Properties of Astronomical Interferometers

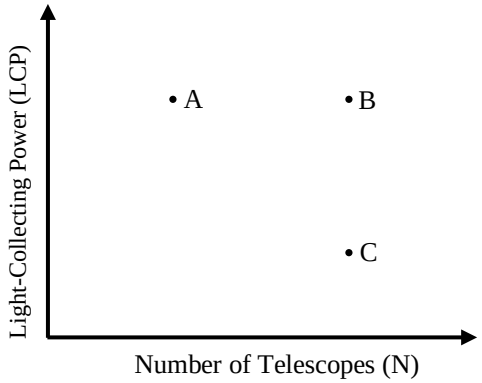
An interferometer is a group of telescopes that work together as a single telescope. Because an interferometer consists of multiple telescopes, it can make observations that are not possible with a single telescope.

The **light-collecting power** (LCP) of an interferometer describes how much light it can collect. The greater an interferometer's LCP, the better it is able to detect dim objects. The equation for the LCP of an interferometer is $LCP = N \times A$. In this equation, *N* is the number of individual telescopes in the interferometer, and *A* is the area of each telescope.

The Light-Collecting Power (LCP) and Number of Telescopes (N) of three interferometers (A, B and C) are plotted in the graph at right.

1) Rank the light-collecting power of the interferometers (A, B and C) from greatest to least.

2) Which of the interferometers has the smallest (average) sized telescopes? Explain your reasoning.

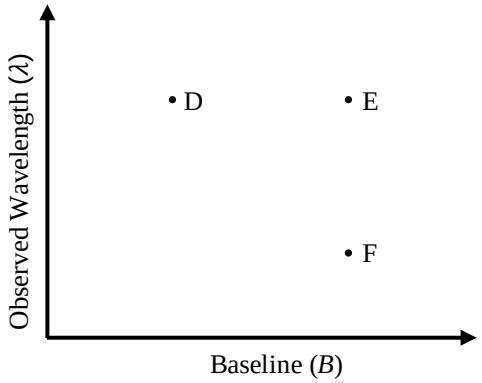


The **resolution** of an interferometer describes how detailed an observation it is able to make. A small resolution means that the interferometer can resolve, or distinguish, sources of light that are separated by a small amount. The equation for the resolution of an interferometer is $R \propto \lambda / B$. *R* is the resolution, λ is the wavelength of light being observed, and *B* is the baseline of the interferometer.

The Observed Wavelength (λ) and Baseline (*B*) of three interferometers (D, E and F) are plotted in the graph at right.

3) Rank the resolution of the three interferometers (D, E and F) from smallest to largest.

4) If all three interferometers (D, E, and F) observe the same object, which interferometer could produce images with the greatest amount of fine details? Explain your reasoning.



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5) Two students are discussing their answers to Questions 3 and 4:

Student 1: *I think you get a better image when the resolution is small, because then you can see details that are only separated by a small amount. The resolution is the wavelength divided by the baseline, so when the wavelength is small, and the baseline is large, you get a really small resolution because that's a small number divided by a large number. That means Interferometer F would produce images with the greatest amount of fine details.*

Student 2: *I disagree. I think a large resolution is good because that means you can see a large number of details. What you said about dividing two numbers makes sense, though. So to get a large resolution, you should observe at long wavelengths with a short baseline. That means Interferometer D would produce images with the greatest amount of fine details.*

Do you agree or disagree with either or both of the students? Explain your reasoning.

6) Consider two different interferometers whose properties are given in the table below.

	Interferometer 1	Interferometer 2
Number of Telescopes	15	5
Wavelength Observed	Long	Short
Baseline	Small	Large
Size of Telescopes	Large	Small

Compare the two interferometers by completing the blanks in the sentences below by circling the correct words or phrases.

Interferometer 1 contains a _____ (larger/smaller) number of telescopes that are _____ (larger/smaller) in size; therefore, it has a _____ (larger/smaller) LCP than Interferometer 2. Interferometer 2 has a _____ (larger/smaller) baseline and observes light at _____ (longer/shorter) wavelengths; therefore, it has a _____ (larger/smaller) resolution than Interferometer 1. So, Interferometer _____ (1/2) would be better at detecting dim objects, and Interferometer _____ (1/2) would be better at producing images with fine details.

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Figure 1, below, shows four different images of the same region of the sky. Each image was produced by a different interferometer. When an area of the image appears brighter, it means that more light was collected from that part of the sky.

Image A

Image B

Image C

Image D

Figure 1

7) Match each of the interferometer descriptions below with the correct image from Figure 1.

a. Small resolution and large LCP

b. Small resolution and small LCP

c. Large resolution and large LCP

d. Large resolution and small LCP

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Figure 2, below, depicts four different interferometers. The label for each interferometer includes the wavelength at which it observes the sky. The area of each large telescope is 4 times the area of each small telescope and the baseline of Interferometers H and J is twice the baseline of Interferometers G and I.

$\lambda = 21\ cm$
Interferometer G

$\lambda = 21\ cm$
Interferometer H

$\lambda = 84\ cm$
Interferometer I

$\lambda = 84\ cm$
Interferometer J

Figure 2

8) Rank the LCP of the interferometers shown in Figure 2 from least to greatest.

9) Rank the resolution of the interferometers shown in Figure 2 from smallest to largest.

10) Match each of the four images of the sky in Figure 1 with the interferometer from Figure 2 that best matches the LCP and resolution of that image. Explain your reasoning.

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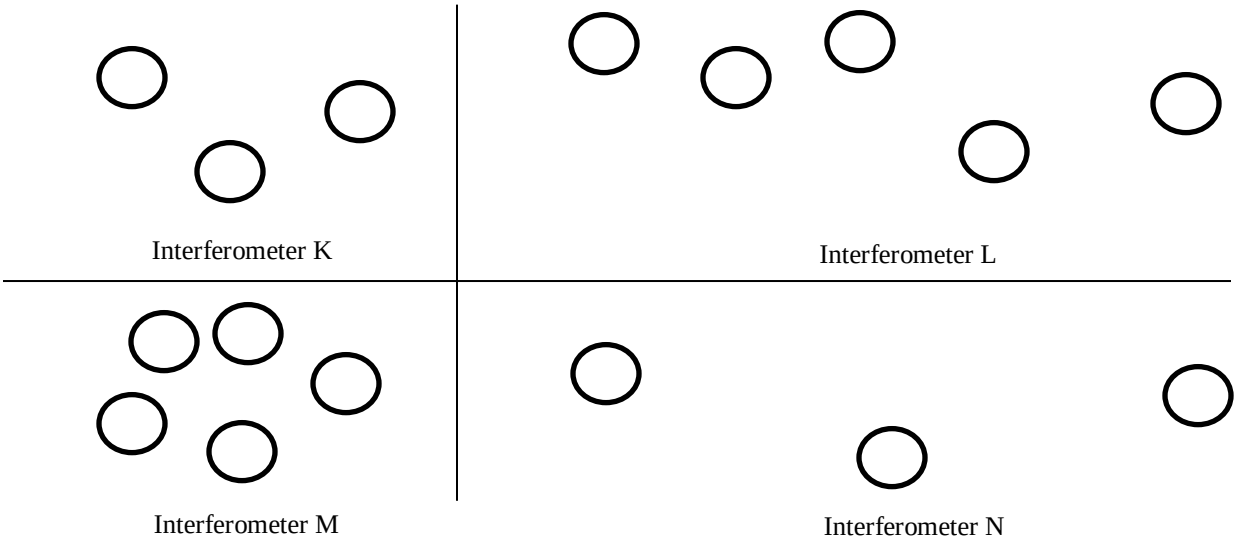
Properties of Astronomical Interferometers

You are in charge of a committee that assigns interferometer access to teams of astronomers. Currently there are four teams requesting access, and you have four interferometers available, so you need to choose which interferometer is most appropriate for each team. Each team wants to observe a different object in the sky, so they need different amounts of LCP and resolution. The table below contains information about the object that each of the four teams wants to observe. All teams will make observations at the same wavelength.

The figure below depicts the four interferometers that are currently available. Recall that the maximum baseline for an interferometer is the distance between the telescopes that are furthest apart. The table below contains information about the object that each of the four teams wants to observe.



Team	Object Observed	Object's Apparent Brightness	Resolution Required
1	Binary Star	Dim	Good
2	Star	Bright	Poor
3	Galaxy	Bright	Moderate
4	Nebula	Dim	Moderate

11) State which of the four interferometers (K-N) you would assign to each of the four teams, and explain your reasoning.

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