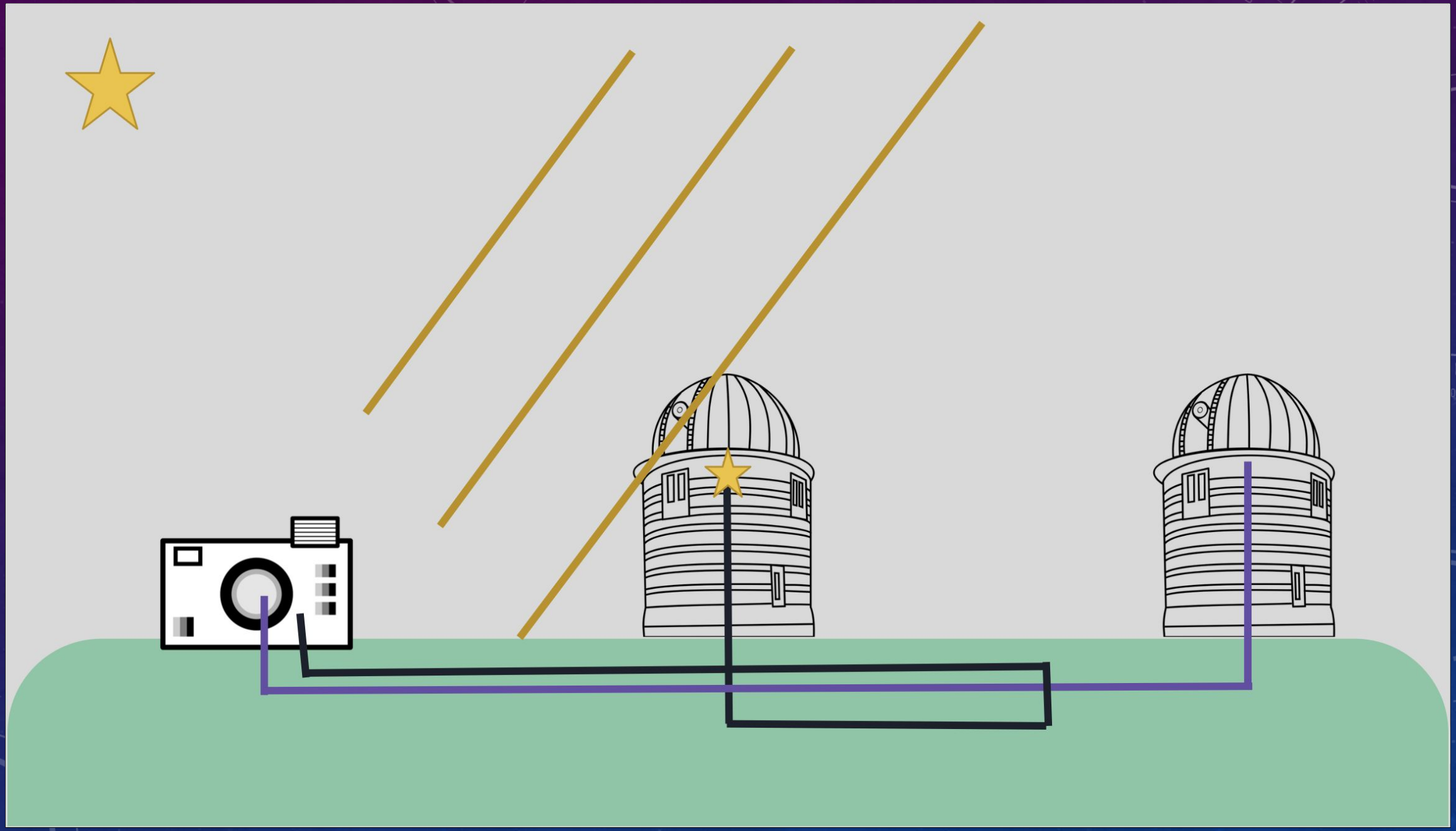


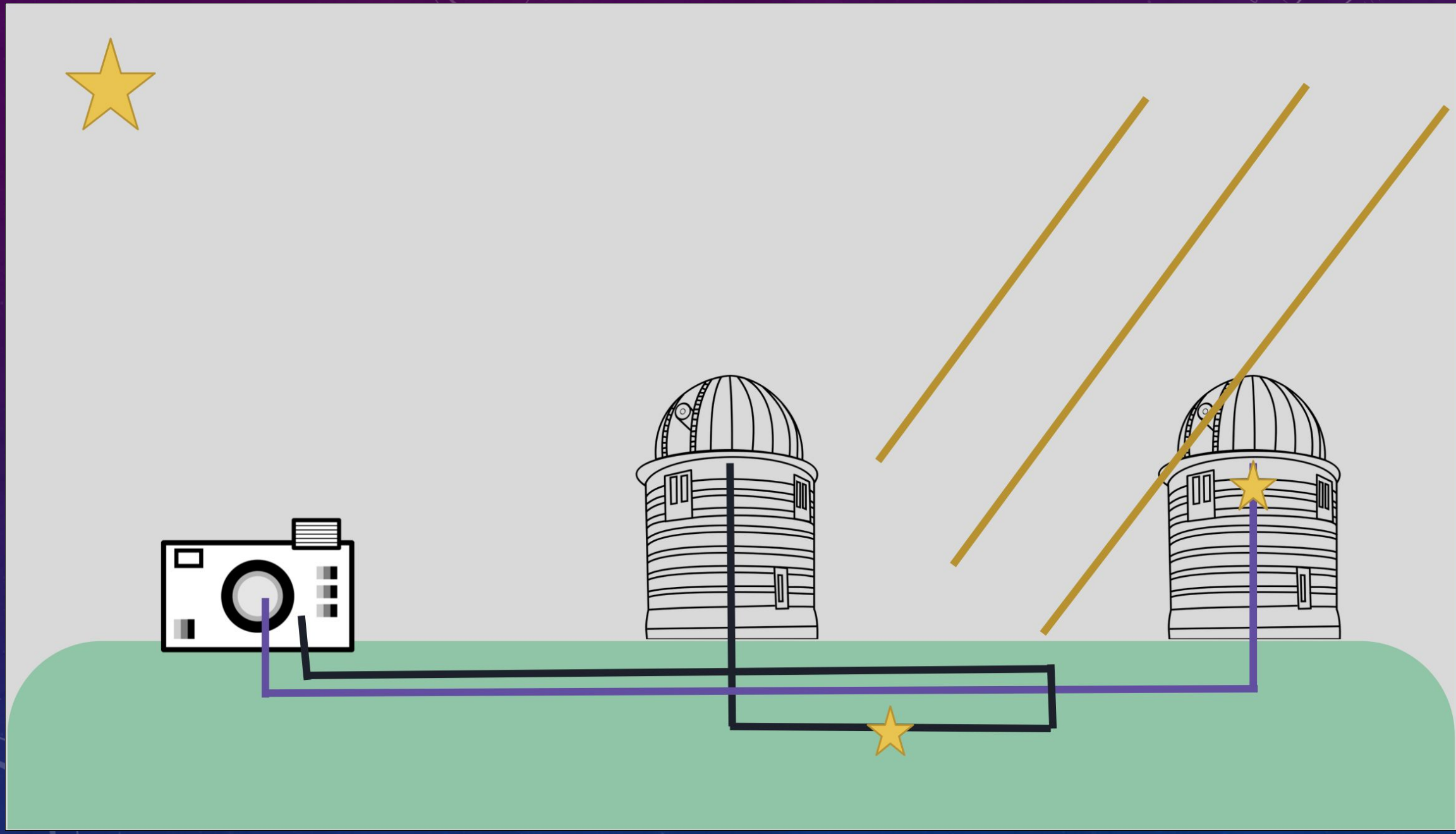
Image Credit: *XKCD*

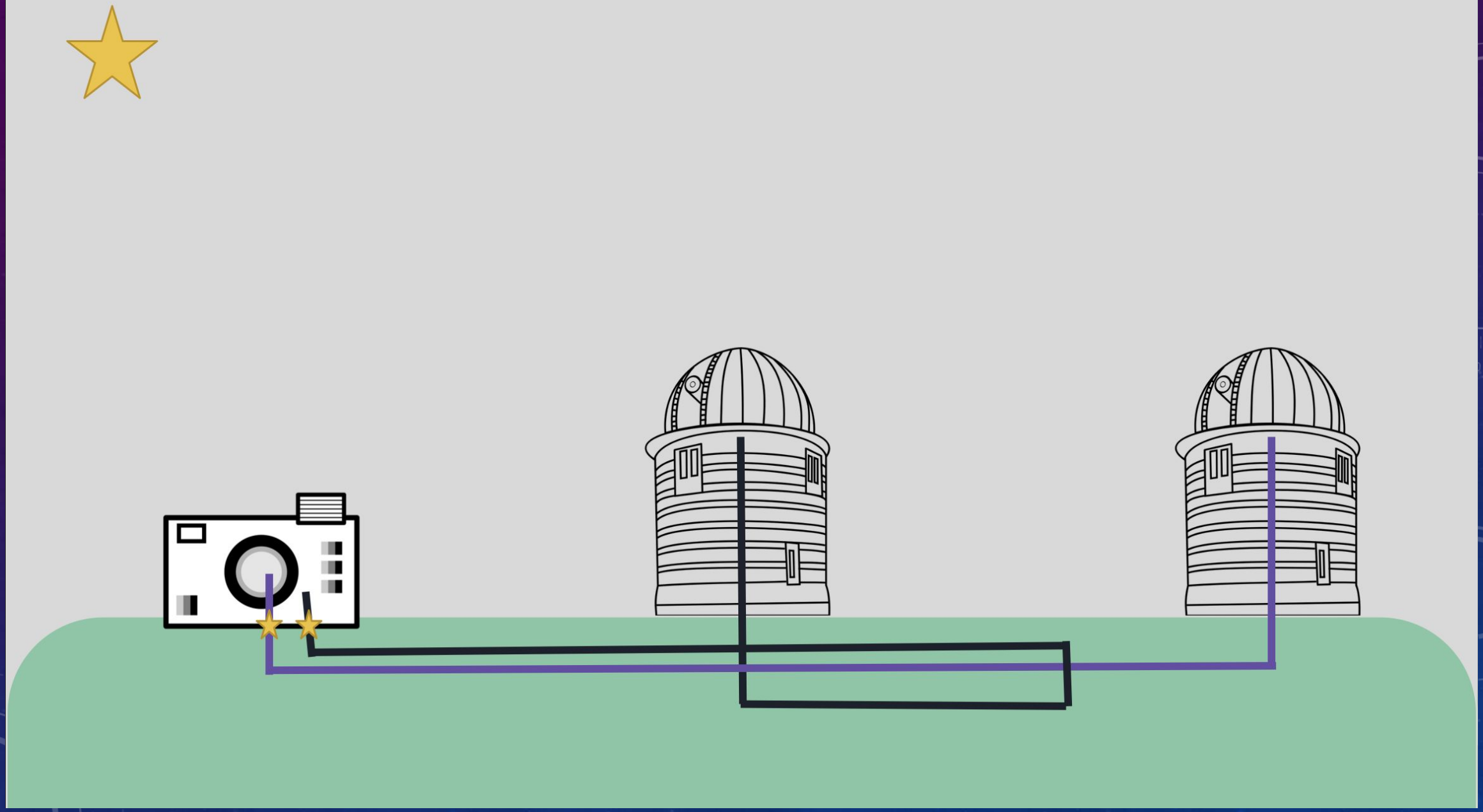

CHASA Array
Very Large Telescope
Great Paris Exhibition Telescope
Large Sky Area Multi-Object Fiber Spectroscopic Telescope
Gran Telescopio Canarias
Keck Telescope
Thirty Meter Telescope
Yerkes Observatory
Hooker (100")
Hale (200")
Hobby-Eberly Telescope
Southern African Large Telescope
Gemini North
Subaru Telescope
Multi Mirror Telescope
Gemini South
RTA-6 (Large Altazimuth Telescope)
Large Binocular Telescope
Large Synoptic Survey Telescope
Large Zenith Telescope
European Extremely Large Telescope
Very Large Telescope
James Webb Space Telescope
Hubble Space Telescope
Magellan Telescopes
Giant Magellan Telescope
Overwhelmingly Large Telescope
(cancelled)











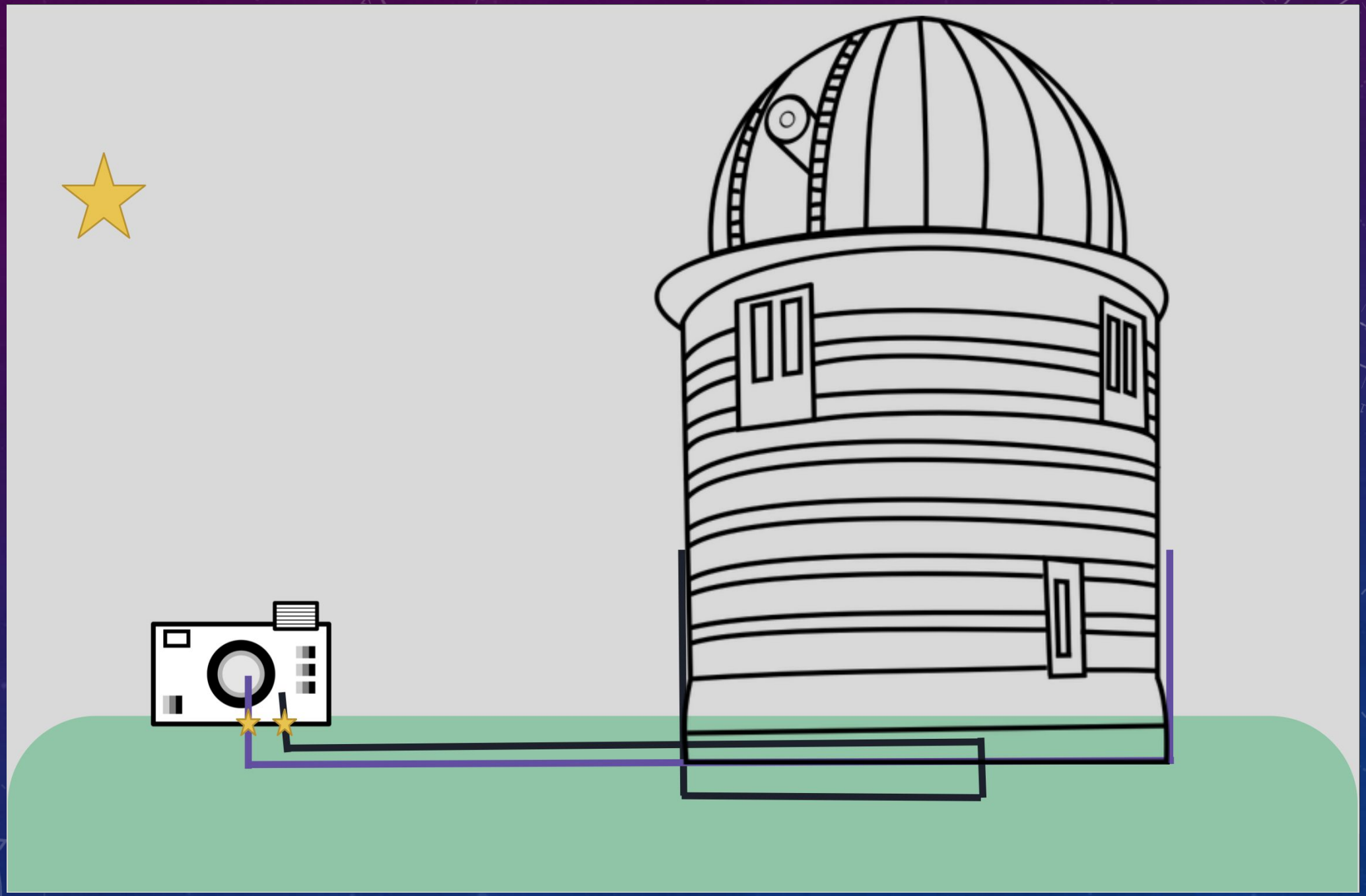


Image Credits: *CHARA Array*

IMPORTANT OPTICAL INTERFEROMETRY ARRAYS

CHARA ARRAY

- Location: Mount Wilson, CA
- Diameter: 300m
- Number of Telescopes: 6 (1m)

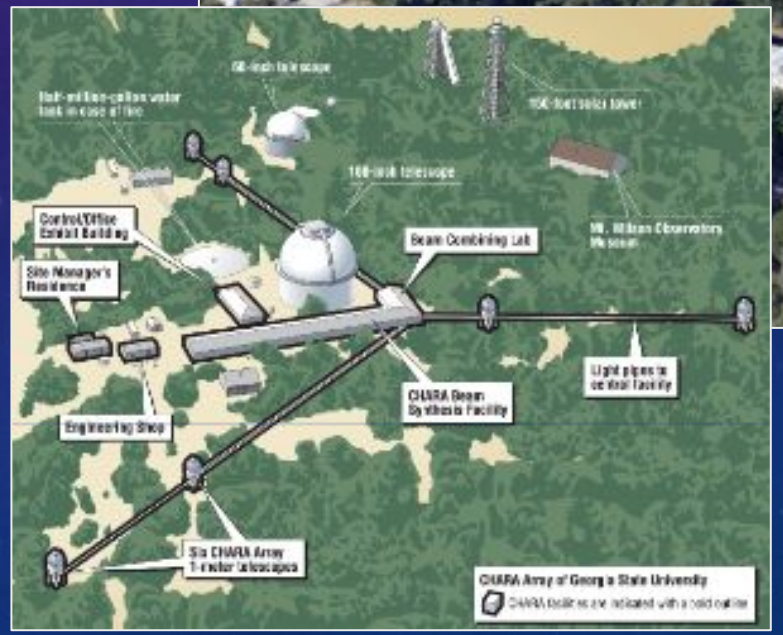


Image Credits: *CHARA Array, Eric Simison of Sea West Enterprises*

VERY LARGE TELESCOPE INTERFEROMETER

- Location: Mount Paranal, Chile
- Diameter: up to 130m
- Number of Telescopes:
  - 4 large (8m)
  - 4 small (1.8m)

Image Credits: *ESO*

SCIENCE WITH OPTICAL INTERFEROMETRY

MEASURING STELLAR DIAMETERS

- Most important job of interferometry
- One of the most accurate ways to determine an object's size
- Improves understanding of stellar evolution

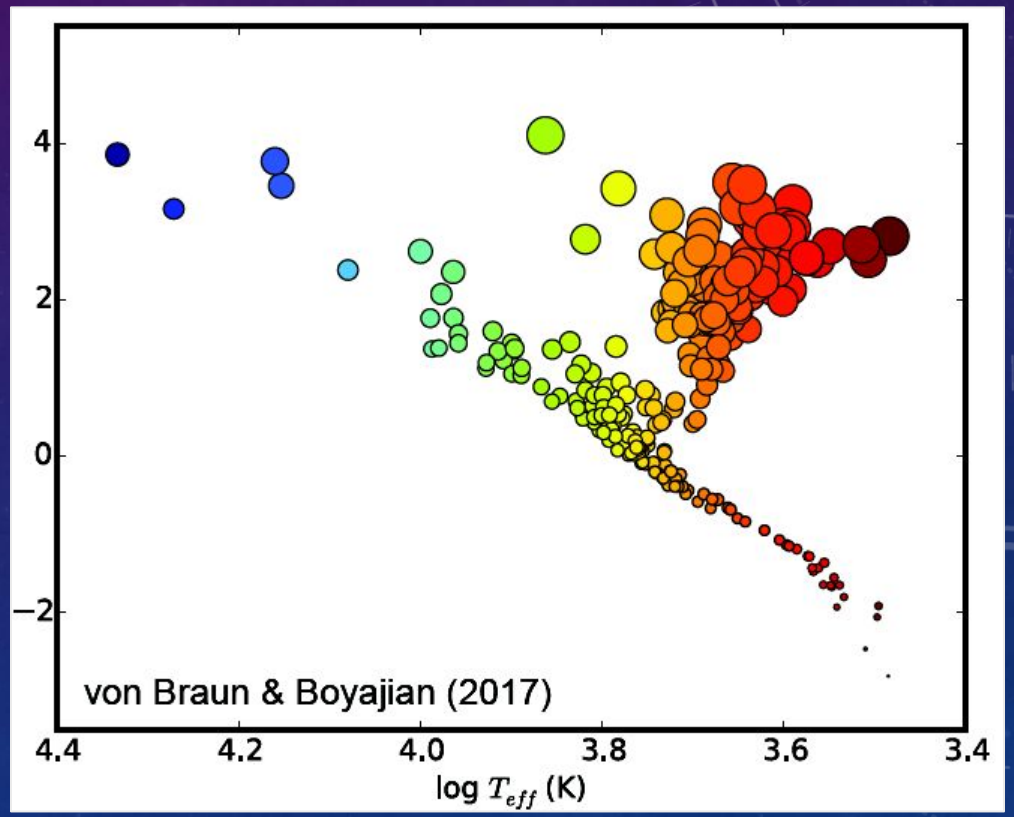
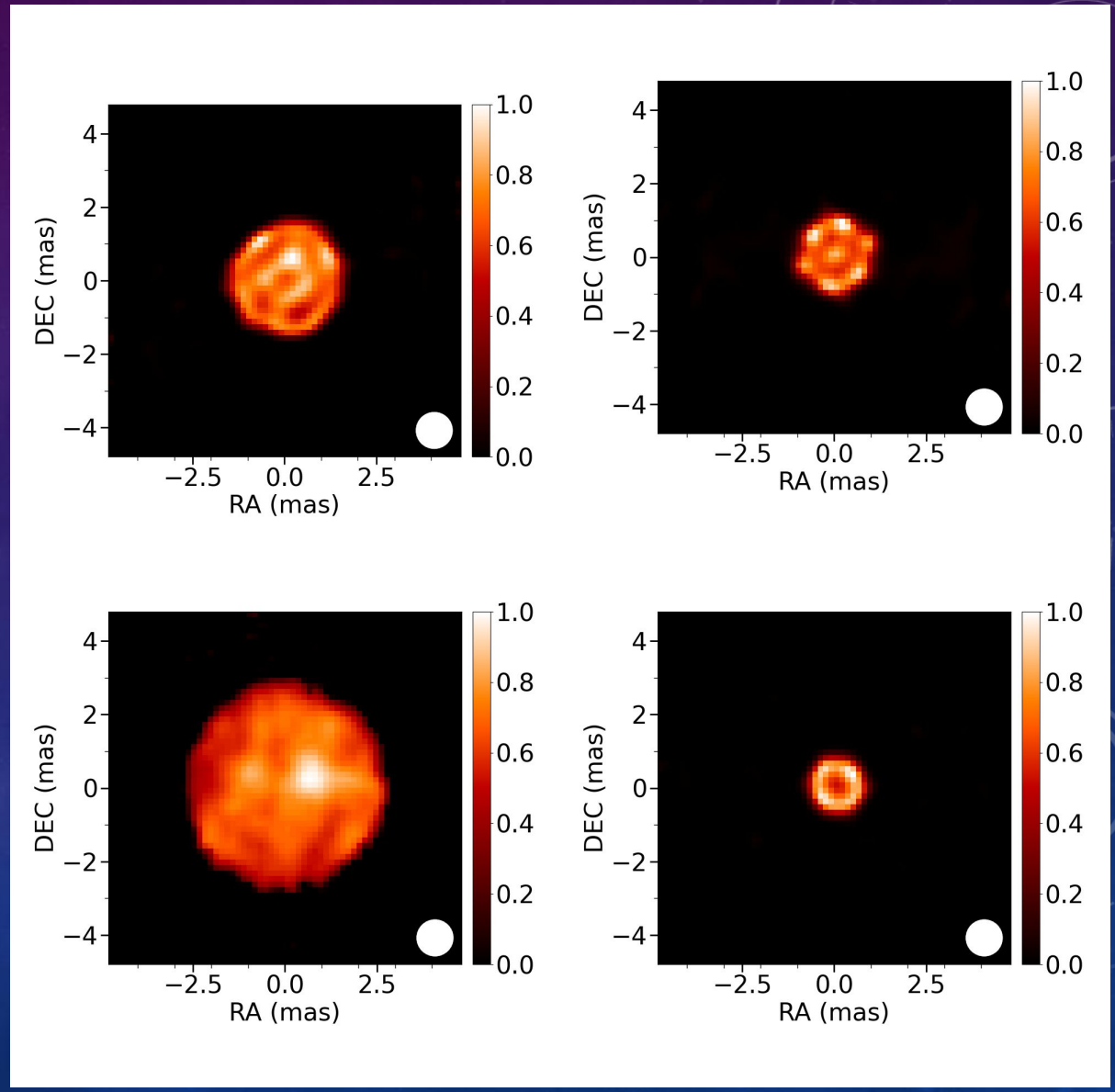


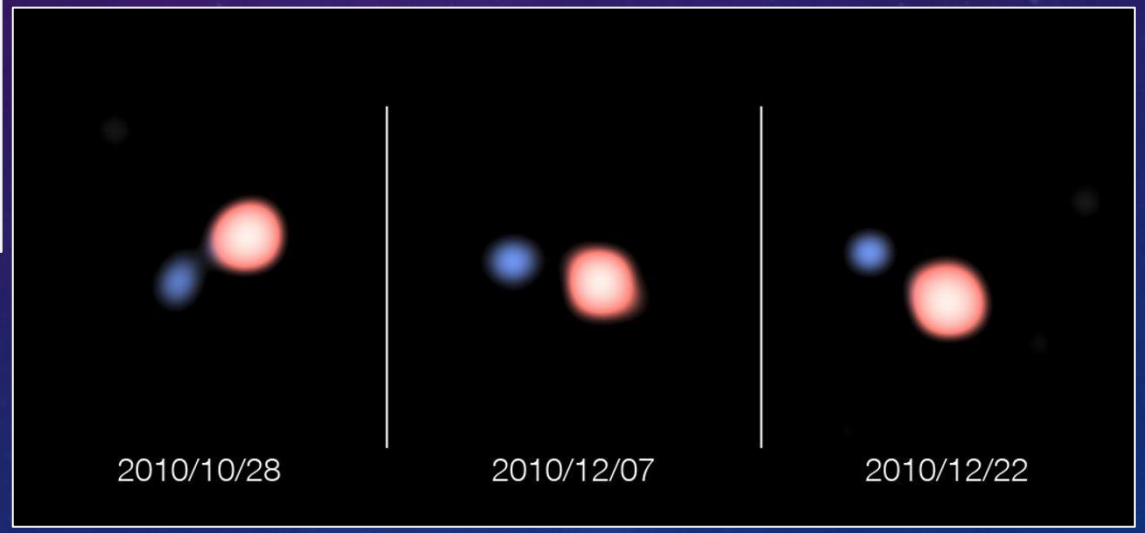
Image Credit: *von Braun and Boyajian 2017*

SHAPES OF STARS

- Stars aren't always spherical:
  - Binary distortion
  - Lumpy convection
  - Surrounded by disk
- Interferometry allows different star shapes to be tested



RESOLVING INTERACTING BINARY STARS



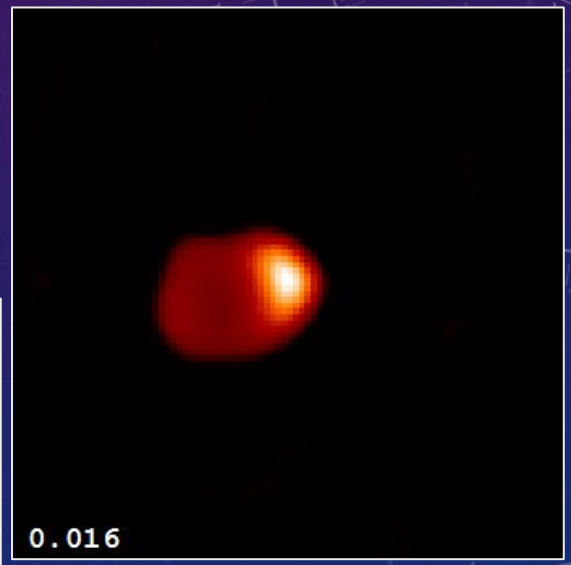
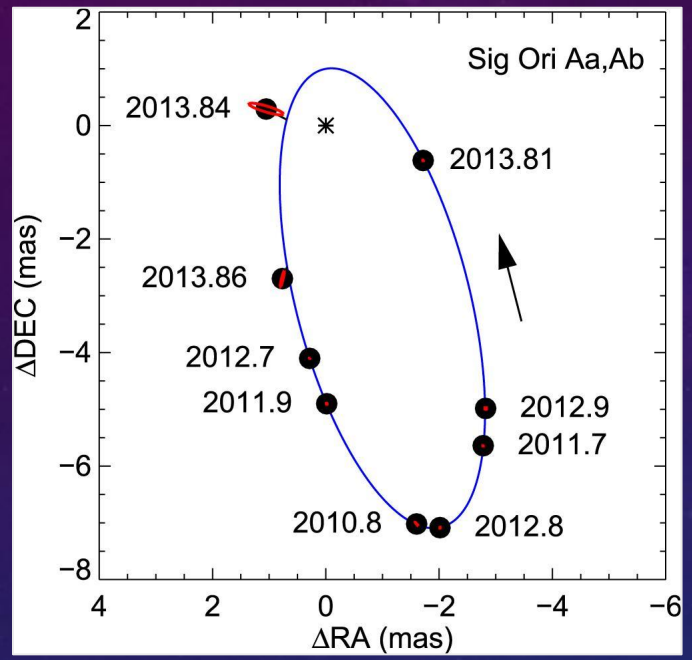
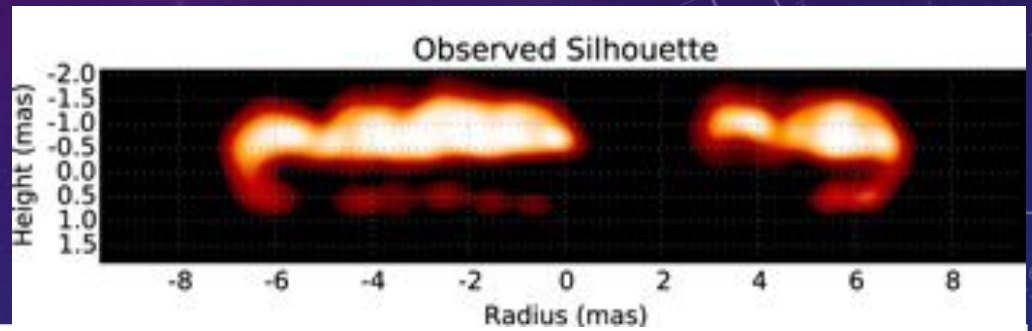


Image Credits: *Zhao et al. 2008, ESO/PIONEER/IPAG, Baron et al. 2012*

BINARY ORBITS AND ECLIPSES





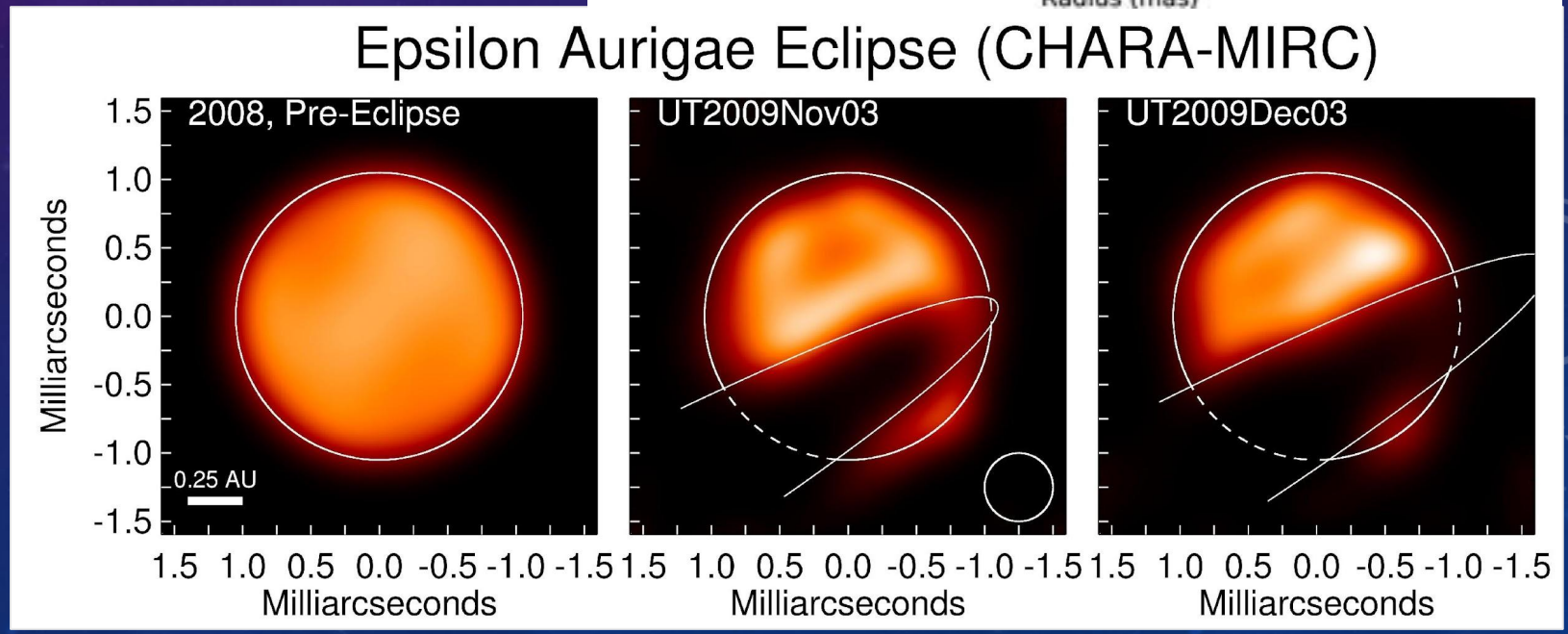


Image Credits: *Schafer et al. 2016, Baron et al. 2012*

STAR SPOT RESEARCH

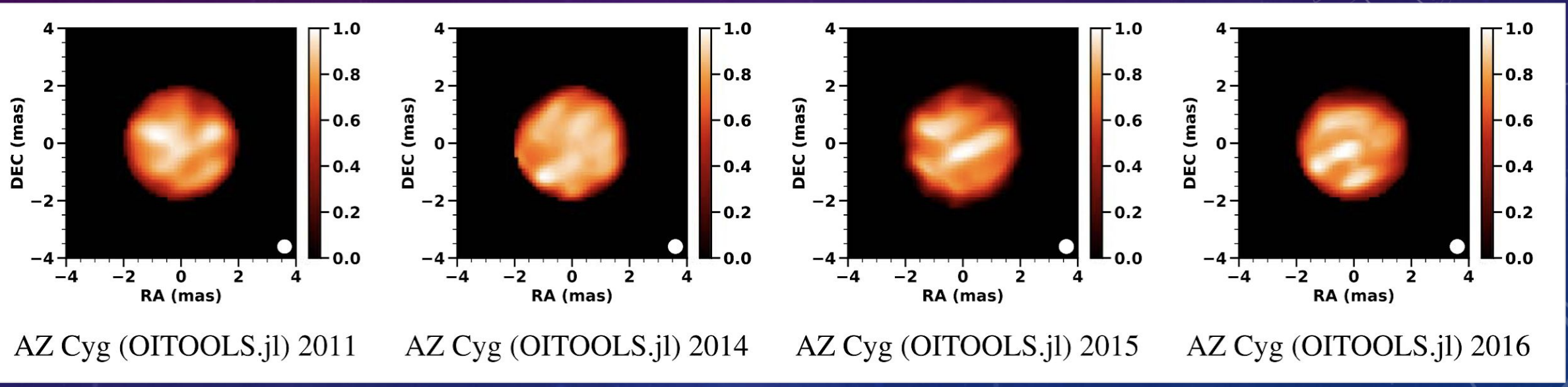


Image Credit: *Norris et al. 2021*

BETELGEUSE DIMMING EVENT

- Betelgeuse is one of the nearest old giant stars
- Star dimmed dramatically in 2019-2020
- Interferometry imaging was able to diagnose cause of dimming:
  - Cool spot on star's surface caused dust to form
  - Resulting cloud blocked light from star

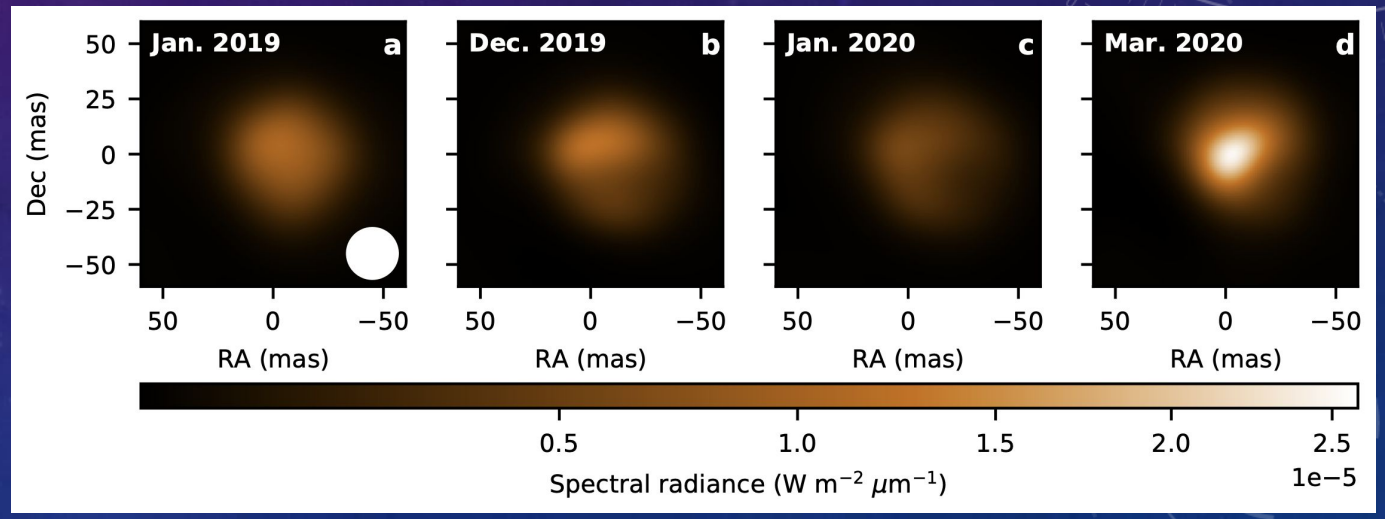


Image Credit: *Montarges et al. 2022*

THE FUTURE

ADVANCES IN OPTICAL INTERFEROMETRY

- Coming improvements to existing arrays:
  - New wavelength bands
  - Larger arrays
  - More telescopes

- Next Array Up:
  - Magdalena Ridge Observatory Interferometer (MROI)

QUESTIONS?