Dear Cheap Astronomy - Episode 004

Question 1:

Dear Cheap Astronomy - Why can we view the Southern Cross every night of the year? Is it something to do with the position it has relative to the Sun and the Earth? (Lee from South Africa)

Hi Lee from South Africa. Well, you can view the Southern Cross every day of the year if you live in the Southern Hemisphere. Your position on the Earth's surface is the key issue here. The Southern Cross is a southern circumpolar constellation. The South Celestial Pole is a fixed point in the sky that would be directly overhead of you were standing at the South Pole - and it would be right down on the horizon if you were standing on the Equator. The Southern Cross is relatively close to the South Celestial Pole and so it appears to shift around the pole as the Earth rotates. At least, that what it appears to do from the point of view of people living in the Southern Hemisphere. If you live in the Northern Hemisphere you will only see the Southern Cross for part of the year - and you won't see it at all if you are in a very northerly latitude.

Anyhow, in one full orbit of the Earth (which takes twenty three hours and 56 minutes), if you are far enough South you might be able to see that the Southern Cross does a full 360 degree movement about the South Celestial Pole. But of course, unless you are actually at the South Geographic Pole in mid-winter, you will only see part of that shift each night because each day the Earth's rotation inevitably turns you into line with the Sun again, which will turn the sky blue and block out your view of the night sky for the next twelve hours or so - depending on where your latitude is.

Still, even if you can't always see it, it is true that the Southern Cross does a full rotation about the Southern Celestial Pole every 23 hours and 56 minutes, because of the rotation of the Earth.

But you are also right that there is that important issue of the position of the Sun and the Earth. If you live in a southerly latitude and you stick your head out the window at about 9pm at night in June, you will find that the Southern Cross is pretty much overhead - almost directly above the South Celestial Pole. But if you stick your head out the window at 9pm at night in December, it will be down near the horizon, almost directly below the Southern Celestial Pole. This is because in June you are making an observation from one side of the Earth's orbit around the Sun - and in December you are making an observation from the other side of Earth's orbit around the Sun.

Remember that the Earth rotates once on its axis every 23 hours and 56 minutes. The extra four minutes that makes up our solar day of 24 hours, being the time measured from one sunrise to the next sunrise, results from the fact that, each day, the Earth shifts around a little in its 365.25 day orbit around the Sun. This slight shift makes the Sun appears to stay in the sky two minutes longer in the day and also to rise two minutes later each night.

So although a circumpolar constellation like the Southern Cross rotates 360 degrees around the Southern Celestial Pole every 23 hours and fifty six minutes, we set our clocks to a full 24 hour day which is the time from one sunrise to the next. So every day, all the stars, including the Southern Cross, gain an extra four minutes of rotation compared to the previous day. That extra 4 minutes a day adds up to 28 minutes a week, which is about 2 hours a month, which is about 12 hours every six months. So the Southern Cross gains an extra 12 hours in rotation every six months. Since 12 hours is about half a day, or about half an Earth rotation, the constellation is rotated 180 degrees away from the position it had at the same time of night 6 months ago. I hope that makes sense.

Oh and one footnote here - of course it's true that if you live really close to the northern or southern geographic pole, the rule that there is always 24 hours between one sunrise and the next sunrise may not apply - but we have to remember that the people who first invented 24 hour clocks didn't live in those sort of places.

Question 2:

Dear Cheap Astronomy - Please explain Lagrangian Points and why they are important to space probes. John from the UK.

Hi John - Lagrangian points are an interesting feature of orbital mechanics which we'll explain as we go. But first let's think about the space probe part of your question. There are two main types of space probes. Exploratory probes are sent on a journey of exploration - like the Voyager probes which flew by the gas giants and out to the edge of the solar system, or the Messenger mission which we sent inwards to explore Mercury. But there's also an important collection of observational probes which we just park out in space, often for ten years or more, to study the universe or to study the Sun, from a safe distance.

But, of course parking a probe in space is no straight-forward matter. Space is not the sort of place where anything can really be considered stationary. The Earth only maintains a stable orbit around the Sun because it is moving at about 30 kilometres a second. Slow it down and its orbit will decay towards the Sun - speed it up and its orbit will rise away from the Sun.

The same rule apply to space probes. If you don't immediately want your probe to plummet headlong into the Sun you are going to have to place it in a fast-moving orbit. And although there are plenty of different solar orbits you could put it in - if it's not moving at the same orbital velocity as the Earth, then there will be times when it will disappear behind the Sun and you will lose valuable data collection time.

So what you really want is to have your observational probe move alongside the Earth and to have it move at exactly the same orbital velocity around the Sun as the Earth moves. One easy solution to this problem is to just put the probe into orbit around Earth - which is what we have done with the Hubble Space Telescope, for example. Hubble works quite well in Earth orbit since it can study bits of the sky to the north or the south continuously and it can track other objects for a long part of an orbit, until the Earth gets in the way.

And for a lot of astronomy, that's all you need. Like cameras here on Earth, the longer exposure time you will need to capture its image. Hubble does an orbit of Earth every 96 minutes which is actually a lot of exposure time for most objects and you can often get away with stacking multiple exposures from different orbits if you need to. For example, the iconic Hubble Deep Field image, which shows a sky full of faint and distant galaxies, was composed of 342 exposures taken over ten consecutive days.

But for very faint objects - and indeed the faintest light of all, the cosmic microwave background, you might still need a better solution. Indeed you really want a solution that avoids a lot Earth-related background noise like reflective Earthshine, the Earth's own thermal black body radiation and of course all that non-stop radio babble that is generated by us humans.

Wouldn't it be great if there was somewhere you could park a spacecraft that was a) distant from Earth, but b) still moved at exactly the same orbital velocity as Earth. And this is where the Sun-Earth Lagrangian points come in.

There's another point 1.5 million kilometres closer to the Sun than Earth's orbit, where you'd expect an object would have to move faster than Earth to maintain a stable solar orbit. But at this point, Lagrangian point 1, if an object does try to move faster the gravity of Earth drags it back again. Lagrangian Point 1 is where we have parked some of our long-term solar observation probes like SOHO (since 1996), ACE (since 1997) and Wind (since 2004).

And there's a point about 1.5 million kilometres further out from the Sun where's things should move slower that Earth, but Earth keeps on giving them an acceleratory pull of gravity assist. So, objects at this Lagrangian point 2 also move at Earth orbit velocity even though they are 1.5 million kilometres further out from the Sun than Earth's orbit. Lagrangian point 2 is where we can park our deep universe observation probes that need radiation quiet and cold temperatures to operate effectively. For example, parked at Lagrangian point 2 are the microwave background probes WMAP and Planck and also the infrared probe Herschel - and sometime after 2018, the James Webb Space Telescope.

I hope that answers your question.