3D Constellation of Orion

Student guide

Material List:

A table
Blocks of wood, styrofoam, etc.
Sticks (60-80 cm)
Small round objects
2 Black cardboard posters
Measuring tape
Tack-it, tape, etc.
Pencil
PC and projector (optional)
Pencil and a calculator

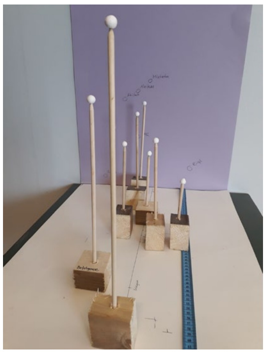
Outline

In this activity we are going to calculate the distances between the stars in the Orion constellation. We use simple mathematics to convert real distances between the stars in space to 3-dimensional positions in a model built on a table in your classroom. Through this excercise we will experience how astronomers find distances using parallax and how much a constellation will change if we change our perspective.

Procedure:

1. Draw a picture of the constellation Orion a large cardboard (make sure you include the named stars in table 1, incl. the Orion nebula M42). You can do this by hand or use a projector, scale an image of Orion onto the wall so it fits on to the piece of cardboard and copy the stars positions with a pencil from the projected image.

2. Place a table next to a wall with the short edge towards the wall. Attach your poster of Orion on to the wall where your table is positioned, just above the table surface. Place your last (blank) cardboard poster onto the table. Fasten it with tape so it will stay in one position while you work.



Measure the length of your table or the cardboard on the table. This will be the length of your model (‘A’ in the next part of the assignment).

3 Use table 1 to calculate the ratio Y between the length of your model (in centimeters) and the actual distances between the stars (given in light years). The ratio is given by Y=A/B, where A is the length of your model and B is the distance in light years between the sun and the most distant star.

Y = ______________

Table 1. Calculate the distances between the stars in your model (source: Stellarium).

Star	Position	Distance X (light years)	Distance X*Y = (centimeters)
Sun	Your position	0	
Betelgeuse (α Ori)	Left shoulder	497	
Bellatrix (γ Ori)	Right shoulder	252	
Meissa (λ Ori)	Head	1055	
Alnitak (ζ Ori)	Belt (left)	817	
Alnilam (ε Ori)	Belt (middle)	1976	
Mintaka (δ Ori)	Belt (right)	916	
Saiph (κ Ori)	Left knee	647	
Rigel (β Ori)	Right knee	863	
Oriontåken (M42)	Dagger	1344	

4 Calculate each stars position in the model (X*Y). Draw a line from the sun towards your Orion poster on the cardboard on the table. Mark the position of each star along the line.

5 Cut blocks of styrofoam, wood or other suitable material and make holes into which you can place the wooden sticks (you need 10 blocks and sticks).

Fasten the block to the table using tape, Tack-it, etc.

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Imagine that you are in the position of the sun and place a stick at the end of the table away from the wall, about half the height of the image, with the pointy end up. Sit next to the stick so that you can aim from the tip of this stick towards the poster.

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Place sticks in blocks on to the table for each star, at the distances from the sun as you calculated in table 1. One student remains seated in the position of the sun, aiming towards each star and instructing his/her fellow students as to where each stick shall be. Try to place the stick as straight/vertical as possible, and with the pointy end up.

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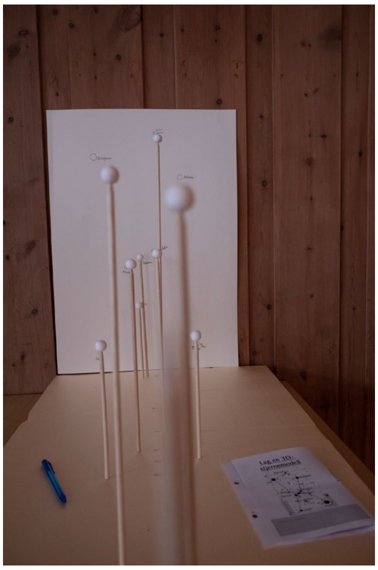
Cut the sticks so that the tip of the stick is exactly in the line of sight from the sun to each star. Place small round objects on the tip to represent the stars.

Sit down next to the table and aim with one open eye, with your open eye as close to the sun as you possibly can. Are you able to "see" Orion from the sun? How much do you have to move before the constellation no longer looks like Orion?



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You probably noticed how tiny errors in placing the stars out could change your Orion image when aiming from the sun. And to compensate you probably checked (and double checked) that the stars were in the right distance from the sun. However, we astronomers also struggle with uncertainty and we do not know exactly how distant all the stars are from us.

Use the same scaling factor Y to calculate the uncertainties, given in table 2 for each star, to centimeters, and compare this with your own precision when you built the model. You can also mark the uncertainties with error bars on the poster/table.

Table 2. Calculate the uncertainty from light years to cm.

Star	**Distance (light years)**	**Uncertainty Z (light years)**	**Uncertainty Z * Y = (centimeters)**
Sun	0	0	
Betelgeuse (α Ori)	497	+/- 56	
Bellatrix (γ Ori)	252	+/- 10	
Meissa (λ Ori)	1055	+/- 160	
Alnitak (ζ Ori)	817	+/- 113	
Alnilam (ε Ori)	1976	+/- 424	
Mintaka (δ Ori)	916	+/- 128	
Saiph (κ Ori)	647	+/- 28	
Rigel (β Ori)	863	+/- 71	
Oriontåken (M42)	1344	+/- 59	

Further Resources/Activities:

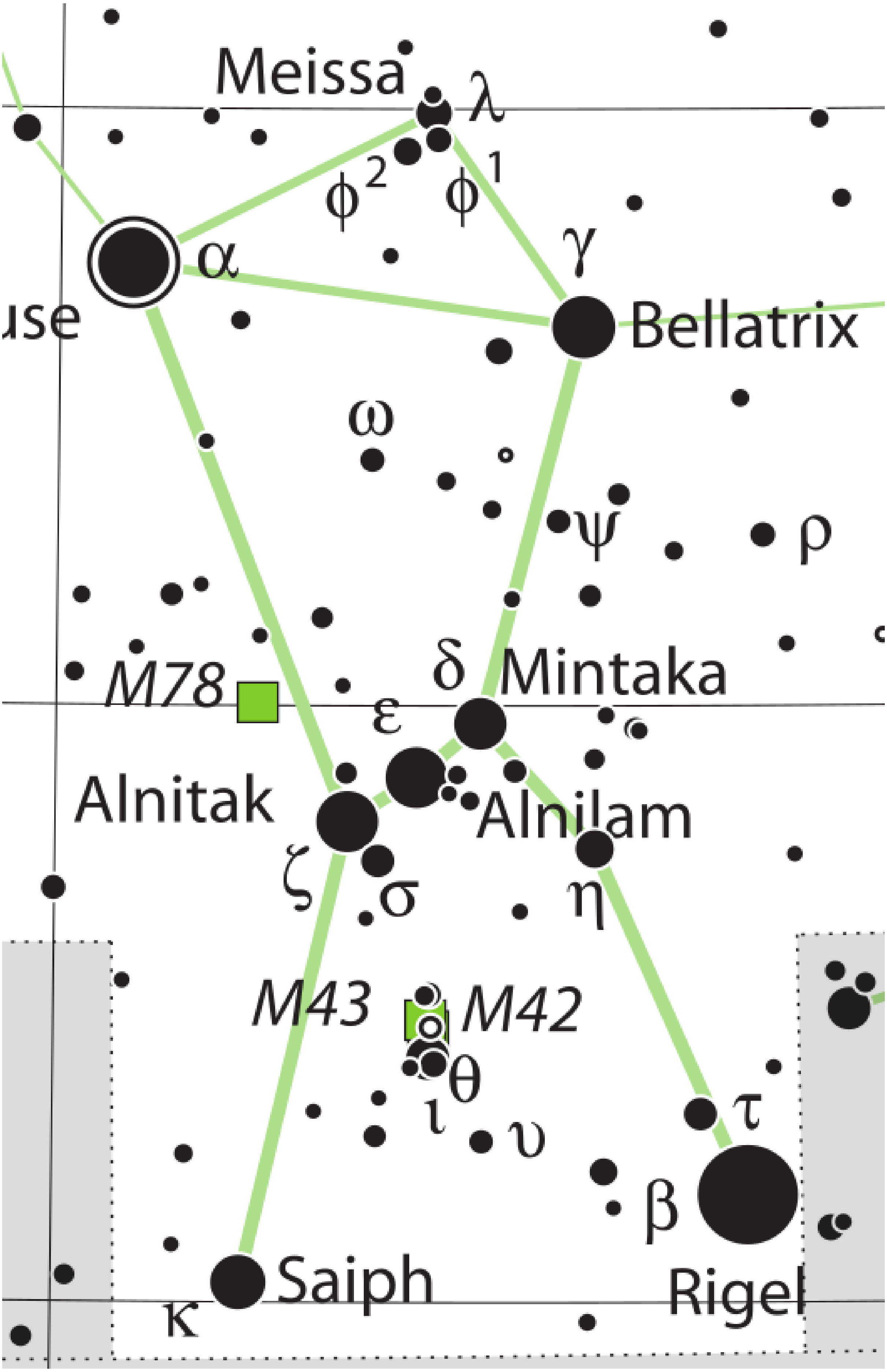
There are various constellations that is suited for this activity. Look through Stellarium for other constellations, and click each star to retrieve a table with the distances to each star. Similar models can also be built bigger using strings to suspend the balls from the ceiling or on tightened strings between both floor and ceiling. You can also colour them with fluorescent paint so that they glow in the dark.

Assessment:

Describe what parts of this excercise was most vulnerable to human error.

How do these uncertainties compare to the actual uncertainties in our observations of the stars positions in space?

Read up on some select objects in Orion: Betelgeuse (red supergiant), Rigel (blue giant) and M42 (a “star-birth” nebula).



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