

Dear Cheap Astronomy - Episode 006, Getting skeptical

*There are some tall tales told out in the astronomy hinterlands. Sometimes these stories get picked and run with without anyone actually checking facts behind the story. So, while everyone deserves the right to be heard - everyone also deserves the right to be skeptical about whether what they are hearing is really true.*

*But are the skeptics always right? No - although they are right with their general message that it doesn't matter who is saying something, the important thing is whether or not it's true.*

### **Question 1:**

*Dear Cheap Astronomy - Is Cruithne really the Earth's second moon?*

Quick answer, no. Longer answer, no, non, nein, nyet. In no way should Cruithne be considered to be a moon of Earth. It isn't... not even a little bit.

Cruithne, or to get technical about it 3753 Cruithne, is a near Earth object that very clearly and very obviously orbits the Sun. It was incorrectly declared to be a second Moon of Earth in an early episode of QI - a panel talk show, hosted by Stephen Fry - but it just isn't true.

The misunderstanding, which - not meaning to be too harsh, just seems to be the result of poor research - perhaps arises from providing our frame of reference on Earth with an unreasonable degree of centrality.

In other words, if you naively assumed that Earth was the center of the Solar System, then yes, you might then be tricked into believing that Cruithne orbits the Earth. Indeed you might be tricked into believing that Venus, Mars and all the other planets orbit the Earth. But come on folks - we sorted all this out four hundred years ago.

Kepler's Third Law says that if you closely orbit the Sun you have to orbit it really fast - but if you orbit it further out then you can orbit it more slowly. As it happens, Cruithne orbits the Sun once every three hundred and sixty four days. So it almost matches Earth's orbital period - and so you shouldn't be surprised to learn that it orbits the Sun at about the same distance from it as the Earth does hence it sometimes comes into close proximity with the Earth.

But Cruithne is tiny, around 5 kilometres in diameter. So, with an insignificant mass, Cruithne is insignificantly affected by the gravitational influences that work to ensure that all the massive planets and orbit the Sun in a roughly flat orbital plane. Cruithne's solar orbit is tilted at about 20 degrees to Earth's solar orbit, although the orbits of Earth and Cruithne do not intersect at any point.

But there are times when Cruithne appears to approach the Earth - and then recedes away again. It is possible that for a brief moment this might have got the first astronomers who identified Cruithne in 1986, to speculate that it could have been in a wide elliptical orbit around the Earth. But after continuing to observe it, it would have soon become apparent that Cruithne was just another near-Earth object in a solar orbit.

In fact, there are a whole bunch of other near Earth objects (or NEOs) in solar orbits. As of 20 October 2012, we know of 9,315 of them, of which 1,336 are classified as potentially

hazardous. And in fact, there are a whole bunch of satellites in Earth orbit - over 8,000 at last count - but the very, very large majority of them were built by us. The exact number of known, natural satellites that persistently orbit the Earth is one and it's called the Moon.

But the Earth does briefly host a number of transient mini-moons, which are less than a metre or so in diameter and may loosely orbit the Earth for up to a year or more, until they drift back into a solar orbit. It's estimated that at any point in time, Earth does a second natural satellite, it's just not the same satellite for any persistent length of time. And to the best of our knowledge it never has been, and never will be, Cruithne.

*And thanks Duranee. The lesson here is that the orbit of a celestial body can take a year or two to really nail down, so don't take a first tentative announcement of what it appears to be as a final conclusion. Wait for the data.*

*And now here's, well me, talking about another astronomical press release that did not really deserve the air time that it got.*

## **Question 2:**

*Dear Cheap Astronomy - What do you think of this latest suggestion that the Pioneer anomaly can be explained by the expansion of the universe.*

Well to be honest, I don't think much of it - but I am happy to talk about it if someone can convince me it's really true. When it was released, the story was picked up by a few perhaps over-credulous science communicators – for example: (SGU excerpt). And once again, I did first write to the Skeptics Guide team to point out the problem. I do always write first – it's polite and respectful.

Anyhow, my skepticism arises from knowing that the October 2012 paper by Sergei Kopeikin - which I probably mispronounced - came out just a month after a September 2012 paper, in a publication associated with the journal Nature, announcing confirmation that thermal radiation recoil could completely account for the unanticipated spacecraft deceleration that represents the so-called Pioneer anomaly.

Kopeikin's claim that thermal radiation accounts for just 15% of the Pioneer anomaly arises from a technically correct, but way out-of-date, citation of the initial announcements of the Pioneer anomaly back in the 1980s.

Those 1980 announcements were superseded by 30 more years of intensive research – which resulted in the 2012 Nature article by Turyshev et al - which I probably also mispronounced. Turyshev's laborious and unprecedented analysis of the Pioneer data really did confirm that thermal radiation recoil was the cause of the Pioneer spacecrafts' unanticipated deceleration.

Kopeikin's paper is really about potential inaccuracies in astronomical measurements that could arise from the expansion of the Universe. Perhaps unwisely, Kopeikin pointed to the Pioneer anomaly as an example of such a potential inaccuracy - but he made no apparent attempt to analyse the Pioneer data himself to justify this claim. So, it seems he has based his theory on a phenomenon which is no longer thought to exist.

Kopeikin's commentary makes it quite clear that he thinks that the universe's expansion has been affecting photons moving to and from the Pioneer spacecraft - in other words that the Solar System was actually expanding in the same way that the whole universe is expanding. There are not a lot of cosmologists around who would be comfortable with this view.

Current thinking is that most of the expansion of the Universe involves expansion of space-time between galaxies and galactic clusters. The slightest amount of gravitational attraction between massive objects is thought to vastly outweigh the potential space-time expansion that can take place in very empty intergalactic voids.

It has been estimated that at the million light year scale of galactic clusters, the outward push that drives the overall expansion of the Universe is 10 million times smaller than the gravitational pull that is prevalent across a galactic cluster. Ten million is a back-of-an-envelope estimate - but it does show that the apparent forces underlying the expansion of the universe would have no hope of overcoming the apparent forces that keep the planets in fixed orbits about the Sun.

Also, we should consider that we didn't stop exploring the cosmos with the Pioneer spacecraft – which were launched in the early seventies and were operational until the early 2000s. Currently, like today, we are tracking the still operational Voyager 1 and 2 probes - which are way further out than either Pioneer 10 or 11 - and we are currently guiding the New Horizons spacecraft on a pinpoint trajectory for a fly-by of Pluto in 2015. You don't hear NASA rocket scientists discussing how they have to keep modifying the trajectory of their spacecraft to compensate for the expansion of the Universe. And that's because they don't.

Also, the math of general relativity is needed to account for an otherwise apparent anomaly in Mercury's orbit? Now, no-one seems to be talking about how the Universe's expansion is required to explain an apparent anomaly in Neptune's orbit or indeed any other planet. This is because all the data we have about pretty much everything flying about the Solar System confirms the view that the Solar System is virtually unaffected by the expansion of the Universe.

So folks, I think the large majority of the scientific community is in agreement that there is no Pioneer anomaly any more. The Pioneer spacecraft were very-slightly slowed down by the thermal radiation from their heated surfaces. It took us more than 30 years to confirm this, but we did eventually confirm it. So, if you want to propose that the Solar System is expanding the first thing you will need is evidence – and since it is an extraordinary claim you will need extraordinary evidence.

*And thanks me. Perhaps the real punchline to this one was that the research was funded by a grant from the Templeton Foundation –which shouldn't be seen as automatically damning – but is what you might call a red flag.*

*Got questions? Just send them to [cheapastro@gmail.com](mailto:cheapastro@gmail.com). We might get the answer wrong, but we will try not to and if we do bollocks it up, it will make for a good follow-up episode.*