

The (Stellar) Parallax View

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Many new astronomers marvel at the vast distances separating astronomical objects, but after a while wonder how do we know for sure how big these distances are. After all we cannot send a probe to the star Altair to confirm that it is 17 light years away. So how do we measure the distances to the stars and galaxies?

The most basic technique is called the Stellar Parallax method. Everyone has seen parallax in action, even if they don't know the word. Parallax is the apparent movement of an object against a background due to a change in the observer's position. Here is a little experiment to demonstrate this effect. Next time you are a passenger in a car on a straight stretch of road, look out of the side window (definitely don't try this if you're driving!) If there are trees or hills in the distance, see if you can pick out an object, say a church, between your car and the trees or hills, and note where it is with respect to your car. Keep watching and you will see that the nearby object seems to be moving with respect to the background! Of course, it is stationary and it is you who is really moving. This principle has been understood for centuries, and surveyors still use it to determine the distance to a target object. They look at the object, walk along a known distance called the baseline and observe it again, noting the angle the target has apparently moved through by parallax. Using this angle and the baseline length, it is a matter of very simple maths to calculate how far away the target is (the longer the baseline the more accurate the result will be). When you think about it we are actually doing this all the time without thinking about it. Human beings can instinctively estimate distances well enough to navigate through the environment or perform activities like catching balls just through experience and observation.

It was inevitable that this technique would be



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Friedrich Wilhelm Bessel (1784-1846) He has a crater in the Moon's Mare Serenitatis and asteroid 1552 Bessel named in his honour.

extended beyond Earth. Say we observe a star's position very accurately in January. Then we wait six months and do it again. Why six months? The

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Earth goes around the Sun in one year, so in six month it is in the opposite position in its orbit. As a result, we have a baseline the diameter of the Earth's orbit, roughly 300 million km. The angle the star moves through, its parallax, will be very small, a fraction of an arcsecond at best. If that sounds odd, remember that one degree of angle is divided into 60 arcminutes and each arcminute into 60 arcseconds. Hence we need to measure angles smaller than one 3600th of a degree.

Up to the nineteenth century we could only guess at how far away the stars were, but once measuring instruments became precise enough it became possible to measure interstellar distance by parallax. A sort of race to be first to do this followed and the 'winner' was the great

German mathematician and astronomer Fredrich Bessel, despite his year long distraction by the 1835 apparition of Halley's Comet. In 1838 Bessel determined that the star 61 Cygni had a parallax of 0.314 arcseconds and therefore the star was about ten light years away (today the distance is more precisely measured to be 11.4 light years). In that pre-electronic age this result was an extraordinary feat, the fruit of hours of careful calculations and as many as a dozen painstaking observations in a night.

Contemporary astronomers were delighted by this result. John Herschel called it "the greatest and most glorious triumph which practical astronomy has ever witnessed". Astronomers were also staggered by this value, 61 Cygni was relatively close to us but was still enormously distant. The sheer scale and emptiness of the Universe were becoming clear.

The technique pioneered by Bessel is still used today and is so fundamental that a unit of distance has been designed around it. This is

the parsec which professional astronomers are more likely to use than the light year. Parsec is a contraction of parallax second, and it is defined so that if something is one parsec from the Sun, then in six months it will move through one arc-second. A parsec is about 3.26 light years (so 61 Cygni is 3.5 parsecs away).

In 1989, the European Space Agency launched the Hipparcos satellite. It was designed to measure the parallaxes of nearby stars more accurately than ever before. Despite suffering the embarrassment of being accidentally placed in the wrong orbit, it was a great success. The final Hipparcos Catalogue contains 120 000 stars with parallaxes measured to within 1 milli-arcseconds. Due to the difficulty of measuring very small angles (the more distant the star, the smaller its parallax), we are even today only able to measure parallax angles for stars up to about 1600 light-years away. Beyond this distance we must find other techniques to determine how far away the stars are. We'll discuss these methods in another Astronotes.